



camcore

Global partners for the future of our forests

2008 Annual Report



NC STATE UNIVERSITY

2008 CAMCORE ANNUAL REPORT

International Tree Conservation and Domestication

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EXECUTIVE SUMMARY

1. Three active members joined Camcore in 2008: Chikweti Forests (Mozambique), Refocosta (Colombia), and East Africa (Kenya, Tanzania and Uganda). The East African membership is actually a renewal of a past membership. We welcome all three organizations to Camcore.
2. Seed collections continued in natural stands of *P. maximinoi*, *P. oocarpa* and *P. tecunumanii* in Central America. One-hundred eighty-nine trees were sampled.
3. Eighty-two trees in nine provenances of Eastern hemlock (*Tsuga canadensis*) and 14 trees in four provenances of Carolina hemlock (*Tsuga caroliniana*) in the southern and eastern US were collected by Camcore in 2008. Arauco-Bioforest established its first *ex situ* conservation bank of Carolina hemlock in Chile. Camcore received a \$47,500 grant from the USDA Forest Service for a genetic diversity study of Eastern hemlock.
4. The six South African members began planting Conservation Parks to protect genetic material collected by Camcore over the past three decades. The Conservation Parks are approximately 25 hectares in size and contain as many as 40 different provenances each.
5. A range-wide genetic diversity assessment of *P. oocarpa* using microsatellite markers was completed by Camcore. Results indicate that the species has two centers of diversity, one in central Mexico and another in Central America. *Pinus tecunumanii* appears to have evolved from *P. oocarpa* in Honduras and Nicaragua. Marker analysis indicates that gene exchange between the two species is common in natural stands; a result that has long been suspected based on observations in field trials and plantings.
6. Members established 21 pine hybrid trials in 2007 and 2008: three in Argentina, six in Brazil, three in Colombia and nine in South Africa.
7. The Camcore staff completed a seedling cold hardiness study of 15 pine species from 27 different regions in environmentally controlled growth chambers at NC State. Results closely mimicked field observations in progeny trials. With cold tolerance quantified for pure species, Camcore will now take a closer look at the inheritance patterns of cold tolerance in specific hybrid crosses.
8. Pitch canker assessments were made on seedlings from 50 provenances of *P. oocarpa* in Mexico and Central America grown at the USDA FS screening center in North Carolina. There was little natural variation. Provenance stem kill values ranged from 3 to 8% and indicate that the species has good resistance to the disease throughout its natural range.
9. Provenances of *P. greggii* were also screened for pitch canker resistance in a separate study. Results indicate that northern sources (var. *greggii*) are very susceptible to pitch canker and southern sources (var. *australis*) are more resistant, with *P. patula* slightly less resistant than var. *australis*.
10. A number of the Camcore species produce wood superior to *P. taeda* and *P. radiata*. Sub-tropical species like *P. tecunumanii* and *P. maximinoi*, offer more uniform pith-to-bark profiles for density, and have much lower microfibril angles resulting in stronger wood, particularly in the juvenile core of the tree.
11. In terms of fiber cross-sectional dimensions, *P. patula* and *P. greggii* appear to have thinner cell walls than *P. taeda*, and should produce paper of equal or greater tensile strength with lower refining costs.
12. Kitt Payn (Mondi) and Nhora Isaza (Smurfit Colombia) completed their Ph. D. and MS degrees, respectively, with Camcore at NC State. Kitt's work examined the evolutionary history of *E. urophylla* and Nhora studied flower production in *P. maximinoi* and *P. tecunumanii* in Colombia. Robert Jetton (Camcore) also completed his Ph.D. in forest entomology. Robert's thesis focused on the hemlock woolly adelgid.
13. Camcore staff authored or co-authored 13 publications, 3 posters, and gave 2 presentations in 2008. Bill Dvorak was given an Award for Service to the Environment & Society in a ceremony at NC State University. Gary Hodge was promoted to full Professor at NC State University.

1. Tres miembros activos se afiliaron a Camcore en el 2008: Chikweti Forests, (Mozambique) Refocosta, (Colombia) y Africa del Este (Kenya, Tanzania y Uganda). La afiliación de Africa del Este es realmente la renovación de su membresía de años anteriores. Le damos la bienvenida a las tres organizaciones a Camcore.
2. Las colectas de semillas continúan en los rodales naturales de *P. maximinoi*, *P. oocarpa* y *P. tecunumanii* en Centroamérica. Se colectaron semillas de ciento ochenta y nueve árboles.
3. Se colectaron semillas de ochenta y dos árboles de nueve procedencias del abeto del Este (*Tsuga canadensis*) y 14 árboles de cuatro procedencias del abeto Carolina (*Tsuga caroliniana*) en el sur y el este de los Estados Unidos por Camcore en el 2008. Bioforest-Arauco estableció su primer banco de conservación ex situ del abeto Carolina en Chile. Camcore recibió fondos del Servicio Forestal de los Estados Unidos por valor de \$47,500 dólares para un estudio de diversidad genética del abeto del Este.
4. Los seis miembros Surafricanos empezaron a plantar los Parques de Conservación para proteger el material genético colectado por Camcore durante las tres últimas décadas. Los Parques de Conservación tienen aproximadamente un tamaño de 25 hectáreas y contienen hasta 40 procedencias distintas cada uno.
5. Se completó una evaluación de amplio rango de diversidad genética de *P. oocarpa* usando marcadores microsatelitales por Camcore. Los resultados indican que la especie tiene dos centros de diversidad, uno en el centro de México y otro en Centroamérica. El *P. tecunumanii* parece haber evolucionado del *P. oocarpa* en Honduras y Nicaragua. El análisis de marcadores indica que el intercambio de genes entre las dos especies es común en los rodales naturales.
6. Los miembros establecieron 21 ensayos de híbridos de pino durante el 2007 y el 2008: tres en Argentina, seis en Brasil, tres en Colombia y nueve en Sur Africa.
7. El personal de Camcore completó un estudio de tolerancia al frío de plántulas de 15 especies de pino de 27 regiones diferentes en cámaras de ambiente controlado en la Universidad Estatal de Carolina del Norte. Los resultados reflejaron en una forma muy aproximada las observaciones de campo de los ensayos de progenie. Con la tolerancia al frío ya cuantificada para las especies puras, Camcore examinará con más detalle los patrones de herencia de la tolerancia al frío en cruces híbridos específicos.
8. Se realizaron evaluaciones del cáncer del pino en plántulas de 50 procedencias de *P. oocarpa* de México y Centroamérica, las cuales exhibieron baja variación natural. Los valores de tallos muertos por procedencia variaron entre el 3 y el 8% e indican que la especie tiene buena resistencia a la enfermedad en todo su rango natural.
9. Algunas procedencias de *P. greggii* también fueron evaluadas para determinar su resistencia al cáncer del pino en un estudio aparte. Los resultados indican que las fuentes del norte (var. *greggii*) son muy susceptibles a cáncer del pino, y las fuentes del sur (var. *australis*) son más resistentes, siendo el *P. patula* es poco menos resistente que var. *australis*.
10. Muchas de las especies de Camcore produjeron madera superior a la del *P. taeda* y *P. radiata*. Especies subtropicales como el *P. tecunumanii* y el *P. maximinoi* ofrecen perfiles de densidad de la madera desde la médula hasta la corteza más uniformes y tienen los ángulos de las microfibrillas mucho más pequeños que originan en la producción de madera más fuerte, particularmente en la parte central juvenil del árbol.
11. En términos de las dimensiones de la sección transversal de las fibras, el *P. patula* y el *P. greggii* parecen tener paredes celulares más delgadas que las del *P. taeda*, y deberían permitir la producción de papel con la misma ó mayor resistencia a la tensión y costos de refinación más bajos.
12. Kitt Payn (Mondi) y Nhora Isaza (Smurfit Colombia) completaron sus grados de doctorado y maestría respectivamente con Camcore en la Universidad Estatal de Carolina del Norte. Kitt, en su trabajo examinó la historia evolutiva del *E. urophylla* y Nhora estudió la producción de flores de *P. maximinoi* y *P. tecunumanii* en Colombia. Robert Jetton (Camcore) también completó sus estudios de doctorado en entomología forestal. Su tesis estuvo enfocado a la investigación del *Adelges tsugae* en el abeto
13. El personal de Camcore fue el autor o coautor de 13 publicaciones y 3 posters en el 2008. Bill Dvorak recibió un Premio por su Servicio al Ambiente y la Sociedad en una ceremonia realizada en la Universidad Estatal de Carolina del Norte. Gary Hodge fue promovido a profesor de tiempo completo en la universidad.

1. Três membros executivos se juntaram ao Camcore em 2008: Chikweti Forests (Moçambique), Refocosta (Colômbia), e East Africa (Quênia, Tanzânia e Uganda). A entrada da East Africa é na verdade uma renovação de participação passada. Nós damos as boas-vindas às três organizações ao Camcore.
2. As colheitas de sementes continuaram em povoamentos naturais de *P. maximinoi*, *P. oocarpa* e *P. tecunumanii* na América Central. Cento e oitenta e nove árvores foram amostradas.
3. Oitenta e duas árvores de nove procedências de Eastern hemlock (*Tsuga canadensis*) e 14 árvores de quatro procedências de Carolina hemlock (*Tsuga caroliniana*) foram coletados por Camcore no Sul e Leste dos EUA em 2008. Arauco-Bioforest estabeleceu sua primeira conservação *ex situ* de Carolina hemlock no Chile. Camcore recebeu uma concessão de \$47,000 do Serviço Florestal Americano para um estudo de diversidade genética de Eastern hemlock.
4. Os seis membros da África do Sul começaram a plantar Parques de Conservação para proteger material genético coletado por Camcore nas últimas três décadas. Os Parques de Conservação tem um tamanho aproximado de 25 hectares cada um, e contém no máximo 40 procedências.
5. Camcore completou uma avaliação de diversidade genética em todo a gama natural de *P. oocarpa* usando marcadores de microsatélite. Os resultados indicam que a espécie tem dois centros de diversidade, um no centro do México e outro na América Central. *Pinus tecunumanii* aparenta ter evolvido de *P. oocarpa* em Honduras e Nicaragua. A análise de marcadores indica que o intercâmbio genético entre as duas espécies é comum em povoamentos naturais; um resultado que havia sido suspeitado baseado em observações de ensaios de campo e plantações.
6. Membros estabeleceram 21 ensaios de híbridos de pinho em 2007 e 2008: três na Argentina, seis no Brasil, três na Colômbia e nove na África do Sul.
7. Os funcionários do Camcore completaram um estudo de resistência ao frio de mudas de 15 espécies de pinho de 27 diferentes regiões em câmaras de crescimento de ambiente controladas na universidade de NC State. Os resultados se assemelham bastante às observações de campo nos ensaios de progênie. Com a tolerância ao frio quantificada para as espécies puras, Camcore agora efocará nos padrões de herdabilidade de tolerância ao frio em cruces híbridas específicas.
8. Avaliações de “*Fusarium*” foram feitas em mudas de 50 procedências de *P. oocarpa* no México e na América Central semeadas no USFS Centro de Avaliação de Resistência em Carolina do Norte e exibiram pouca variação natural. Valores de morte de talo por procedência variaram de 3 a 8% e indicam que a espécie tem boa resistência à doença através de toda sua área de ocorrência natural.
9. Procedências de *P. greggii* também foram examinados para resistência a *Fusarium* em outro estudo separado. Resultados indicam que fontes do norte (var. *greggii*) são muito susceptíveis ao *Fusarium* e fontes do sul (var. *australis*) são mais resistentes, com *P. patula* um pouco menos resistente que a var. *australis*.
10. Várias das espécies do Camcore produzem madeira de qualidade superior à madeira de *P. taeda* e *P. radiata*. Espécies sub-tropicais como *P. tecunumanii* e *P. maximinoi* oferecem perfis mais uniformes de medula-a-casca para densidade, e têm ângulos microfibrilos muito mais baixos, resultando em madeira mais forte, particularmente no centro juvenil da árvore.
11. Em termos de dimensões de fibras cruz-seccionais, *P. patula* e *P. greggii* aparentam ter paredes celulares mais finais que o *P. taeda*, e devem produzir papel de mesma ou de maior força tênil com custos de refinamento mais baixos.
12. Kitt Payn (Mondi) e Nhora Isaza (Smurfit Colômbia) completaram seus cursos de Ph.D. e MS, respectivamente com Camcore na NC State University. O projeto de Kitt examinou a evolução histórica de *E. urophylla* e Nhora estudou a produção de flores em *P. maximinoi* e *P. tecunumanii* na Colômbia. Robert Jetton (Camcore) também completou seu Ph.D. em entomologia florestal. Seu tesis enfocou no pulgão *Adelges tsugae*.
13. Os funcionários do Camcore também foram autores ou co-autores de 13 publicações e 3 posteres no 2008. Bill Dvorak recebeu um prêmio por Serviço ao Meio Ambiente e Sociedade em uma cerimônia na NC State University. Gary Hodge foi promovido para professor doutor na NC State University.

1. Tiga anggota aktif bergabung Camcore di tahun 2008: Chikweti Forests (Mozambik), Refocosta (Kolumbia), dan Afrika Timur (Kenya, Tanzania dan Uganda). Keanggotaan Afrika Timur sebenarnya adalah pembaharuan dari keanggotaan terdahulu. Kami menyambut gembira ketiga organisasi tersebut ke dalam Camcore.
2. Pengumpulan benih dari tegakan alam telah berlanjut untuk *P. maximinoi*, *P. oocarpa* dan *P. tecunumanii* di Amerika Tengah. Seratus delapan puluh sembilan pohon diambil sampelnya.
3. Delapan puluh dua pohon di sembilan provenance dari Eastern hemlock (*Tsuga canadensis*) dan 14 pohon di empat provenance dari Carolina hemlock (*Tsuga caroliniana*) di bagian selatan dan timur USA dikumpulkan oleh Camcore pada 2008. Arauco-Bioforest mendirikan *ex situ* konservasi pertama untuk Carolina Hemlock di Chile. Camcore menerima hibah sebesar \$ 47,000 dari USDA Forest Service untuk studi keanekaragaman genetika dari Eastern hemlock.
4. Anggota dari enam negara Afrika Selatan mulai menanam Taman Konservasi untuk melindungi bahan genetika yang dikumpulkan oleh Camcore selama tiga dekade terakhir. Luas Taman Konservasi tersebut adalah sekitar 25 hektar dan masing-masing berisi sebanyak 40 provenance yang berbeda.
5. Penilaian berbagai keanekaragaman genetika dari *P. oocarpa* menggunakan microsatellite markers telah diselesaikan oleh Camcore. Hasil menunjukkan bahwa spesies tersebut memiliki dua pusat keanekaragaman, satu di tengah Meksiko dan lainnya di Amerika Tengah. *Pinus tecunumanii* kelihatannya telah berkembang dari *P. oocarpa* di Honduras dan Nikaragua. Analisa marker menunjukkan bahwa pertukaran genetika antara kedua spesies adalah umum di tegakan alam; suatu hasil yang telah lama diduga berdasarkan pengamatan di percobaan lapang dan penanaman sesungguhnya.
6. Para anggota membangun 21 percobaan pinus hibrida: tiga di Argentina, enam di Brasil, tiga di Kolumbia dan sembilan di Afrika Selatan.
7. Staf Camcore telah menyelesaikan studi ketahanan-dingin bit terhadap 15 spesies pinus dari 27 daerah yang berbeda di dalam ruang pertumbuhan yang lingkungannya terkontrol di NC State University. Hasilnya sangat mirip dengan pengamatan lapangan di percobaan progeny. Dengan toleransi dingin diukur untuk spesies murni, Camcore sekarang akan melihat lebih dekat pada pola warisan toleransi dingin di persilangan hibrida tertentu.
8. Penilaian batang busuk (pitch canker) dilakukan pada bibit dari 50 provenance *P. oocarpa* di Meksiko dan Amerika Tengah yang tumbuh di USFS screening center di North Carolina dan menampakkan sedikit perbedaan alami. Nilai batang mati dari provenance berkisar antara 3 hingga 8% dan menunjukkan bahwa spesies tersebut memiliki ketahanan yang baik terhadap penyakit itu sejauh jangkauan alamnya.
9. Provenance dari *P. greggii* juga telah disaring untuk ketahanannya terhadap pitch canker dalam studi terpisah. Hasil menunjukkan bahwa sumber dari utara (var. *greggii*) adalah sangat rentan terhadap pitch canker dan sumber dari selatan (var. *australis*) adalah lebih tahan, dengan *P. patula* sedikit kurang tahan daripada var. *australis*.
10. Sejumlah spesies dari Camcore menghasilkan kayu yang lebih unggul daripada *P. taeda* dan *P. radiata*. Spesies sub-tropis seperti *P. tecunumanii* dan *P. maximinoi* lebih seragam kepadatannya di profil tengah kayu ke kulitnya, dan memiliki sudut microfibril yang jauh lebih rendah, sehingga menyebabkan kayu yang lebih kuat, terutama pada bagian inti kayu muda.
11. Dalam hal dimensi potongan melintang serabut, *P. patula* dan *P. greggii* tampaknya memiliki dinding sel yang lebih tipis dibandingkan *P. taeda*, dan seharusnya menghasilkan kertas yang sama atau lebih kuat daya tariknya dengan biaya perbaikan lebih rendah.
12. Kitt Payn (Mondi) dan Nhora Isaza (Smurfit Kolumbia) telah menyelesaikan Ph. D. dan MS, sesuai urutan, dengan Camcore di NC State. Pekerjaan Kitt adalah menguji sejarah evolusi *E. urophylla* dan Nhora belajar produksi bunga pada *P. maximinoi* dan *P. tecunumanii* di Kolombia.
13. Staf Camcore menulis atau membantu menulis 13 publikasi di tahun 2008. Bill Dvorak mendapatkan Award for Service to the Environment & Society di suatu dalam sebuah upacara di NC State University. Gary Hodge diangkat menjadi Profesor penuh di NC State University.

Message From the Director

Camcore represents an opportunity for the private sector to play a significant role in forest conservation and sustainability. We continue to field test species and populations to find those that are more productive and disease resistant than species currently being used commercially in plantations. In 2008, we finished our wood assessment of the Central American & Mexican pines that included a sample of more than 3000 wood cores taken across a number of species, countries and sites. We found that most subtropical pines have better chemical and physical wood properties than *Pinus taeda* from the southern US when planted in exotic environments. As we expected, *P. tecunumanii* and *P. maximinoi* exhibited excellent wood properties. The results of some of our wood studies are provided in this report.

Camcore continues to develop an important knowledge base about the Central American & Mexican pines. Nhora Isaza of Smurfit Colombia did her MS work on how hormone application on the tropical pines affects flower and cone production in the highlands of Colombia. Her results will likely be applicable elsewhere. Currently we are assessing the cold hardiness of the Central American & Mexican pines in growth chambers at NC State University to determine if we can better understand cold resistance patterns observed in field trials. The results will have practical application in examining how cold hardiness is inherited in pine hybrid crosses and ultimately might sway our decision on what species, populations, or parents are used in the development of hybrids to maximize cold resistance. Of particular interest in the study is determining how quickly selection pressures in a new environment can change adaptability (e.g. cold resistance).

As we work to develop better adapted, faster growing pine species with superior wood quality, we see an acceleration of an interesting trend in the tropics and subtropics. Areas once being planted to pines are often being convert-

ed to faster growing eucalypt or acacia plantations. The reason is economics. With increased demand for crops like maize and soybeans, forestry land is in direct competition with agricultural areas, the cost of which has increased dramatically over the past several years. To obtain a better return on investment, forestry companies are opting to plant eucalypts rather than pines. Mill managers are learning how to use less long fiber in the mill for products that were mostly long fiber only 7 years ago. The trend not only pertains to existing plantation areas, but also applies to new forestry projects where the grower has the option to plant either eucalypts or pines. Is this pronounced shift to short fiber plantations a good strategy, or simply a road to an oversupply of short fiber and depressed markets?

Camcore members made some important decisions at the annual meeting in 2008. First, it was decided to compile and share “best practice” procedures to enhance our knowledge base across a wide spectra of commercially important tree genera. This should improve the management of the Camcore species across companies and countries. Second, we decided to include several additional eucalypt species and teak in the Camcore portfolio of species. We formed a subcommittee to examine research opportunities and direction for Camcore as the balance shifts from long fiber to short fiber plantations in the tropics and subtropics. Third, we have set up a subcommittee to determine how best to work together on developing somatic embryogenesis protocols for some of our tropical and subtropical pines. Interesting times!

Camcore enjoyed a very successful year in 2008. Three new active members joined the program. The annual meeting in Indonesia was a great success. Thank you again for your support of the program. We will all need to work closely together during this period of economic downturn.

Bill Dvorak, Director

2008 Camcore Membership

Active, Associate & Contributing Members



Argentina

- ◆ Alto Paraná
- ◆ Bosques del Plata



Brazil

- ◆ Klabin
- ◆ Masisa do Brasil Ltda.
- ◆ Rigesa-Mead Westvaco



Chile

- ◆ Arauco Bioforest
- ◆ CMPC Forestal Mininco



Colombia

- ◆ Pizano/Monterrey Forestal
- ◆ Reforestadora de la Costa
- ◆ Smurfit Kappa Cartón de Colombia



Guatemala

- ◆ Grupo DeGuate (Associate)



Indonesia

- ◆ PT Sumalindo Lestari Jaya
- ◆ PT Surya Hutani Jaya



East Africa

- ◆ Kenya, Uganda, Tanzania



México

- ◆ Forestaciones Operativas de México (FOMEX)
- ◆ Gobierno del Estado de Veracruz (Associate)



Moçambique

- ◆ Chikweti Forests



Republic of South Africa

- ◆ Hans Merensky Holdings
- ◆ Komatiland Forests
- ◆ Mondi South Africa
- ◆ MTO Forestry
- ◆ PG Bison Holdings
- ◆ Sappi Forests



United States of America

- ◆ USDA Forest Service (Associate)
- ◆ Weyerhaeuser Company (Contributing)



Uruguay

- ◆ Stora Enso Uruguay
- ◆ Weyerhaeuser Company



Venezuela

- ◆ Smurfit Kappa Cartón de Venezuela
- ◆ Terranova de Venezuela

Honorary Members



Belize

- ◆ Ministry of Natural Resources



Honduras

- ◆ Escuela Nacional de Ciencias Forestales (ESNACIFOR)



El Salvador

- ◆ Centro Nacional de Tecnología Agropecuaria (CENTA)



México

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



Guatemala

- ◆ Instituto Nacional de Bosques (INAB)



Nicaragua

- ◆ Instituto Nacional Forestal (INAFOR)

The 2008 Annual Meeting in Indonesia

Selamat Datang, or “Welcome” to Indonesia. This is how the participants of the 2008 Camcore Annual Meeting felt everywhere they traveled in this diverse, expansive country. The hardworking staff of Camcore member PT Sumalindo Lestari Jaya planned and orchestrated a busy and exciting two-week trip that included a good mix of meetings, field and mill tours, and cultural explorations. Indonesia is a tropical country comprised of 17,500 islands! The Camcore contingency stopped at several of the larger ones: Java, Borneo, and Bali. The weather during the last two weeks of October was expectedly warm, and the skies remained sunny for nearly the whole time.

Indonesia has large tracts of forested land and a strong timber industry that uses wood from both natural and planted stands. Pines are of minor importance in the country so meeting participants got to learn about several important tropical hardwoods. Two species in Camcore’s “portfolio” are present in Indonesian plantations: *Gmelina arborea* and *Eucalyptus urophylla*, the latter being endemic to the country and an important species to Camcore members around the world. Other species that were studied included *E. pellita*, *Acacia mangium*, *Tectona grandis* (teak), and *Swietenia macrophylla* (mahogany).

The group convened on the island of Borneo in Balikpapan, East Kalimantan. After registration and committee meetings, participants traveled north by bus to Samarinda, a center of operations for Sumalindo. On the way, they visited the Wanariset Samoja Orangutan Reintroduction Project and the Bukit Bangkirai canopy bridge. At the canopy bridge, an informal ceremony announced the “adoption” of a protected tree by the Camcore membership (see picture). Camcore’s new “child” is a healthy Borneo Ironwood tree, *Eusideroxlon zwageri*. Two days of field trips included many stops: Sumalindo’s acacia plantations, cable harvesting of gmelina and an MDF mill that produces 200,000 m³/yr of product from acacia and gmelina. At one stop, Sumalindo staff had arranged for each member to plant a single acacia tree (see picture). The betting is heavy on whose tree will be the tallest in a year. Also visited were a number of PT Surya Hutani Jaya’s *Euca-*



Some participants at the 2008 Annual Meeting in front of the adopted *Eusideroxlon zwageri*.

lyptus pellita projects: a clonal nursery, half- and full-sib progeny trials and a clonal conservation bank. The group then flew to Jakarta for a day and a half of technical meetings, including a session of presentations by local scientists and government officials. After a visit to the Sumalindo Jakarta plywood mill (capacity of 180,000 m³/yr) they traveled by bus to Puncak, and by plane to Yogyakarta which served as a base for several days. The Wanagama Educational and Experimental Forest had a number of projects to see, with work that included teak, mahogany, ebony, and sandalwood. The center serves as a research and teaching forest for Gadjah Mada University. The state-owned company Perum Perhutani reports 2.4M hect-



Rudolf Rahn of SKCC plants a Sumalindo *Acacia mangium*.

YEAR IN REVIEW

ares of plantation, mostly on Java and composed mostly of teak (50%). They showed the Camcore participants a number of plantations, trials, clonal plantings and a container nursery (*see picture*). There were a few non-forestry visits on Java: the tea plantation at Gunung Mas and the Wildlife Safari Park. The only major rainstorm during the trip postponed a trip to Bogor Botanical Garden which was successfully rescheduled. The lush gardens are full of interesting plant collections and receive over 3500mm of rainfall annually.

The final leg of the journey was a flight to the island of Bali. The group stayed in a very comfortable hotel on the beach. There were two technical sessions, and the wrap-up business and

executive meetings, and numerous small groups met to plan and collaborate on future projects in their home countries. Participants with enough energy were able to do some sightseeing and shopping on this popular island while others used the time to complete projects or recuperate before the long journey home. Once again, the meeting attendees were given an intense forestry and cultural experience. Despite large distances between stops and the remoteness of some of the sites, every detail of the trip seemed to have been planned and successfully addressed by Sumalindo. The participants returned home without any stories of hardships or inconvenience, but full of memories and gratitude to the many Indonesian hosts.



The PT Surya Hutani Jaya *Eucalyptus pellita* nursery.



The PT Sumalindo plywood mill uses FSC certified plantation-grown *Gmelina arborea* and native hardwoods.



Developments in Camcore

In 2008, Chikweti Forests (Mozambique) and Reforestadora de la Costa (Refosta, Colombia) joined the Camcore program. Additionally, East Africa (Kenya, Tanzania, and Uganda) rejoined Camcore after an absence of several years. Chikweti has 4 different forestry projects in northern Mozambique including pines, eucalypts, and teak. The latitude of the Chikweti land holdings are similar to latitudes in Honduras and Nicaragua. These similar latitudes in Central America offer Mozambique a good species/climate match. Refocosta also plants pines, eucalypts and teak in northern Colombia and has plans for expansion of their forestry projects. The East African membership represents a myriad of land types, altitudes and precipitation ranges in the three countries and is well suited for a whole host of different species. We welcome these three members into our program.

As always, the Camcore staff spent much of their year visiting members to discuss conservation, breeding, and research issues. Following is a summary of the 2008 visits.

Argentina

Juan López visited **Bosques del Plata** (BDP) during the month of July to discuss achievements and future activities with Camcore. Camcore continues to help BDP in activities related to its tree improvement program, including shipments of seeds collected in the natural forest for first generation progeny trials, and hybrid seeds produced and collected by different members. Camcore is also coordinating seed shipments from selections by other members of *P. patula* and *P. greggii* in Camcore trials for the establishment of second generation studies at BDP. Bosques del Plata has played a very active role as a regional coordinator in the Camcore pine hybrid program, propagating hybrid seeds and growing cuttings for establishment of field trials on its own and Alto Paraná's land. Juan visited the nursery, the first Camcore pine hybrid trial planted by the company in Argentina, the GxE trials of *P. taeda*, and other field trials and clone banks.

The forestry research staff at **Alto Paraná** (APSA) continues to work actively with the Cam-



Raul Schenone standing beside a tree of *P. greggii* var. *australis* from Laguna Atezca in Mexico, one of the best provenances in the BDP trial at Timbauva.

core pine hybrid program, making controlled crosses, sending hybrid seeds to Raleigh, and planting hybrid trials in the field. During the Camcore trip in July, Juan López visited the Camcore pine hybrid trial planted in November 2007 with Mónica Gelid and Juan Schapovaloff. At 3 years of age, *Pinus tecunumanii* and *P. maximinoi* continue to show good growth potential in the Camcore trials. These species and maybe some of their hybrids will offer a great alternative to the company to diversify its forestry portfolio in the near future.

Brazil

In July, Bill Dvorak and Gary Hodge visited the three Camcore members in Brazil. Bill and Gary spent time with **Klabin** in both Santa Catarina and Paraná. Klabin plans to expand its eucalypt land base over the next several years. Much effort is going into the development of *E. benthamii* and *E. dunnii* for the colder areas of Santa Catarina. At the same time, Klabin is beginning to develop clonal forestry of *P. taeda* through the use of somatic embryogenesis, and has initiated commercial plantings of *P. maximinoi*. Bill Dvorak gave presentations at both Klabin PR and Klabin SC emphasizing the bal-

ance between long and short fiber, increased insect and disease attacks, and the potential benefits from improvements in breeding technology. Bill anticipates a serious imbalance between long and short fiber supplies in the next 15 to 20 years, and warned Klabin that it must not fall into the trap of neglecting its long fiber resources.

The Klabin research team continues to do good work. The pine hybrid studies have been established, and the *P. taeda* GxE trials look excellent. Development of rooted cutting technology for *P. taeda* continues, and the first hedges of good *P. maximinoi* families have been established. Open-pollinated seed for progeny tests and commercial plantings is being collected. At Klabin SC, Romullo Luiz Simão presented results from wood properties studies which indicated that *P. patula* is as good as *P. taeda* for most pulp and paper traits, and that *P. greggii* is better than *P. taeda* for most traits, including % pulp yield, % lignin and viscosity.

The **Rigesa** research team did a tremendous job producing hybrid cuttings for field trials for all the Brazilian members, and continued to produce cuttings to be transported to Uruguay for our two member companies there. The development of the clonal banks of *P. patula* and *P. greggii* are mostly finished, and grafting success has been vastly improved by grafting the Mexican pines onto *P. taeda*. The *P. greggii* clonal bank is developing very nicely, but the *P. patula* bank

is not as healthy. Recommendations were made to fertilize the clone banks with calcium and other nutrients and spray for insects. As a backup, Rigesa also plans to topgraft the *P. patula* selections into older *P. taeda* surrounding the clone bank. We also visited some advanced generation full-sib tests of *P. taeda* and discussed strategies to evaluate this material for wood properties.

Masisa has done a nice job establishing their pine hybrid trials and their *P. taeda* GxE trial. In addition, they have begun collections of seed from the *P. patula* land race selections made at Bituva Grande. Masisa also hosted the Camcore Southern Latin America Technical Meeting with members from Brazil, Argentina and Uruguay (see Box “Camcore Technical Meetings”).

Chile

Robert Jetton and Andy Whittier visited **Arauco-Bioforest** in April and met with Claudio Balocchi, Jaime Zapata, Iván Appel, and Pepe Ordóñez, La Posada Nursery Manager, to discuss plans for the Carolina hemlock (*Tsuga caroliniana*) conservation bank. During the visit, Robert and Andy visited the nursery to see the development of the Carolina hemlock seedlings that Arauco has been growing for the past 3 years. They also traveled with Jaime, Pepe, and Victor Molina to view 3 potential outplanting sites for the hemlocks in the Los Alamos zone. The group agreed that the seedlings should be planted at Predio Cuyimpalihue in a single-tree plot design. Outplanting of the hemlock conservation bank occurred in September, 2008, and Arauco is to be commended for reaching this important milestone in this conservation effort of great importance in the U.S.

In April, Gary Hodge visited **CMPC Forestal Mininco** to discuss various aspects of wood properties in both pines and eucalyptus. Gary summarized the results of a joint Camcore-CMPC project to develop NIR models to predict pulp yield and density in *E. nitens*. The model was based on 99 samples ranging in age from 5 to 18 years, and gave satisfactory results ($R = 0.81$) for screening operational breeding populations. The model was used to make operational assessments for 125 eucalyptus hybrids in the CMPC breeding program. In addition, Gary and the CMPC team discussed different methods for taking wood



Gary Hodge and Gleison dos Santos in the *P. taeda* GxE trial at Klabin, Paraná, Brazil.

samples for NIR in the field, future NIR projects with *P. radiata*, the results of the Camcore Wood Properties Species Characterization project, and CMPC research regarding optimal drying conditions to produce *E. nitens* sawtimber.

Colombia

Bill Dvorak visited **Smurfit Kappa Cartón de Colombia** (SKCC) in January. Good progress is being made establishing 2nd generation trials but the contamination of *P. tecunumanii* orchards with foreign *P. patula* pollen continues to be a problem. The SKCC research team is gaining valuable experience in the operational mass production of *P. tecunumanii* and *P. maximinoi* cuttings from seedlings. Maturation rates of cuttings vary dramatically depending on whether they come from an original or recycled hedge. SKCC and Camcore are also working closely together to develop a long-term conservation strategy for the many species and populations that the company has planted over the years.

Juan López visited the forestry project of **Pizano/Monterrey Forestal** in June. He provided practical tips on nursery practices and basic principles on hedge management, helping the company to improve the operational rooting protocols for *Gmelina arborea* in the nursery. He also helped to pick an adequate site for the establishment of new seed orchards of *G. arborea* and *Pachira quinata* with genetically superior trees selected in the Camcore trials. The establishment of these seed orchards is a very important step in the development of the tree improvement plan agreed on by Pizano and Camcore in previous years. Camcore also assisted Pizano with the analysis of *G. arborea* clonal data to select the best clones for the operational planting program.

Juan also visited new member **Reforestadora de la Costa** (Refocosta) in June. Camcore hopes to help Refocosta develop its tree improvement program strategy, and send seeds for the establishment of provenance/progeny trials of different species. Camcore is also helping the company to make the best use of current clonal and progeny tests of *E. tereticornis*, *Tectona grandis*, *P. caribaea* and *P. tecunumanii* planted by Refocosta in previous years. The company manages projects on the Atlantic coast and in the eastern plains of



Development of a *P. maximinoi* cutting at the SKCC nursery.

Colombia. Juan gave technical recommendations and useful basic principles for the development of rooted cuttings and hedge management of teak and *E. tereticornis* in both locations. Camcore began an exchange of genetic material of teak among its members, in which Refocosta will play a major role. Camcore has scheduled a data management and statistical trial design course to be given in 2009 for the technical personnel of Refocosta and other members in Colombia and Venezuela.

East Africa

East Africa (Kenya, Tanzania and Uganda) rejoined Camcore the second semester of 2008. They will be involved in planting Camcore trials of pines, eucalypts and teak. Bill plans to visit the East African group in February 2009 to update the current work plan and make additional plans for the future. Our hope is that representatives of the East African group will be able to attend technical meetings and short-courses being held in South Africa in 2009.

Guatemala

Michael Tighe and Juan López made the Camcore technical visit to Guatemala in July. **Grupo DeGuate** is an enthusiastic pool of forestry companies working with Camcore on tree improvement of several forestry species. In agreement with the Guatemalan National Forest Institute (INAB, an honorary member of Cam-

core), Grupo DeGuate has been using Camcore seeds originally sent to INAB for the establishment of new reintroduction studies. Mike and Juan met with Grupo DeGuate representatives and INAB staff at the Pilonos de Antigua nursery, where they made presentations on Camcore activities, seed and pollen management techniques, and the economic importance of tree improvement. In the field visits, Juan and Mike made technical recommendations on plantations and genetic trial management at three plantation sites. Juan also presented an invited lecture on Camcore activities to professional foresters and technicians during the celebration of the ExpoMueble Forest and Furniture fair in Guatemala City.

The week of September 8 to 12, Camcore and INAB were the hosts of a field tour in Guatemala for the personnel of the National Institute of Forests of Nicaragua (INAFOR). The purpose of this visit was to exchange knowledge and experience in forestry-related activities between the two countries. In the four departments visited, the 14 employees of INAFOR had the opportunity to see four nurseries and several certified natural stands of *Pinus maximinoi* and *P. tecunumanii*. They discussed aspects related to seed collections, seedling production systems, vegetative propagation techniques and certification of seed stands. Elmer Gutiérrez from Camcore and Carlos Ramírez from INAB coordinated the tour with Bernabé Caballero from INAFOR. Camcore and honorary member INAFOR have been working together for many years to conserve the forestry species of Nicaragua.

Indonesia

Because of the intense preparations needed to prepare for the annual meeting in 2008, it was decided to hold off on a technical visit to **PT Sumalindo** until early 2009 when Bill Dvorak will visit in March. Sumalindo is making great progress in the breeding and propagation of *Gmelina arborea* and have now made a second small collection of *Gmelina moluccana* to enlarge its genetic base.

Mexico

In March 2008, Juan López and Andy Whittier helped **Fomex** to verify the mean annual increment of the *E. urophylla* plantations in the state of Tabasco. Based on tree measure-



A group of foresters representing the government of Nicaragua (INAFOR) visiting natural stands in Guatemala where certified pine seeds will be produced.

ments on different sites, as well as the current genetic and silvicultural management practices of the company, Juan and Andy predicted the biological growth and yield potential Fomex could expect in the future. Several technical recommendations were also given to improve the current vegetative propagation protocols through rooted cuttings of *E. urophylla* in the nursery.

Later in the year, Juan visited the central zone of the forestry project in the states of México and Michoacán. For several years Camcore has been sending seed of different forestry species to Fomex for the establishment and assessment of field trials in this area. Camcore continues helping the company to choose the best sites for potential forestry species, recommending the best management practices and detecting early potential problems in plantation forestry in these two states.

Camcore will help the **Government of Veracruz** in Mexico to implement the strategic forestry plan of the state in 2009, providing seeds for the establishment of reintroduction studies. Juan will visit the state of Veracruz in May 2009 to discuss long-term seed supply strategies with government representatives.

Mozambique

Bill Dvorak visited **Chikweti Forests** for the first time in 2008 and was hosted by Dr. Åsa Tham. Bill's primary focus was to assist Chikweti Forests in making sure that they were using the correct species. The high-elevation

areas of northern Mozambique are well suited for the subtropical pines, *P. tecunumanii* and *P. maximinoi*. The low elevation areas, which are very hot, with sandy soils, are best suited for *E. pellita* or *E. pellita* hybrids. Chikweti Forests has received seeds of several Camcore trials. These will be established in the field in 2009.

South Africa

Bill visited **MTO Forestry** in the southern and eastern Cape. A lot of good work has been done establishing 2nd generation Camcore trials of *P. tecunumanii* and *P. maximinoi* as well as breeding work with *P. radiata*. MTO continues to develop the *P. elliottii* x *P. caribaea* hybrid for the eastern Cape and has initiated a plus-tree seed collection of *P. taeda* as a future genetic base to avoid total reliance on *P. radiata* in case the pitch canker problem worsens in the area.

Bill & Gary visited **Sappi** and **Mondi** in April. At Sappi, time was spent reviewing the developments in the tropical and subtropical eucalypt program with Terry Stanger and his research team. The effect of plot size on clone ranking was discussed at several field stops. The Sappi eucalypt program has made some impressive gains in

recent years. Gary also spent half a day teaching a BLUP refresher course while Bill visited a *P. tecunumanii* seed orchard with Arnulf Kanzler.

At Mondi, Johan Vermaak showed Bill and Gary some of the older plantings (10 years) of pine hybrids. These included *P. greggii* x *P. tecunumanii*, *P. taeda* x *P. tecunumanii*, and *P. taeda* x *P. greggii*. Several individual hybrid progeny were outstanding in each cross. Although it was possible to see some intermediate morphologic traits in several hybrids, confirmation of their identity still needs to be verified by molecular markers.

Bill Dvorak and Gary Hodge also visited **Hans Merensky** (HM) in April (Singisi Forests at Weza) and in June (Northern Timbers at Tzaneen). At Singisi, we saw second-generation tests of *P. tecunumanii* and *P. maximinoi*. The limiting factor for planting these species is frost tolerance. The test site experienced a severe freeze shortly after planting, with *P. tecunumanii* suffering 8% mortality while *P. maximinoi* had approximately 25% mortality. We do not know if the difference in mortality is because *P. maximinoi* was established lower on the slope than *P. tecunumanii*, or because *P. tecunumanii* contains some natural hybrids with the more cold-hardy *P. patula*. This visit initiated discussions of species-site trials which later expanded into a South Africa-wide test series involving all members (see Domestication section of this report). At Tzaneen, Gary visited the *E. urophylla* Camcore trials, discussed the HM *E. grandis* breeding strategy, and the potential of *P. patula* x *P. tecunumanii* hybrids. We also outlined a workplan for a large effort of *P. maximinoi* grafting for the Camcore conservation parks in late 2008 and 2009.

Gary Hodge visited **Komatiland Forests** (KLF) in June. KLF has established 2nd-generation Camcore trials of *P. maximinoi*, *P. tecunumanii*, and *P. chiapensis* at three locations. In addition, KLF is establishing field progeny tests of more than 100 *P. patula* x *P. tecunumanii* hybrid families, as well as conducting artificial screening of these families for *Fusarium* (pitch canker) resistance. Francois Malan presented some very interesting results comparing Tree Sonic acoustic measurements on green logs (comparable to standing trees) and MOE assessments on boards sawn from those logs. The results confirm that breed-



Andre van der Hoef looks at 2nd generation seedling in a Camcore *P. tecunumanii* trial established at MTO.

ing programs could make good use of the Tree Sonic to measure wood strength in standing trees. Gary and the KLF team also spent time discussing strategies for the *P. caribaea* breeding program, and long-term breeding priorities for the company. KLF has a large proportion of “lowveld” sites where fire, frost and *Fusarium* risks present a challenge to successful plantation establishment. *Pinus elliottii* is currently the best species choice in terms of survival, but is sub-optimal in terms of growth potential and wood quality.

Uruguay

Bill held a joint visit with **Stora Enso** and **Weyerhaeuser**. Stora Enso is busy establishing a number of eucalypt trials to find species that exhibit good growth and cold resistance. Camcore has helped the company with the design of some of these trials. Juan Posse at Weyerhaeuser showed us a 6-year-old Camcore pine trial. *Pinus patula*, *P. greggii* and *P. caribaea* var. *bahamensis* all survived the cold very well, while other species like *P. tecumanii* and *P. maximinoi* exhibited varying levels of success. Of great interest were the cold hardiness patterns for *P. tecumanii*. High-elevation (HE) populations from Chiapas showed greater resistance than HE from central Guatemala which in turn were more cold hardy than low-elevation populations from Nicaragua. The cold hardiness patterns are in line with our observations in natural stands in Mesoamerica and also mimic results from our indoor cold hardiness screening study at NC State (see section on “Quantifying Cold Hardiness” in this report). The Stora Enso and Weyerhaeuser researchers also spent a day discussing plans for the 2009 annual meeting in Uruguay.

Venezuela

Bill Dvorak visited Edgar Londoño, (President, **Smurfit Kappa Carton de Venezuela**) in Valencia, where they talked about the future directions of research and genetic improvement in the company. SKCV continues to look for a tract of land at high elevations in order to establish a breeding seed orchard of *Pinus caribaea*. The forestry division needs the seed orchard to make progress in the tree improvement program with this species. In his Camcore visit in December,



Miguel Jelambi and Alba Rosales standing in a Camcore provenance-progeny trial of *P. caribaea* established by Terranova in Monagas, Venezuela.

Juan López recommended the purchase of one of the tracts that was visited that offers technical and strategic advantages to the company. The site has good production of cones and viable seeds making it suitable for controlled crosses. Juan also gave technical recommendations on pine hybrid hedge management during his visit to the nursery. SKCV is propagating hybrid seeds sent by Camcore, and will share rooted cuttings with Terranova in the planting of pine hybrid trials.

Camcore has been helping **Terranova** with technical recommendations on plantation management to increase productivity per hectare with *Pinus caribaea* for several years. Statistical designs of fertilization and herbicide studies have been sent to the company on several occasions. Juan López visited Terranova in December, and discussed the advantages and disadvantages of working with alternative species like *Acacia mangium*. The *A. mangium* plantings and experience of Proforca with the species in the region were used as a point of reference to analyze the chances of success for Terranova. Juan recommended the establishment of silvicultural and genetic tests, before starting a commercial-scale operation with the species. During his visit to the nursery, Juan gave important recommendations to the research team to improve the existing conditions in the greenhouse in order to start developing protocols for vegetative propagation of *P. caribaea*. He also gave some practical suggestions for hedge management of the species.

The Camcore Regional Technical Meetings

In the last several years, Camcore and its members have worked to hold short mid-year technical meetings to keep everyone abreast of research developments and to work on common problems. Generally the meetings are structured to include one day of field trips and one day of indoor meetings. In 2008, the Southern African technical meeting was hosted by PG Bison on the Northeastern Cape, South Africa. In attendance were representatives from the 6 companies in South Africa and the one member from Mozambique. We visited some old Camcore trials on PG Bison land holdings and toured the particle board plant. We discussed better ways to coordinate Camcore testing and record keeping. There was an update of the status of the Camcore Conservation Parks in South Africa. We also discussed the need for a Tree Improvement Shortcourse for Camcore members in the region in 2009, the majority of which will be taught by senior tree improvement staff of the individual companies.

In South America, the Camcore/Southern Latin American Camcore meeting was hosted by Masisa, Brazil. It was attended by Camcore technical representatives in Argentina, Brazil and Uruguay. We visited Masisa's first Camcore plantings, pine hybrid trials, and seed orchards. At the indoor meeting there were discussions about finalizing a strategy for second generation trials, the status of grafting Camcore selections, and the pine hybrid program.

We want to thank both PG Bison and Masisa for hosting the 2008 technical meetings in their respective regions. The mid-year technical meetings offer everyone an opportunity to voice their opinions, and is a means to keep us all up to date on progress and developments.



Camcore representatives at regional technical meetings gather in Brazil (left) and South Africa (right) to discuss research issues important to the regional development of the program.

Genetic Diversity in *Pinus oocarpa*

Bill Dvorak, Kevin Potter, Gary Hodge (Department of Forestry & Environmental Resources, NCSU), and Valerie Hipkins (USDA Forest Service, National Forest Genetics Laboratory) completed their study on genetic diversity in *Pinus oocarpa* (see 2007 Camcore annual report).

The study used 11 highly polymorphic microsatellite markers to determine the genetic structure and levels of diversity in 51 natural populations of *P. oocarpa* across its geographic range of 3000 km in Mesoamerica. The study also included 17 populations of *P. patula* and *P. tecunumanii* chosen for their resistance or susceptibility to the pitch canker fungus based on previous research. Seedlings from all 68 populations were screened for pitch canker resistance and results were correlated to mean genetic diversity and collection site variables. Results indicate that *P. oocarpa* exhibits average to above average levels of genetic diversity ($A = 19.82$, $A_R = 11.86$, $H_E = 0.711$) relative to other conifers, a result one

would expect for a species with a large geographic range. Bayesian analysis grouped *P. oocarpa* into four genetic clusters highly correlated to geography, and distinct from *P. patula* and *P. tecunumanii*. Historic gene flow across *P. oocarpa* clusters was observed ($Nm = 1.1$ to 2.7) but the most pronounced values were found between *P. oocarpa* and *P. tecunumanii* (low altitude provenances) in Central America ($Nm = 9.7$). *Pinus oocarpa* appears to have two main centers of diversity, one in the Eje Transversal Volcánico in central México and the other in Central America. Introgression between *P. oocarpa* and *P. tecunumanii* populations appears to be common. For example, the well-known Villa Santa source of *P. tecunumanii* was found to have 21% admixture with *P. oocarpa*, a result which makes much practical sense since the Villa Santa population is bordered on all sides by natural populations of *P. oocarpa* in Honduras.

Analysis suggested that *P. tecunumanii* evolved from the Honduras/Nicaraguan sources of *P. oocarpa*. For the most part, microsatellite markers did a good job of distinguishing between high- and low-elevation populations of *P. tecunumanii*. The one exception was that the low-elevation Sacul, Guatemala population grouped with high-elevation sources, suggesting that the genetic differences between the two subpopulations might be more based on geographic location (longitude) than on altitude of the provenance above sea level. The full manuscript will be published in the *International Journal of Plant Sciences* in mid-2009.



Wood cutters in the Villa Santa provenance of *P. tecunumanii* during a Camcore collection trip in 1985. Microsatellite marker analysis indicated that this population has 21% admixture with *P. oocarpa*.

2008 Seed Collections

In 2008 Camcore continued to make pine seed collections in natural stands in Central America (Table 1). Our recent seed collection efforts focus on populations with low representation in the Camcore trials and conservation banks. The seeds will be used by members for the establishment of provenance/progeny trials as well as the development of conservation plantings.

Some of the more long-standing members of Camcore in Brazil, Colombia and South Africa have gone to great efforts to collect seeds in their trials and seed orchards of *Pinus greggii*, *P. maximinoi*, *P. patula* and *P. tecunumanii*. These seeds will be distributed among the Camcore members for the establishment of second-generation genetic tests.

Table 1. Summary of seed collections completed in Central America in 2008.

Country	Species	Provenance	Status	Latitude	Longitude	Trees
Guatemala	<i>P. tecunumanii</i> low elev.	Sacul Arriba	Critically Endangered	16° 30'	89° 16'	28
	<i>P. tecunumanii</i> high elev.	San Jerónimo	Vulnerable	15° 03'	90° 18'	11
	<i>P. maximinoi</i>	San Jerónimo	Vulnerable	15° 01'	90° 16'	15
	<i>P. maximinoi</i>	Cobán	Vulnerable	15° 23'	90° 24'	15
	<i>P. oocarpa</i>	San José La Arada	Vulnerable	14° 42'	89° 37'	15
	<i>P. oocarpa</i>	San Lorenzo	Low Risk	15° 05'	89° 40'	15
Honduras	<i>P. tecunumanii</i> low elev.	Villa Santa	Vulnerable	14° 12'	86° 17'	15
	<i>P. tecunumanii</i> low elev.	La Esperanza	Vulnerable	14° 22'	88° 09'	10
	<i>P. maximinoi</i>	Dulce Nombre de Copán	Endangered	14° 50'	88° 51'	15
Nicaragua	<i>P. oocarpa</i>	San José Cusmapa	Low Risk	13° 17'	86° 39'	15
	<i>P. tecunumanii</i> low elev.	Yucul	Low Risk	12° 55'	85° 44'	20
	<i>P. tecunumanii</i> low elev.	San Rafael del Norte	Endangered	13° 14'	86° 07'	15

Camcore Receives a Grant from the USDA Forest Service to Study Hemlock Genetic Diversity

In June, Camcore was awarded a \$47,500 grant from the Washington, D.C. office of Forest Health Protection, USDA Forest Service, for a microsatellite (SSR) diversity analysis of Eastern hemlock (*Tsuga canadensis*). The funding is for one year with the objective of describing patterns of genetic diversity in Eastern hemlock distributed across the northern portion of the species range. In total, we will sample 1000 trees, 20 trees in each of 50 populations, located in 16 northern states (Connecticut, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin). Sample collection for the study will occur from January through March of 2009, and the lab work will be conducted by the USDA Forest Service National Forest Genetics Laboratory in Placerville, CA. Understanding the patterns of genetic diversity in the northern portion of the Eastern hemlock range will allow Camcore to better plan and carry out conservation seed collections for the species in these regions of the country, a proposed four-year project for which we anticipate receiving full funding from the USDA Forest Service in 2009.

Conservation Parks in South Africa Become a Reality

For several years now, Camcore and its members in South Africa have been discussing ways to promote the long-term conservation of its pine and eucalypt populations. The Camcore technical committee first examined what would be an appropriate effective population size for each of the populations to be conserved, and then a design was developed to form Conservation Parks. These were to be protected areas of 20 to 25 hectares established by each member in the country, with quarter-hectare plots of as many families as possible representing each population. Each member was required to protect 7 to 8 species. The Sappi Park is in the process of being established on the KwaZululand Coast, the Mondi Park will be at Mountain Home outside Pietermaritzburg, the Komatiland Forests Park is in the Sabie region, the Han Merensky Park is at Weza, the MTO Park is located near Stellenbosch, and the PG Bison Park will be in the Northeastern Cape region, possibly divided into two separate plantings at differ-

ent elevations. The establishment of the Camcore Conservation Parks represents a big commitment by individual members and demonstrates industry's understanding that the long-term protection of these valuable genetic bases is important.



Camcore/KLF conservation Park area near Sabie, South Africa

Conservation Status of *Pinus taeda* in the Southern US

Pinus taeda is the most important commercial pine species in the United States. Its geographic range covers 15 southern and mid-Atlantic states from east Texas in the west to Delaware/New Jersey in the northeast. When colonists first arrived in the United States in the 1600s, *P. taeda* was a minor species confined to swampy or upland (Piedmont) areas where fires were infrequent. An aggressive pioneer species, it became the predominant pine species in the southern US after the Civil War (the 1860s) when it became established in abandoned fields.

Tree breeding work in *P. taeda* is some of the most advanced in the world. Breeding populations are large, but the question remains whether the alleles contained in clonal archives adequately represent all of the genetic diversity present in the remaining natural populations. As highlighted in our 2007 annual report, Camcore and the Weyerhaeuser Foundation, in association with the North Carolina State Tree Improvement Program (NCSU), the Cooperative Forest Genetics Research Program (Uni-

versity of Florida), and the Western Gulf Cooperative (Texas A & M), as well the USDA Forest Service-Region 8, are working together to better define the conservation status of *P. taeda*.

A questionnaire was sent to the three industrial breeding cooperatives and the USDA Forest Service to ascertain the status of the original selections made during the initiation of the programs in the 1950 and 60s. Complete results will be presented at a special meeting with contributors, but preliminary data is interesting. There were 8,648 selections of *P. taeda* made by the 4 organizations across the geographic range of the species. Of these, 36% of the selections were made in natural stands and 64% in plantations. The next step is to determine how many of these selections still exist in F₁ seed orchards and clonal banks.

A number of questions still need to be addressed to determine if greater effort should be spent on the conservation of this economically important species, and exactly how to go about it in order to maintain adaptive and molecular genetic diversity in a cost efficient way.

Conservation of Hemlock Species in the Eastern US

Introduction

The past year was one of substantial progress for Camcore in our effort to conserve the genetic resources of Carolina (*Tsuga caroliniana*) and Eastern (*T. canadensis*) hemlocks. This project, co-sponsored by the USDA Forest Service and Camcore, is important because an exotic insect called the Hemlock Woolly Adelgid (HWA, *Adelges tsugae*) threatens the long-term stability and survival of these ecologically important species in their natural environments. In 2008, we had one of our best seed collection years since the project began in 2003. We continued to work toward future conservation plantings in Arkansas (U.S.A.) and Brazil, and the first Carolina hemlock conservation bank was established in the field by Arauco-Bioforest in Chile. Robert Jetton and Andy Whitter visited the British Columbia Ministry of Forests' Cowichan Lake Research Station to learn techniques for accelerated breeding and grafting of hemlocks. In June, Camcore received \$47,500 in funding from the USDA Forest Service for a one-year study to evaluate Eastern hemlock genetic diversity, and in 2009, we anticipate receiving an additional four years of funding for hemlock gene conservation in this same region.

2008 Hemlock Seed Collections

Although the volume of seeds collected from Carolina hemlock has remained relatively consistent during the previous 3 years, our collection efforts for Eastern hemlock throughout the southeastern U.S. during this same period have met with frustration as declining tree health in many hemlock populations resulted in poor seed production. Declining health was attributed to heavy HWA infestations and severe, widespread drought conditions throughout the region during 2005-2007. In 2008, the rangewide drought subsided and trees in many Eastern hemlock populations began to recover. Additionally, we altered our approach to seed exploration and focused our effort on portions of the hemlock range with little or no HWA infestations and on populations where the adelgid is being actively managed with chemical (insecticides) and biological (HWA predators) controls. The result was an increased

volume of Eastern hemlock seeds collected 2300g compared to less than 600g total in 2005, 2006 and 2007. Our hope is that continued improvements in tree health and our refocused exploration efforts will help us to reach our hemlock seed collections goals in the southeastern U.S. during the next two years. We owe a special thanks to Resource Biologist Tom Remaley and his staff at the Great Smoky Mountains National Park (GSMNP) who collected nearly 1,400 grams of Eastern hemlock seed from 24 mother trees for Camcore this year. Our total collections of hemlock seeds since 2003 are 195 mother trees in 26 populations of Eastern hemlock and 97 mother trees in 13 populations of Carolina hemlock.

Ex Situ Conservation of Hemlocks

During the past year, Camcore members in Chile and Brazil and cooperators with the University of Arkansas in the U.S. continued to work towards the production of hemlock seedlings for conservation bank establishment. Although nurseries in Brazil and the U.S. have experienced some mortality, Gisela Andrejow and Laercio Duda at Rigesa and Dr. Brad Murphy and Matthew Peltó with the University of Arkansas have worked diligently to stabilize survival. We anticipate having hemlock seedlings for outplanting in these areas within the next two years. Both Rigesa and the University of Arkansas are growing Carolina and Eastern hemlocks and will receive additional seed shipments in 2009.

In Chile, Arauco-Bioforest has completed nursery production of its first group of Carolina hemlock seedlings. These were outplanted into Camcore's first operational hemlock conservation bank in September 2008, located in the Los Alamos zone at Predio Cuyimpalihue approximately 140 kilometers south of Concepción. The planting contains 1,140 seedlings established as single-tree plots and represents all 64 open-pollinated Carolina hemlock families collected in 2003. We are very excited to have reached this important stage in our Carolina hemlock conservation program and congratulate Jaime Zapata, Pepe Ordóñez, Iván Appel, Claudio Balocchi, and the rest of Arauco for a job well done. We

hope to expand this planting in the future with additional Carolina hemlock families collected in 2005-2008. Forestal Mininco is working with Camcore to establish conservation banks of Eastern hemlock in Chile and will receive and sow seeds in 2009. This effort is being coordinated by Verónica Emhart and Marcela Labra.

In addition to Arauco's planting, Camcore has also established a small Carolina hemlock seed orchard at the NCSU Upper Mountain Research Station in North Carolina. This orchard contains the 64 OP families collected in 2003. The seedlings are surviving and developing nicely, and we plan to expand this planting to include additional Carolina and Eastern hemlock genotypes in the future. The purpose for the orchard is for research related to hemlock breeding techniques described in the following section.

Hemlock Breeding

Carolina hemlock conservation banks are now in place in Chile and the U.S., and more plantings for this species and Eastern hemlock will soon follow. It is important that Camcore and the USDA Forest Service begin to consider how to best utilize these genetic resources to support hemlock restoration efforts in the eastern U.S. The conservation banks will be well suited for use as breeding orchards for the production of hemlock planting stock for reforestation efforts, whether that be pure species for use in areas where HWA biological controls are well established, or adelgid resistant genetic entities (interspecific hybrids or clones) for areas where HWA control remains elusive. A key component to this will be our ability to shorten the breeding cycle of the hemlocks by developing methods to promote early flowering so that suitable quantities of stock plants for restoration are available in a timely manner. Male and female flowers normally begin to develop on trees in natural stands when they reach approximately 20 to 30 years of age.

As a first step towards addressing this issue, Robert and Andy traveled to Vancouver Island, British Columbia in March 2008 to visit the Western hemlock (*T. heterophylla*) tree improve-

ment program run by the B.C. Ministry of Forests Cowichan Lake Research Station. The purpose of the trip was to learn about nursery production, grafting, and accelerated breeding techniques used for Western hemlock that might be applicable to our future work with Eastern and Carolina hemlocks. Charlie Cartwright (Tree Improvement Director) helped to arrange the visit and provided an overview of selection and breeding program. Ian Carins (Nursery Director) reviewed optimal conditions for greenhouse and nursery production of hemlock seedlings. John Ogg (Propagation Director) gave Robert and Andy hands-on lessons in side veneer grafting techniques that are best suited for small caliper hemlock scions. Finally, Oldrich Hak (Breeding Director) demonstrated the use of stem injections of gibberellins ($GA_{4/7}$) for promoting early flowering in Western hemlock seedlings and saplings. We extend our thanks to everyone at the Cowichan Lake Research Station for taking time to share their knowledge and skills in hemlock breeding with Camcore, and we look forward to adapting the techniques for use with Eastern and Carolina hemlock.



Camcore's Hemlock Project Leader Robert Jetton with one of the Carolina hemlock seedlings planted at NCSU's Upper Mountain Research Station in the North Carolina mountains.

Progress in Tree Improvement

In 2008, Camcore members had another successful year with breeding and improvement activities. In particular, important advances were made in 2nd generation breeding efforts in Brazil, Colombia, and South Africa. The interest in pine 2nd generation progeny tests is accompanied by increasing movement toward commercialization of some of these species due to advantages in growth rate, wood quality, and or disease resistance. In Brazil, Klabin is ramping up the planting of *P. maximinoi*, replacing *P. taeda* on many sites. In South Africa, there is a switch from *P. patula* to *P. tecunumanii*, *P. maximinoi*, and the *P. patula* x *P. tecunumanii* hybrid on sites where there is low risk of frost damage. Lastly, in Colombia, SKCC has switched from *P. patula* to *P. tecunumanii* and *P. maximinoi* across a wide elevation range.

2nd Generation Pine Breeding and Testing

At the end of 2007 and in the first half of 2008, a number of second-generation tests of *P. tecunumanii* (7) and *P. maximinoi* (6) were established in South Africa. The genetic material in these tests consists of open-pollinated seedlots collected in thinned first-generation progeny trials of KLF and Sappi which were distributed among all six South African members. Second-generation tests of *P. patula* are also on the way. A total of 60 open-pollinated family seedlots of *P. patula* have been collected in the Sappi Lion River seed orchard. The plan is to establish at least four tests with this material at Sappi, KLF, Hans Merensky, and PG Bison.

Building on the success of the second-generation progeny tests, the South Africans are 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 a wide array of species and hybrids, 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.

In 2007, the South African members confirmed a total of 68 selections of *P. leiophylla*



Louis van der Merwe inspects early survival in a KLF 2nd generation test of *P. maximinoi*.

in five trials on Sappi, KLF and PG Bison land. These were the first selections of this species in the Camcore program, and in 2008, Julián Moreno of PG Bison made the first second-generation seed collection of this species at a Camcore test in Eland Height in August 2008. Many of the cones in this test had already opened, which suggests that June or July might be the optimum time for seed collection of *P. leiophylla*.

At the Camcore Regional Technical meeting hosted by Masisa, the seven Camcore members in Brazil, Argentina, and Uruguay made a decision to work together in the establishment of second-generation progeny tests of *P. patula*, *P. greggii*, *P. tecunumanii*, and *P. maximinoi*. The goal is to establish 10 *P. patula* and 14 *P. greggii* trials in 2009, and 10 *P. maximinoi* and 10 *P. tecunumanii* trials in 2010. Currently Klabin has OP seed collected for 55 *P. maximinoi* families, 30 *P. tecunumanii* families, and 54 *P. greggii* families, while Masisa has seed collected from 20 *P. patula* families (out of 32 selections) from a 30-year-old seed stand. Both companies will collect additional seed in December of 2008, with the goal to have seed from 50 to 75 families per species. The seed will be shipped to Camcore and distributed to members.

In Colombia, SKCC has completed pollen

collection from most of their *P. tecunumanii* and *P. maximinoi* selections, and have begun making controlled crosses among the selections. The first full-sib second-generation seed of *P. maximinoi* should be available in late 2009, and from *P. tecunumanii* in 2010. In addition, the research team at SKCC played a huge role assisting Nhora Isaza with her M.S. research on the effect of GA 4/7 applications to promote flower production in pine seed orchards (see article in this Annual Report). The results were quite promising, with the possibility of increasing female flower production by 25 to 50%.

Another exciting development is the exchange of second-generation material between the member companies in Brazil, Colombia and South Africa. Seedlots of 30 to 50 families of *P. maximinoi* and *P. tecunumanii* will be exchanged among the three groups. Although there was a fair amount of overlap among the provenances sent to each country from the original native provenance seed collections, due to seed limitations, not every family went to every member. Over the years, the loss of tests to fire, frost, poor survival, etc., and turnover in membership means that not all provenances and families are represented in each region. For these reasons, this type of seed exchange will play an important role in enhancing the genetic base in the different countries.

Other Species and Projects

Sumalindo continues to make progress with its Gmelina improvement. The company established a new 44-clone seed orchard of *Gmelina arborea*. Pizano/Monterrey also made progress in its Gmelina program, and Camcore helped the company with two BLUP analyses: an analysis of clonal data from 5 trials which we used to revise the list of commercial clones for the company in 2008, and an analysis of seedling progeny test data from 3 trials, which was used to identify 270 selection candidates.

We also completed a BLUP analysis of 5 Pizano trials of *Pachira quinata* (formerly *Bombacopsis quinata*). A list of 232 selection

candidates was developed.

Hans Merensky established a series of 6 provenance / progeny tests of *E. urophylla*.

We continued to work with MTO to make *P. radiata* selections, and in 2008 we generated a list of 252 candidates from Camcore *P. radiata* provenance / progeny test 40-52-02A. Selections from these trials (native stand material) will be protected in the MTO-Camcore Conservation Park.

We continue to help members with genetic test design. In 2008, we provided clonal eucalypt test designs for Masisa, and a number of progeny tests designs and species-source trial designs for cold-tolerant eucalypts for Stora Enso.

The final special project was in the area of wood quality research. We completed a project that we began in 2007 with CMPC Forestal Mininco to refine an NIR equation to predict pulp yield in *E. nitens*. The new model is based on wood samples ranging in age from 5 to 16 years, and it was used to make operational breeding predictions of pulp yield 125 hybrid eucalypt samples.

There was much good work done in 2008. We look forward to a productive 2009.



Ivone Fier and Gleison dos Santos of Klabin (Brazil) in a one-year-old plantation of *P. maximinoi*.

Flower and Cone Survey

Camcore works with 25 different pine species across a number of different sites. Many progeny trials are of the age where some indication of flowering and cone production times can be gathered. We were finding that some members were not paying very much attention to flowering times since a number of the pine species were of secondary or tertiary importance or trial sites were located long distances from the main research office thus limiting frequent observation.

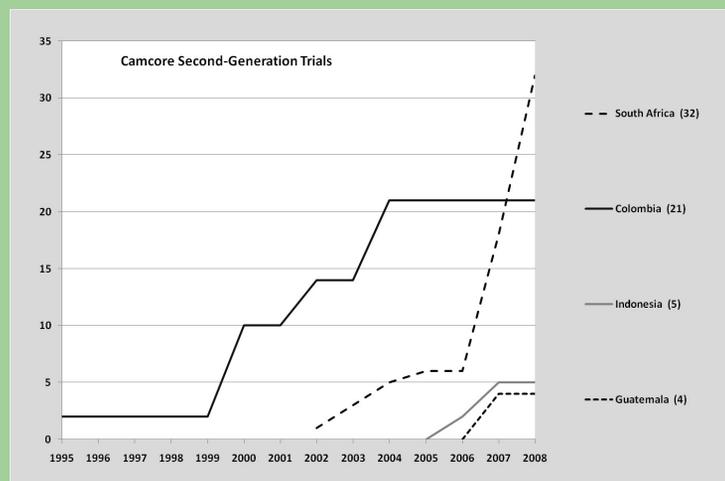
We have therefore initiated a survey of flowering and cone production times across companies and countries to obtain a better idea of general trends. The results will be compiled in early 2009 and presented in a handbook format that can be updated as more information becomes available.



Byron Urrego of Smurfit Kappa Cartón de Colombia examines cone production in the La Catana high-elevation *P. tecunumanii* orchard.

Camcore Second-Generation Trials

Camcore members have planted 62 second-generation trials using seed collected from superior trees in the original progeny provenance trials. Smurfit Kappa Cartón de Colombia was the early leader in this important endeavour, planting F2 trials of *Pinus patula* as early as 1995 and adding a number of species during the next 10 years. In the last 5 years, members in South Africa, led by Komatiland and Sappi, have planted 32 trials of *P. chiapensis*, *P. maximinoi*, and *P. tecunumanii*, 25 of which were established in the last two years. Only a very few have been lost to fire or other disasters and measurements are being sent to Raleigh for analysis. Members continue to make selections and collect seed from mature trials in order to capitalize on the potential genetic gains made possible by the large cooperative testing strategy. In the coming years, we hope to establish more advanced-generation tests, especially in Brazil, Argentina and Uruguay.





Asa Tham looks at a young *P. patula* seedling in an operational planting at Chikweti Forests.



From left, Marcos Mizva, Laercio Duda and Ricardo Paim from Rigesa visiting a Camcore pine hybrid trial in Santa Catarina on a very rainy day.



Nico Olivier and Glen Mitchell inspecting hedges of Camcore pine hybrids in the KLF nursery at Sabie, South Africa.



Operational production of teak plants in the Perum Perhutani nursery. Left to right, Mr. David (Sumalindo), Antonio Villa (Refocosta), Bob Purnell (Weyerhaeuser) and Bill Dvorak (Camcore) exchanging ideas.



Andre van der Hoef and Cassie Carstens standing beside an 11 year old *Pinus elliottii* x *P. caribaea* tree in second generation hybrid trial at MTO.



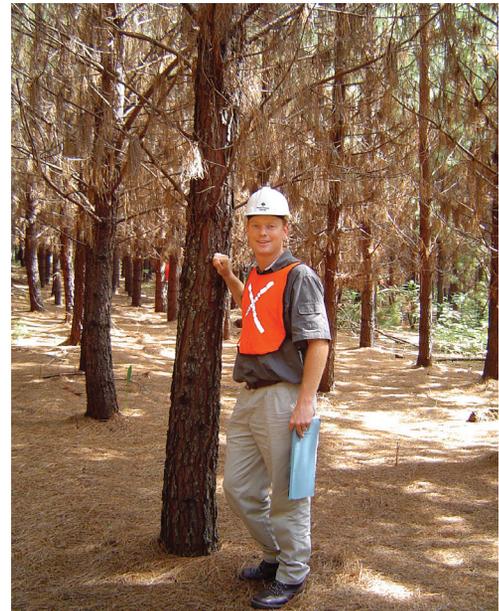
Rebeca Sanhueza (CMPC, Chile) (left) and her research team testing a hand drill to take wood samples for NIR analysis.



Juan López (Camcore) and José Romero (Refocosta) standing in a 10 year old plantation of *Eucalyptus pellita* in the Villanueva project of Refocosta.



Mónica Heberling and Francisco Ferreira stand in a young eucalypt study on StoraEnso land in Uruguay.



Kitt Payn (Mondi) standing beside a *P. taeda* x *P. tecunumanii* tree in a hybrid trial in Natal, South Africa.



Mike Tighe checking germination of pine pollen at NCSU laboratory.



Stuart Charlton (Hans Merensky) and Gary Hodge (Camcore) in a 2nd generation progeny test of *P. tecunumanii* on Singisi Forest land in South Africa.

Wood Properties Species Characterization

In 2008, Camcore completed a three-year project to assess important wood properties of most of its tropical and subtropical pine species. There were four categories of wood properties that we wanted to assess:

1. **Lignin and cellulose content**, which affect pulp yield and mill costs.
2. **Density**, which can affect paper properties, mill production, and solid wood product strength.
3. **Microfibril angle (MFA)**, which affects solid wood strength (modulus of elasticity or MOE), and strength of the individual cellulose fibers.
4. **Fiber dimensions**, which can affect paper strength.

Camcore members took increment cores from over 3300 trees of 17 species, varieties, and hybrids growing on nineteen sites in six countries (Argentina, Brazil, Chile, Colombia, South Africa, and Venezuela) (Table 2). There are up to 45 cores from each of the 81 species-site combinations. Each bark-to-bark core was split in two and a variety of assessments were conducted with each half. Measurement techniques included X-ray densitometry to measure density and growth ring structure, near infrared scanning (NIR) to determine chemical constituents, SilviScan to estimate MFA and MOE, and fiber analysis to measure fiber dimensions and coarseness. The 2007 Camcore Annual Report presented final results from the NIR analyses of lignin and cellulose content. This report presents final results for density, MFA and MOE, and fiber dimensions.

X-Ray Densitometry

Materials and Methods

From the 3300 bark-to-bark cores, 6600 pith-to-bark samples were prepared for analysis by X-ray or Near Infrared scanning. The 2200 samples scanned with the X-ray densitometer represent 67% of the trees, or 30 trees from most of the site-species sample populations.

The task of sampling and processing this large number of cores was a major undertaking by the companies and the Camcore staff, includ-

Table 2. Number of sites and samples for different species in the wood properties study.

Species	Sites	Trees
<i>P. caribaea</i>	3	144
<i>P. car. x P. oocarpa</i>	1	48
<i>P. car. x P. tec.</i>	1	50
<i>P. chiapensis</i>	2	90
<i>P. elliotii</i>	3	135
<i>P. elliotii x PCH</i>	2	90
<i>P. greggii</i> North	5	152
<i>P. greggii</i> South	7	315
<i>P. herrerae</i>	4	147
<i>P. kesiya</i>	1	19
<i>P. leiophylla</i>	4	183
<i>P. maximinoi</i>	8	348
<i>P. oocarpa</i>	3	39
<i>P. patula</i>	13	512
<i>P. radiata</i>	4	177
<i>P. taeda</i>	6	253
<i>P. tecunumanii</i> High	6	262
<i>P. tecunumanii</i> Low	7	314
<i>P. teocote</i>	1	45
Total	81	3,323

ing a dozen graduate students that were hired part time just for this project. Trees ranged in age from 8 to 22 years and diameters from 10 to over 50 cm. The major steps of the process were: 1) sampling trees with increment borers, 2) producing “planklets” from raw cores, 3) scanning planklets with the densitometer and 4) analyzing scan data. The Dept. of Forestry and Environmental Resources has a densitometer, so all the X-ray scanning was done in-house.

The objective of the X-ray analysis was to produce ring-by-ring density profiles of the trees. Companies can use this information to determine the effect of age on the density of harvested trees. With the large sample population, we are able to compare several species on a single site as well as a single species on many sites. The densitometer makes ring analysis easy in samples where rings are well defined due to distinct annual cli-

SPECIES CHARACTERIZATION



Samples from *P. tecunumanii* trees. Top: unprocessed cores from an 18-year-old progeny trial in Brazil. Bottom: 2-mm-thick planklet sawn from a core of a 17-year-old tree from South Africa.

mate patterns. Defining annual growth is more difficult in species grown in tropical latitudes due to the absence of a winter and summer, but the high resolution output from the X-ray scan combined with previous outside-bark diameter measurements made this task possible (see picture).

Results and Discussion

Graphs of density profiles for each site and for each species were produced, and a few are presented here. On most sites, density increased overall with age, usually leveling out or even tapering off after 13 to 15 years. Note that in some graphs, a dip in the final year is due to incomplete sampling of the final late wood band.

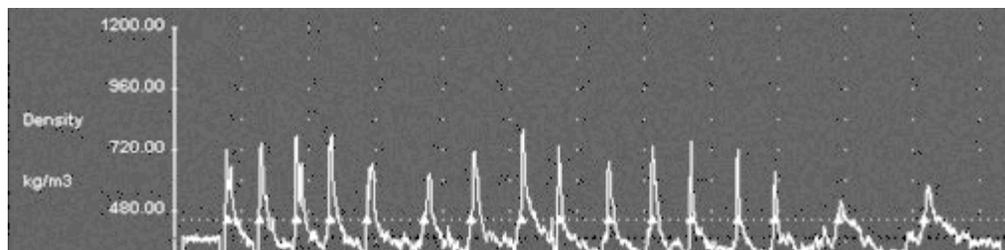
Figure 3 presents an example for the Imbauzinho site belonging to Klabin, Brazil. These are samples from 17 and 18 year-old trees, and data from four species are presented (*P. maximinoi*, *P. taeda*, and *P. tecunumanii* (high elevation), and *P. chiapensis*). The latter species is a white or soft pine, of the sub-genus Haploxyylon. It is very different from the other three species which are of the sub-genus Diploxyylon, the yellow or hard pines. At this site, the age 3 ring density of *P. taeda*, *P. maximinoi* and *P. tecunumanii*

are roughly the same. However, from ring 5 to ring 15, the two sub-tropical species *P. maximinoi* and *P. tecunumanii* have an essentially flat profile with density around 500 kg/m³. In contrast, *P. taeda* does not begin to increase in density until around ring 7, and then reaches maximum density around 550 kg/m³ around ring 12 or 13. The much more uniform density profile of *P. maximinoi* and *P. tecunumanii* may be superior to *P. taeda* for certain wood products. On this site, *P. chiapensis* has a much lower density, as expected.

Other interesting observations can be made on other sites. For example, at Tweefontein, South Africa, *P. maximinoi* and *P. tecunumanii* also have higher density than the common commercial species *P. patula* in the early years (Figure 4). On the Saltaneja site in Venezuela, a comparison of *P. caribaea* to *P. caribaea* x *P. oocarpa* and *P. caribaea* x *P. tecunumanii* hybrids shows that the high density of the *P. oocarpa* and *P. tecunumanii* parents has some effect on the hybrids' wood quality (Figure 5).

These data can also be used to look at profiles of a single species on different sites. The density of *P. caribaea* on Timbauva, Argentina is much lower than on either site in Venezuela (Figure 6). *Pinus patula*, the most heavily sampled species in the study (only half of the sites are included in this graph), shows a very wide range of densities (Figure 7). Known to be of low density, *P. herrerae* is actually fairly dense at Witklip in South Africa. (Figure 8).

Only a small sample of the results can be shown in this article, but Camcore expects to publish more detailed information, including characteristics of early and late wood in 2009.



Well-defined rings in 21-year-old *P. tecunumanii* tree grown in South Africa.

SPECIES CHARACTERIZATION

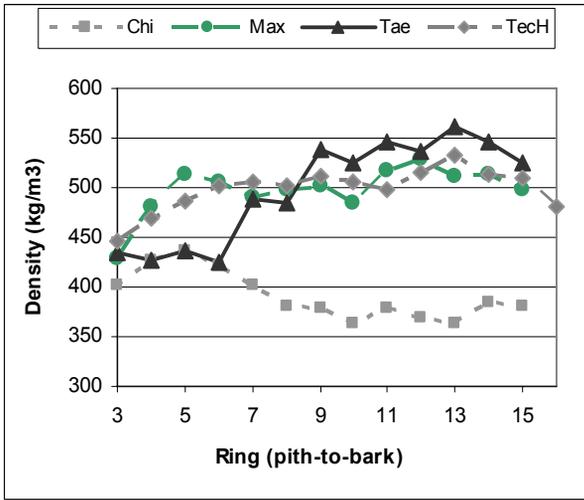


Figure 3. Pith-to-bark profiles for density for four pine species at the Klabin Imbauzinho site in Brazil.

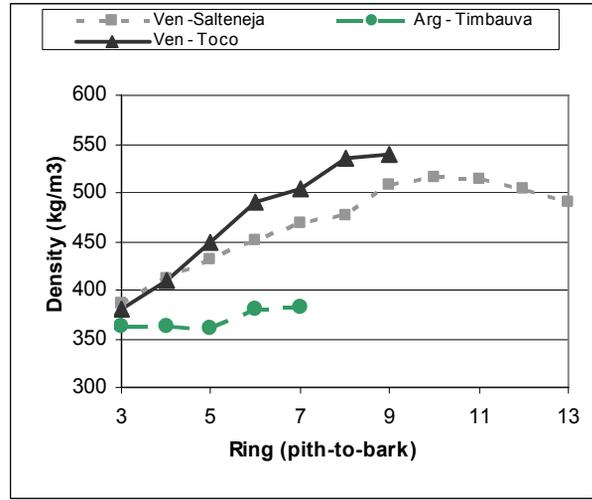


Figure 6. Pith-to-bark profiles for density for *P. caribaea* at three sites.

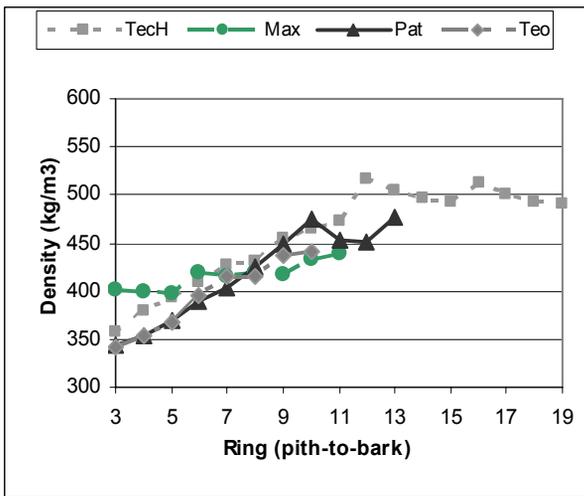


Figure 4. Pith-to-bark profiles for density for four pine species at the KLF Tweefontein in South Africa.

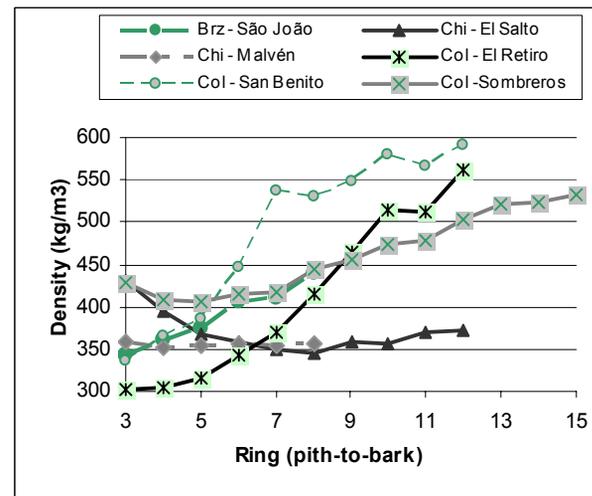


Figure 7. Pith-to-bark profiles for density for *P. patula* at six sites.

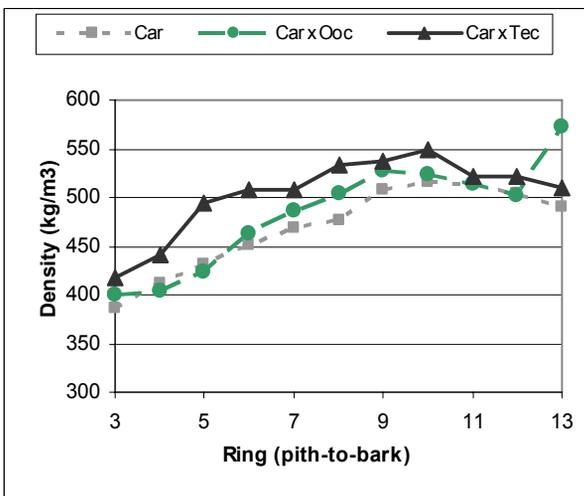


Figure 5. Pith-to-bark profiles for density for three pine species at the SKCV site Venezuela.

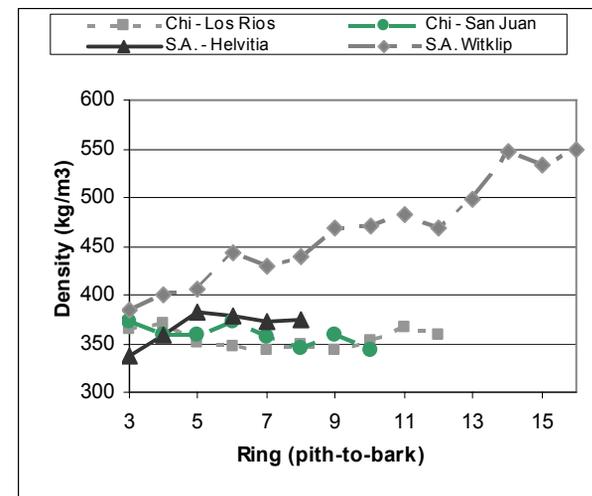


Figure 8. Pith-to-bark profiles for density for *P. herrerae* at four sites.

SPECIES CHARACTERIZATION

MFA and MOE

Materials and Methods

Working with Dr. Laurie Schimleck at the University of Georgia, Camcore developed an NIR model to measure MFA and MOE on increment core samples. There were three steps in the process. (see diagram below).

First, 2124 increment cores were radially sawn into 2 mm thick strips. The samples were measured for NIR reflectance using a modified Foss 5000 spectrometer. A special “mask” was used to allow the spectrometer to measure a series of 10-mm windows running from pith to bark for each sample.

Second, once the NIR assessment was done, a subset of 370 samples (approximately 5 per species-site combination) were sent to the Paper Research Institute of Canada (Paprican) to measure density, MFA and MOE using Silviscan, a machine developed by CSIRO Australia. These data were then used to develop indirect NIR prediction models.

Third, the NIR models were then used to predict density, MOE, and MFA for all of the windows of all 2124 samples.

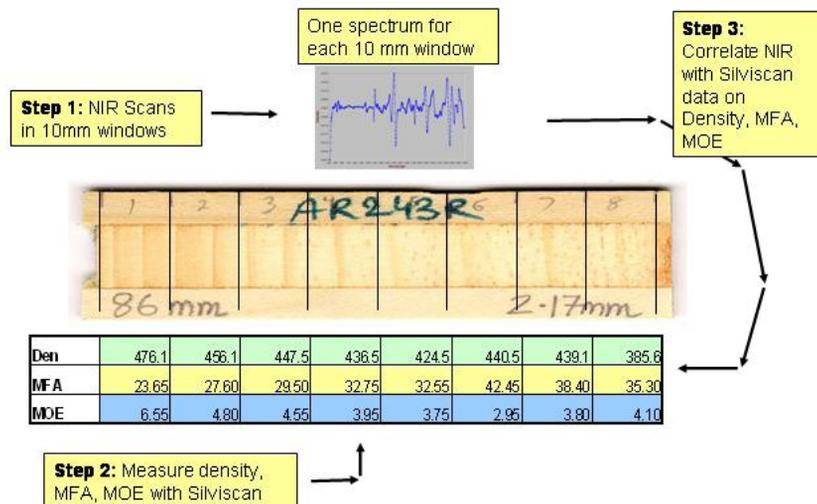
The NIR prediction data were then summarized to provide an average pith-to-bark profile for each species-site combination. Each 10-mm window was assigned a relative position in a pith-to-bark profile from 0 to 100%. For

example, consider the core sample in the diagram below which is 86 mm long. The center of window 8 is 7 mm from the pith, or equivalent to 8.1% of the distance from pith to bark. The center of window 1 is located 77 mm from the pith, or equivalent of 90% of the distance from pith to bark. Similar data were calculated for each window for each core, and then the data points were collected into ten 10-percentile groups (0-10%, 10 to 20%, ... 80 to 90%, and 90 to 100%) for easy display.

Results and Discussion

The NIR models for density, MFA and MOE developed from the 370 sample subset are summarized in Table 3. In general, the density models ranged from fair to good, with average $R^2 = 0.74$ and average standard error of prediction (SEP) of $\pm 40 \text{ kg/m}^3$. The MFA and MOE models were better and more consistently good. For MFA, the average model $R^2 = 0.81$ and $SEP = \pm 2.5^\circ$, while for MOE, the average model $R^2 = 0.90$ and $SEP = \pm 1.0 \text{ Gpa}$.

Using these models, pith-to-bark profiles can be compared for each trait. High density and low MFA will result in higher strength wood, i.e., high MOE. Figure 9 presents an example for a site belonging to Klabin, Brazil. Data for 17 to 18 year-old samples from four species are presented (*P. maximinoi*, *P. taeda*, and *P. tecunumanii* (high elevation), and *P. chiapensis*).



SPECIES CHARACTERIZATION

Table 3. Summary of NIR prediction models for density (Den), microfibril angle (MFA) and modulus of elasticity (MOE).

Country	Member	Den (kg/m ³) (range 300 to 700)		MFA (degrees) (range 5° to 30°)		MOE (Gpa) (range 2 to 15)	
		R ²	SEP	R ²	SEP	R ²	SEP
Argentina	Alto Paraná	0.80	40.0	0.80	2.93	0.90	1.02
	BDP	0.82	31.6	0.87	2.30	0.92	0.82
Brazil	Klabin	0.82	43.6	0.81	3.14	0.88	1.54
	Rigesa	0.84	33.1	0.79	2.30	0.89	0.67
Chile	Arauco	0.68	28.1	0.86	2.55	0.92	0.90
	Mininco	0.56	33.3	0.77	3.05	0.90	0.73
Colombia	SKCC	0.89	36.0	0.82	2.85	0.90	1.60
S.Africa	KLF	0.77	43.0	0.83	3.09	0.91	1.36
	Mondi	0.68	31.8	0.82	0.86	0.92	0.80
	Sappi	0.51	36.9	0.72	3.34	0.81	1.10
Venezuela	SKCV	<i>no Silvscan data, used KLF model for predictions</i>					

On this site, the white pine *P. chiapensis* has a low and very flat pith-to-bark density profile, increasing only from 400 to 450 kg/m³. The tropical hard pines *P. maximinoi* and *P. tecunumanii* have an increasing pith-to-bark density trend, but both are somewhat flatter than *P. taeda*. In other words, *P. maximinoi* and *P. tecunumanii* have a more uniform density profile than *P. taeda*, with higher juvenile wood density, and lower density near the bark.

For these species, the most striking difference appears in the MFA profiles. *Pinus taeda* has higher MFA throughout the profile than all the other species, typically with MFA about 7° higher at an equivalent point in the pith-to-bark profile. Density and MFA together determine MOE. On this site, *P. maximinoi* and *P. tecunumanii* have higher MOE than *P. taeda* across almost the entire pith-to-bark profile. Surprisingly, even low-density *P. chiapensis* has higher MOE across 70% of the profile.

Since the NIR scanning windows were a fixed 10 mm in length, it is difficult to know exactly where in the profile a specific ring, e.g., age 4 or age 8 or age 12, might occur. However, it is clear that the juvenile wood of these species should produce timber of higher quality than juvenile *P. taeda*. If a higher proportion of the wood in the tree meets the minimum strength requirement for building codes, this should increase sawmill recovery, and mean extra profit.

A similar trend is apparent in Figure 10, which compares three species on the El Salto site belonging to Arauco, Chile: *P. radiata*, *P. tecunumanii* (high elevation), and *P. greggii* var. *australis*. The temperate species *P. radiata* shows a typical pith-to-bark increase in density, while the other sub-tropical species have a flatter profile. *Pinus radiata* also has a higher MFA than the other species across almost the entire profile. For example, *P. radiata* has MFA about 10° higher than *P. patula* in the inner core, and around 4° higher at 75% of the profile. The result is that the three sub-tropical species have higher MOE (higher strength wood) in the juvenile core.

Summary

There is insufficient space here to present the results for all traits from all sites. However, some patterns seem clear and consistent. A group of sub-tropical species (*P. maximinoi*, *P. tecunumanii*, *P. oocarpa*, *P. patula*) have better (lower) MFA than *P. taeda* and *P. radiata*. *Pinus maximinoi* and *P. tecunumanii* typically have a more uniform pith-to-bark density profile than *P. radiata* and *P. taeda*, with *P. patula* being somewhat intermediate in this regard. The result is that the sub-tropical species typically have a more uniform MOE profile and higher strength juvenile wood than the temperate species *P. radiata* and *P. taeda*. The full results of this study are being prepared for publication.

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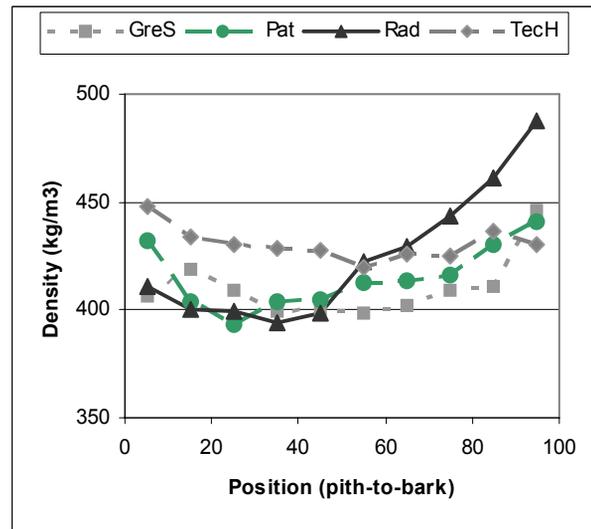
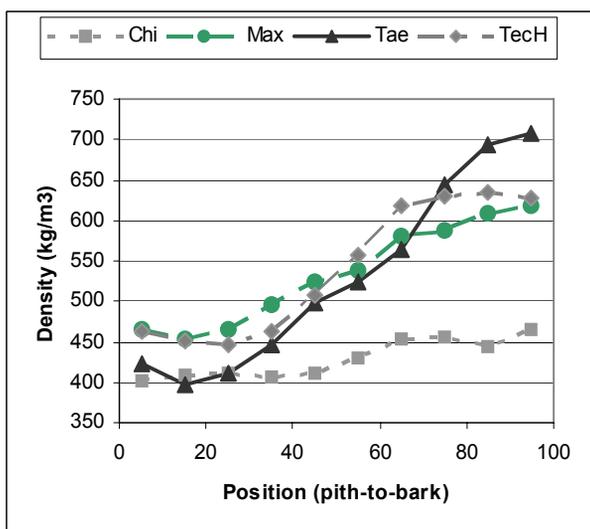
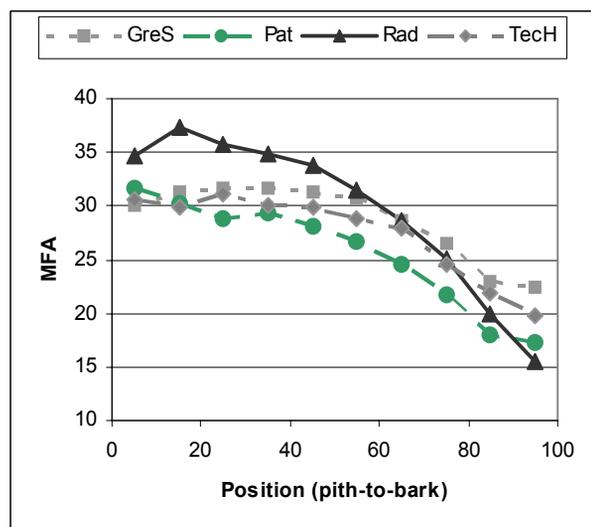
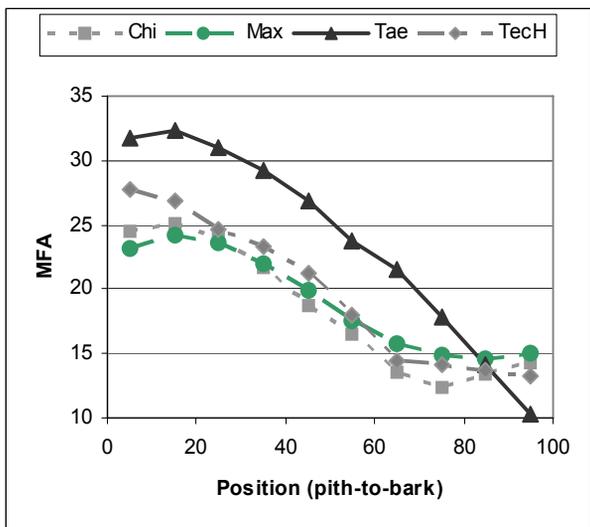
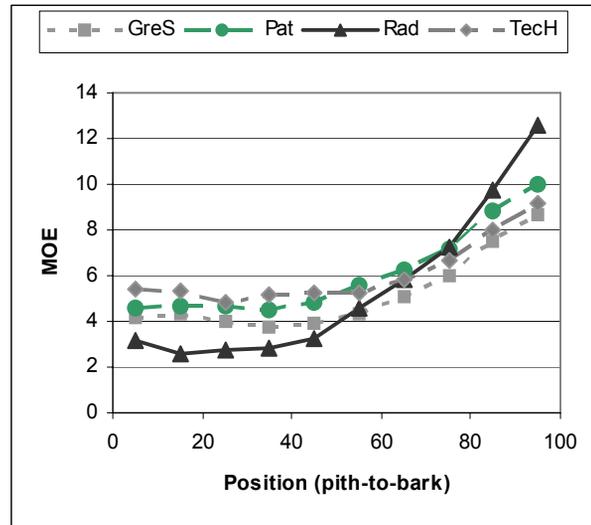
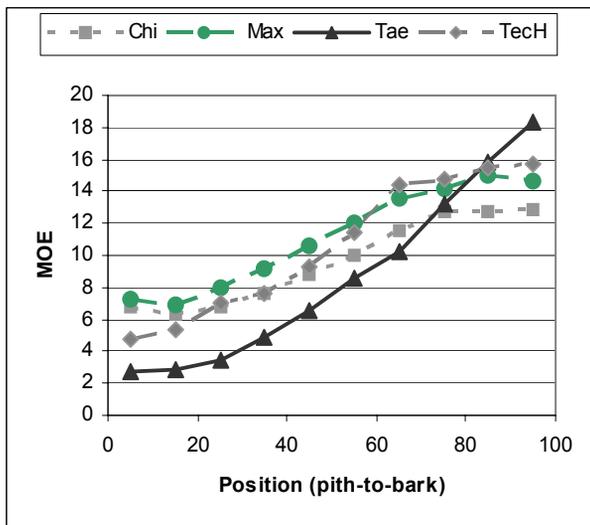


Figure 9. Pith-to-bark profiles for MOE, MFA and Density for four pine species (age 17 and 18 years) at the Klabin Imbauzinho site in Brazil.

Figure 10. Pith-to-bark profiles for MOE, MFA and Density for four pine species (age 15 years) at the Arauco El Salto site in Chile.

Fiber Dimensions

Materials and Methods

Increment core samples from 347 trees (approximately 6 to 7 trees per site-species) were radially sawn into strips (12 mm x 2 mm running from pith to bark). The strips were sent to Dr. Anton Zbonak of the CSIR, Durban, South Africa. There a modified medical microtome was used to slice a very thin transverse (cross sectional) strip, and fiber dimensions were assessed by microscope with image analysis. Growth rings of age 4 and 8 were marked on all cores, and ages 12 and 16 were marked on older samples. The following traits were assessed: fiber diameter (radial and tangential diameter), lumen diameter, cell perimeter, wall thickness, wall area, and Runkel ratio (2 x wall thickness / lumen diameter).

Results and Discussion

As might be expected, there were strong correlations (ranging from 0.93 to 1.00) between ring averages for fiber diameter and all other “cell size” traits such as radial and tangential diameter,

and cell perimeter. The correlation of fiber diameter with lumen diameter was moderately high, at 0.71. For these data, wall thickness was highly correlated with wall area (R = 0.90) and Runkel ratio (R = 0.93). Runkel ratio is related to the collapsibility of the fiber during the refining process, and wall area is essentially equivalent to fiber coarseness (assuming a uniform density for cellulose), which is a familiar trait for pulp and paper scientists. The pattern of correlations among ring averages for all traits suggests that one can study Fiber Diameter and Wall Thickness to examine differences among species.

The ring samples in this data set cover rings of age 4 to 12 years from 16 species/varieties from multiple countries. Wall thickness ranged between 2 to 8 μm, and fiber diameter ranged roughly from 27 to 43 μm. Fibers with thicker wall and/or higher Runkel ratios will require more energy to refine, however, assuming that all fibers can be refined to complete collapse (and are of equal length), paper strength is affected more by wall thickness than by fiber diameter (Figure 11). Fibers with thinner walls should produce paper

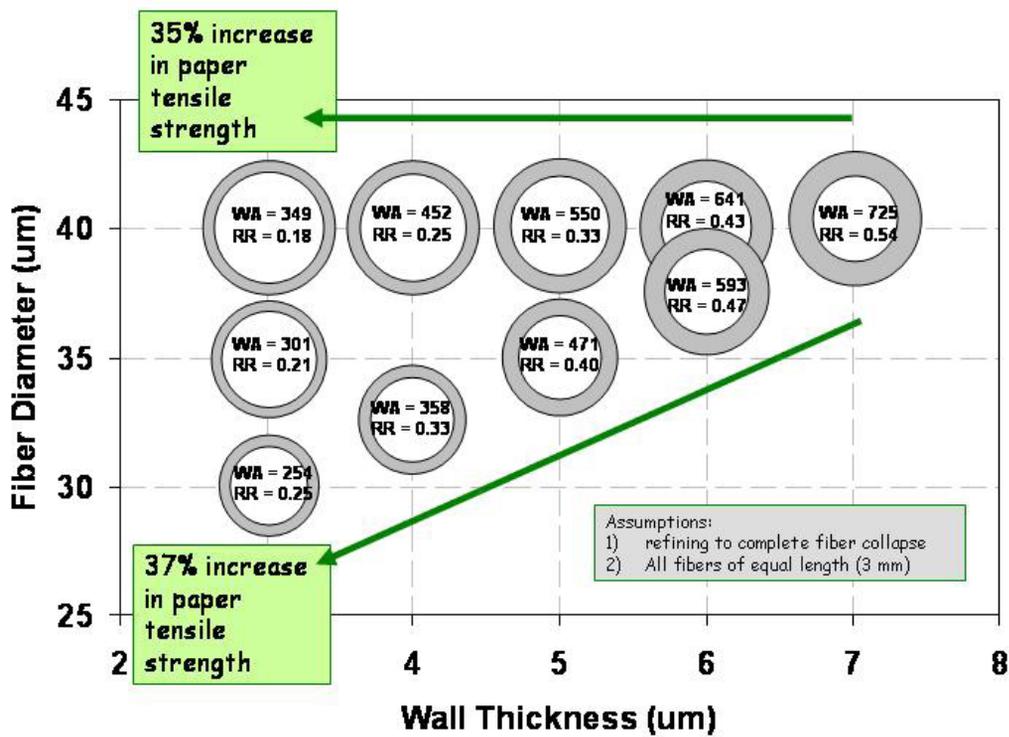


Figure 11. Impact of wall thickness and fiber diameter on tensile strength of paper. Diagram assumes all fibers are refined to complete collapse.

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of greater tensile strength. This summary will therefore focus on differences among the species for wall thickness.

Age 4 rings had thinner cell walls than age 8 rings for almost all species on all sites. However, in general, differences among species were relatively small. On sites in Chile, *P. radiata* had similar wall thickness to *P. greggii* and *P. patula*, while *P. herrerae* and *P. leiophylla* had slightly thinner walls (Figure 12). In Colombia, *P. tecunumanii* had thicker walls than *P. maximinoi*, and on sites in South Africa the pattern was repeated with *P. patula* having thinner walls than both (Figure 13). Finally, in Brazil and Argentina, it appears that *P. taeda*, *P. tecunumanii*, and *P. maximinoi* had similar wall thickness, with *P. patula* and *P. greggii* having thinner walls.

Summary

The great diversity of paper products and pulping and refining techniques, makes it difficult to evaluate species suitability solely on the basis of fiber dimensions. However, it appears likely that most of the sub-tropical species will have fiber similar to or perhaps better than current widely-used commercial species like *P. taeda* and *P. radiata*. In particular, *P. patula* and *P. greggii* appear to have thinner walls than *P. taeda*, and should produce paper of equal or greater tensile strength with lower refining costs. It should be noted that currently we have no data to compare fiber length of these species, and clearly that could affect these preliminary conclusions. Camcore will assess the fiber length of these species in 2009.

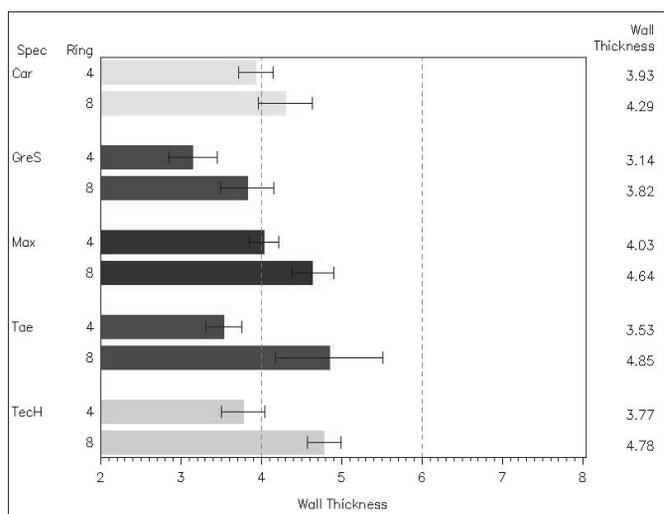


Figure 12. Wall thickness (μm) for five pine species at the Timbauva (BDP) site in Argentina. Samples are from 8-year-old trees.

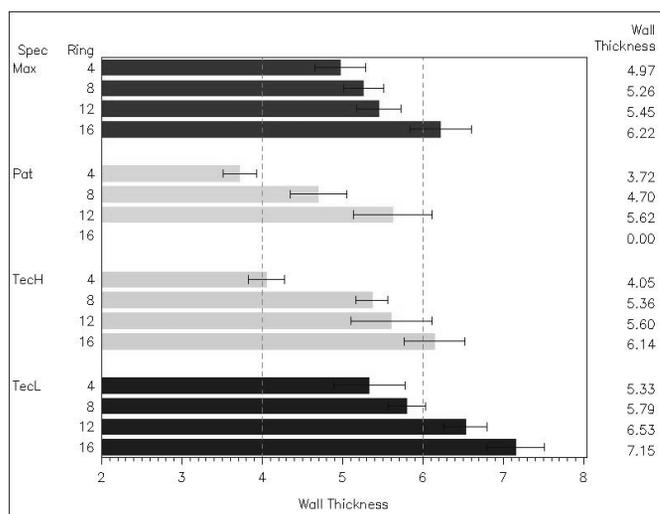


Figure 13. Wall thickness (μm) for four pine species at the Witklip (KLF) site in South Africa. Samples are from 15 to 20-year-old trees.

Density Profiles of Tropical Hardwoods

In 2008, Camcore assessed the wood quality of nine hardwood species grown by members in Colombia, Indonesia, and Venezuela (Table 4). The sample size and the types of analysis were not as extensive as the project with the pines because 1) most of these species do not show annual ring structure in the tropics (see picture) and 2) traits such as lignin content and MFA are not applicable to the wood from these species. However, X-ray densitometry is still a useful tool for measuring density, an important wood quality trait. Samples were processed and scanned with the same method as the pine species and similar graphs were generated. Below is a summary table of the whole-core densities for the tested species.

The density graphs show a profile pattern somewhat different from the pine species (Figures 14-16). Although there is a general increase in density over age, it is not very pronounced, especially in Indonesia. Also, the densities are

fairly steady compared to the pines, possibly due to less variation in climate from year to year on these tropical sites. Note that due to the lack of rings, the graphs are shown in percentage of sample length rather than age and this distorts the profiles somewhat. Some of the species are quite light; below 300 kg/m³. When comparing a single species, *Gmelina arborea*, on all three sites, Indonesia seems to produce denser wood at an early age, but the density is similar on all three sites after several years (Figure 17). In this case, the trees from the three sites are similar in age. Since some of these species are grown on longer rotations for solid wood products, it will be important to get older samples to perform a more thorough comparison of sites and species.



Planklets of *Gmelina arborea* from Colombia.

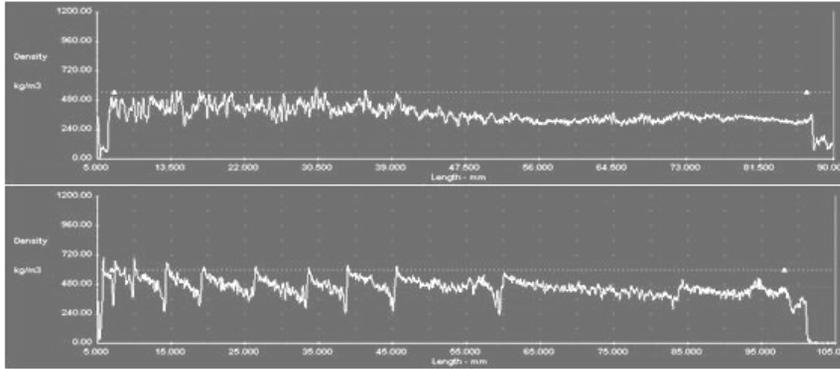


Dina Espinoza scans planklets with the X-ray densitometer.

Table 4. Number of samples and average, minimum and maximum whole-core densities. S.E. is standard error. Density values are in kg/m³.

Country	Species	Age	Num	Ave	Min	Max	S.E.
Colombia	<i>Gmelina arborea</i>	8	15	394	349	453	7
	<i>Pachira quinata</i>	15	15	359	292	415	10
	<i>Sterculia apetala</i>	20	14	310	237	416	13
Indonesia	<i>Acacia mangium</i>	7	39	444	333	538	8
	<i>Gmelina arborea</i>	6	44	415	330	498	6
	<i>Gmelina moluccana</i>	6	44	319	261	357	3
	<i>Hibiscus simillis</i>	6	45	410	361	481	4
	<i>Tectona grandis</i>	6	43	433	324	533	7
Venezuela	<i>Gmelina arborea</i>	10	45	379	286	471	7
	<i>Schizolobium parahybum</i>	20	46	322	272	378	3
	<i>Tectona grandis</i>	12	25	475	405	543	6
	<i>Terminalia spp.</i>	12	50	433	335	543	7

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Density profiles for *Acacia mangium* from Indonesia (top) and *Tectona grandis* from Venezuela (bottom). Teak was the only species in the study with obvious ring structure.

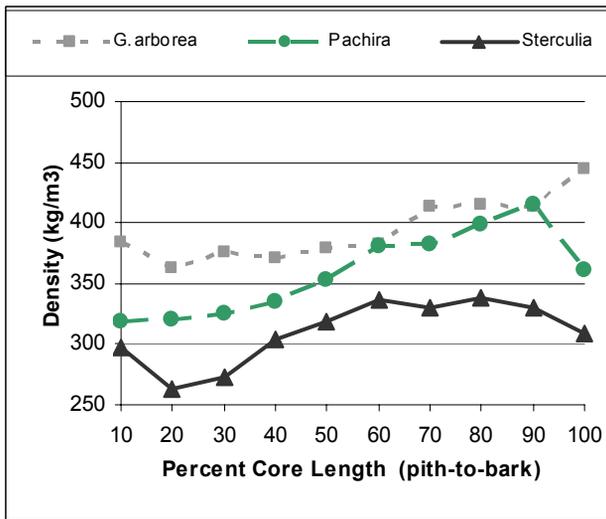


Figure 14. Pith-to-bark profiles for density for three hardwood species (age 8 to 20) planted by Pizano in Colombia.

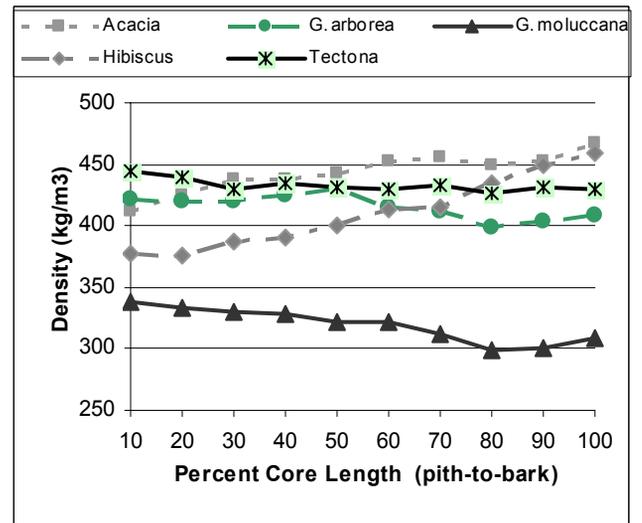


Figure 16. Pith-to-bark profiles for density for three hardwood species (age 6 to 7) planted by Sumalindo in Indonesia.

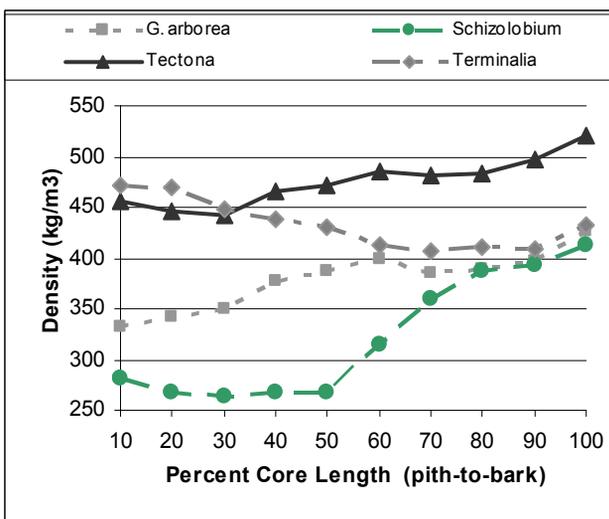


Figure 15. Pith-to-bark profiles for density for three hardwood species (age 10 to 20) planted by SKCV in Venezuela.

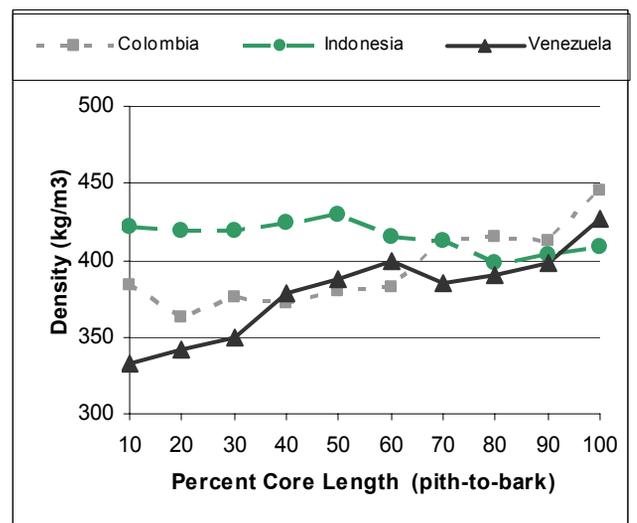


Figure 17. Pith-to-bark profiles for density for *Gmelina arborea* (age 6 to 10) planted in three different countries.

Increasing Flowering in Tropical Pines with GA 4/7

In 2008, Nhora Isaza of Smurfit Kappa Cartón de Colombia (SKCC) completed a Master's of Science degree at NC State University. Nhora's primary research focus was on the use of gibberellin to increase flowering in seed orchards of *P. tecunumanii* and *P. maximinoi* in Colombia. Her full thesis is available online at www.lib.ncsu.edu. This article will summarize her research project.

Background

For pine seed orchards established in tropical environments outside the species natural range, seed production can be very problematic. In tropical environments, there is often poor synchronization between pine pollen dispersal and female strobili receptivity, and the pollen cloud, which is critical for good seed set, is often inadequate. For SKCC, these problems create a severe limitation to cone and seed production of pine species used for commercial plantations. An effective and inexpensive method to increase seed production would be very valuable. The objective of this study was to examine the effectiveness of different applications of gibberellin (GA_{4/7}) stem injections to enhance flowering on seed orchards of *P. tecunumanii* (low elevation) and *P. maximinoi* in Colombia.

Materials and Methods

Timing of Applications and Gibberellin Products

In temperate pine species growing in the northern hemisphere, female and male strobili are initiated in the dry summer months. Although the rainfall distribution in Colombia is relatively uniform throughout the year, there is normally a slight dry season in July and August, so the month of August 2007 was identified as a suitable time to test GA applications.

A commercial GA_{4/7} product called Procone®, manufactured by Valent Biosciences, is specially formulated for foliar spray and/or stem injection for the family *Pinaceae*. However, due to logistical problems, this product was not available for application on the SKCC orchards in August 2007. Another GA_{4/7} product called

ProVide® 10SG, also manufactured by Valent Biosciences was available in August 2007. ProVide® 10SG is formulated for foliar spray application onto fruit trees. The active ingredient in both products is the same.

As a result, two experiments were conducted. Experiment 1 was conducted in August 2007 using ProVide 10SG®, and Experiment 2 was conducted in September 2007 using Procone®.

Plant Material

Two seed orchards were studied: an eleven-year-old *Pinus maximinoi* orchard and a five-year-old *P. tecunumanii* orchard. Details of the location and climatic variables for the two orchards are listed in Table 5. For Experiment 1, 15 clones of both species were selected for treatment, and for Experiment 2, 12 clones of both species were selected for treatment. The clones were stratified among good, average, and poor female strobili producers based on past production. One ramet per clone was randomly assigned to each of four gibberellin treatments.

Hormone Treatments

Experiment 1 in August 2007 used three separate treatments of ProVide® 10 SG. For the three hormone treatments, a volume of 750 mL was prepared by dissolving 18.75, 37.5, and 112.5 grams of Provide® 10 sg in 750 mL of distilled water. The goal was to produce solutions with concentrations of 2.5, 5.0 and 15.0 mg/mL of active ingredient. The three hormone solutions plus a control of distilled water were injected into the stems of the trees. The target was for the trees in the treatments to receive 0, 50, 100, or 300 mg/tree of active ingredient. However, subsequent laboratory analysis showed that the product did not fully dissolve into solution. The analyses suggest that the maximum amount of active ingredient GA_{4/7} that was in solution when the trees were injected was around 8.7 mg / tree. It is unclear what might happen over time to the active ingredient in the precipitate injected into the tree stems.

Experiment 2 in September 2007 used

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Table 5. Climatic, geographic, and establishment description of the SKCC *P. tecunumanii* and *P. maximinoi* seed orchard sites in Colombia.

	Seed Orchard Sites	
	Aguaclara	Cabuyerita
Species	<i>P. tecunumanii</i>	<i>P. maximinoi</i>
Latitude	3° 41' N	2° 31' W
Longitude	76° 32' W	76° 34' W
Elevation (masl)	1585	1810
Area (ha)	3.0	3.5
Rainfall (mm)	1166	2125
Temperature (°C)	22	18
Year planted	2003	1997
Soils	Vertisols	Andisols
Spacing (m)	10 x 5	10 x 10
Number of clones	38	36
Mean height (2007)	6.4 m	17.4 m
Mean DBH (2007)	11.0 cm	31.2 cm

treatments of Procone®. The target was for the trees in the treatments to receive 0, 50, 100, or 300 mg/tree of active ingredient. Since the Procone® product was a liquid, the target amount of active was delivered.

Data Collection

Prior to the hormone applications, all developing female strobili were marked with permanent tree paint so they would not be counted among strobili produced subsequent to hormone treatment. Six months after hormone application, complete inventories of all female strobili in the entire crown of every tree were completed between the end of February and March, 2008. Each female strobilus was classified as a conelet or as a developing female strobilus bud by experienced orchard technicians. Strobili less than 2 months old were classified as “Developing Strobili”, and from 2 to 5 months old as “Conelets”. Dead and damaged strobili, aborted female strobili (counted every two months) were also included in the total inventory.

Data Analysis

The response variables were total conelets (**Cones**), total developing female strobili buds (**Strob**), total dead, damaged, and aborted female strobili (**Dead**), total live female strobili (**FemLive** = the sum of **Cones** and **Strob**), and total female strobili produced (**FemAll** = the sum of conelets, developing female strobili buds, dead, damaged, and aborted female strobili).

Results and Discussion

Experiment 1, ProVide® 10SG

There were limited phytotoxic effects of GA_{4/7} seen in the form of yellowing or burnt needles a few days after treatment in both species, but more severe on *P. tecunumanii*. The symptoms disappeared after approximately two months.

In both species there was a significant response when comparing all three treatments together versus the control. Trees of *P. maximinoi* treated with ProVide® GA_{4/7} averaged 1096 total female strobili per tree vs. 870 for the controls. For *P. tecunumanii* trees, the average total female strobili per tree were 317 vs. 211 for the controls. Orthogonal contrasts of the three hormone treatments vs. the control showed a statistically significant increase in four of the five response variables for both *P. maximinoi* and *P. tecunumani* (Figure 18). For *P. maximinoi*, there was an increase of 26 % total female strobili, while for *P. tecunumanii*, there was a 50% increase in total female strobili. Possibly the smaller size of the *P. tecunumanii* trees may have led to a larger response to the hormone. For both species, there was a significant increase in the variable “Strob” (developing female strobili), indicating a persistent effect of the hormone treatment on strobilus initiation even 4 months after the application.

The data also suggest that GA_{4/7} treatments increase female strobili production primarily in clones that are already producing flowers, but probably will not stimulate trees that have very few strobili to produce substantially more.

Experiment 2, Procone®

As in Experiment 1, there were limited phytotoxic effects from the GA_{4/7} in the form of yellowing or needle burn and slight loss of needles the first month after treatment. Symptoms were more noticeable in *P. tecunumanii* than *P. maximinoi*. The symptoms remained on some clones up to four months after treatment application, but thereafter the trees appeared healthy and the terminal buds were growing well.

Comparisons of all treatments versus the control showed an important effect for *P. maximinoi*. Trees treated with 300, 100, and 50

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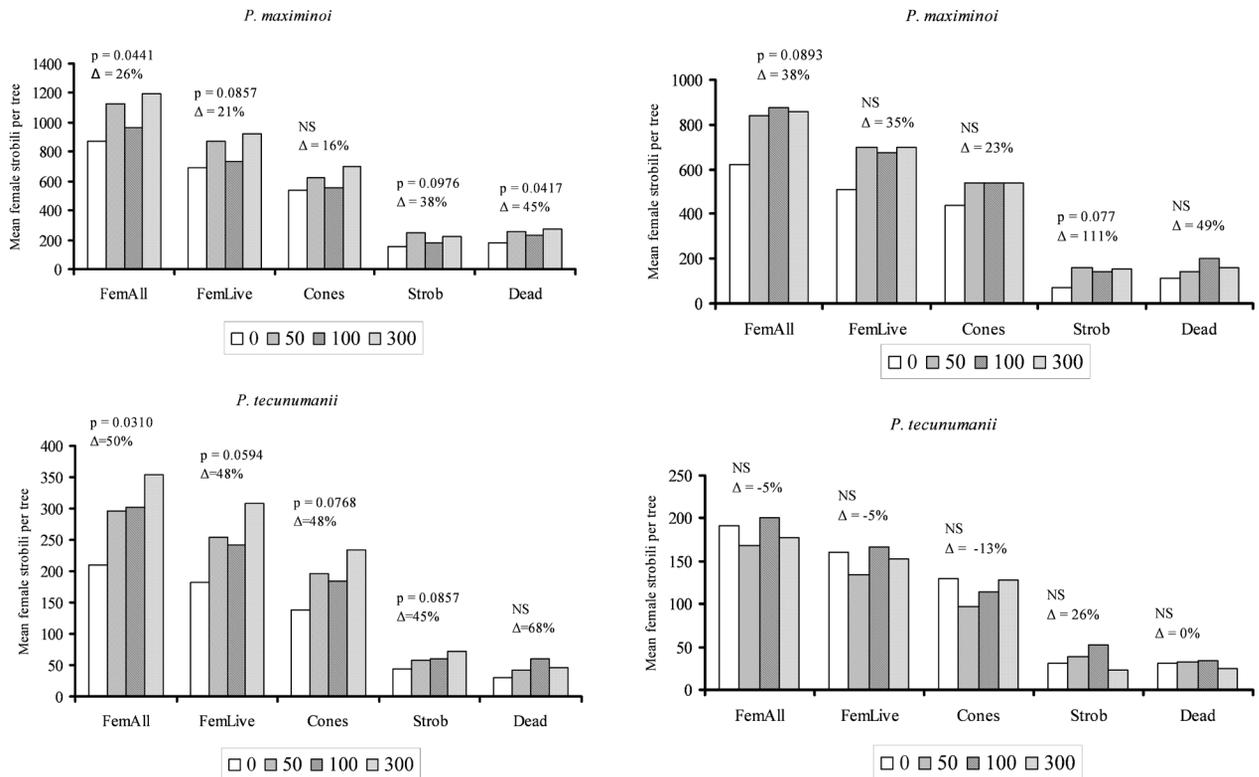


Figure 18. Effect of three levels of GA 4/7 treatment on flower production in *P. maximinoi* and *P. tecunumanii* seed orchards in Colombia. Left = Experiment 1, Right = Experiment 2.

mg of GA_{4/7} averaged 859, 878, 838 total female strobili per tree respectively vs. 623 on average for controls, an increase of 38% (Figure 18). There was also a significant increase, from 72 developing strobili per tree to 152 per tree for the hormone treatments (Figure 18), indicating an effect from the hormone treatments persistent up to 4 months later. For *P. maximinoi*, there was also an indication of increased FemLive and Cones (35% and 23%, respectively), but these differences were not statistically significant.

In contrast to the results for *P. maximinoi*, there was no evidence for any effect of the hormone treatments on female strobili production in *P. tecunumanii*. In fact, the means for many of the response variables was lower for the hormone treatment than for the controls (Figure 18).

The difference between the two species response in Experiment 2 may have been influenced by differences in precipitation at the two orchard sites. For the *P. maximinoi* orchard at Cabuyerita Farm, the precipitation pattern in 2007 was fairly typical, with a dry period from June to

September. For this species, GA_{4/7} applications in both August and September produced an increase in female strobili production. For the *P. tecunumanii* orchard at Aguaclara Farm, precipitation in 2007 was much higher than average from June to August. The high rainfall may have limited the response of *P. tecunumanii* in Experiment 2. In other species, it has been found that under cool and wet conditions, GA_{4/7} is ineffective in promoting flowering.

Conclusions and Recommendations

This study indicates that stem injections of GA_{4/7} into large field-grown trees can promote female strobili production up to six months after treatment in *P. maximinoi* and *P. tecunumanii*. In this study, both GA_{4/7} products (ProVide[®] 10SG and Procone[®]) produced a response. The stem injection treatments are easy and inexpensive, and produce only moderate short-term phytotoxic effects. Further research on optimum timing and dose is needed.

Quantifying the Cold Hardiness of Camcore Species

Critical to the successful development of hybrids suited for northern Argentina, southern Brazil, South Africa and Uruguay will be the ability of the new cultivars to survive winter freezing temperatures in these regions. In our field trials, we have seen noticeable differences in frost resistance of pure species at the provenance level for some of the sub-tropical pines. A number of questions exist. How much variation is present in frost resistance within a species? How is frost resistance inherited in hybrid crosses? Is the trait intermediate between the parental species or does it more resemble the susceptible parent? Does frost resistance change noticeably within a species depending on the environment in which it is planted? If so, should we be careful in which environments we make selections within pure species for the purpose of making hybrid crosses?



Mike Tighe with pine seedlings from a number of species in the controlled environment chamber in the Phytotron at NC State University. Temperature and daylength conditions were managed to simulate an autumn in southern Brazil.

As a first step to answering some of these questions, Camcore initiated a frost tolerance study at NC State on a number of tropical, sub-tropical and temperate species and varieties. Our goal was to quantify the cold resistance of pure species in a preliminary study before screening hybrid seedlings. *Pinus taeda* and *P. elliottii* from different regions in the world served as control lots. Seedlings were grown in environmentally controlled growth chambers in the NCSU Phytotron with light and temperature regimes that mimicked the photoperiod and temperatures typical of Curitiba, Brazil (25° S latitude). Seedlings were grown for approximately 8 to 10 months in the growth chambers to reach normal outplanting height (20-25 cm). Three weeks before the freeze treatment, seedlings were hardened off by lowering day time and night time temperatures to 10° and 4° C, respectively, reducing photoperiod to 10.5 hours, and limiting water and fertilizer application.

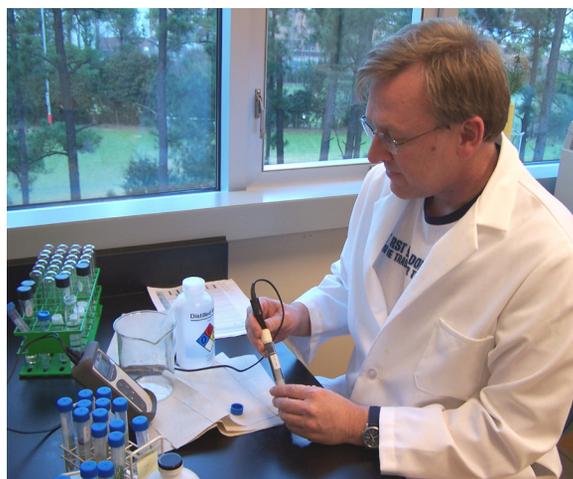
Tissue from seedlings in each of the species/regions was then subjected to electrolyte leakage freeze assessment. This protocol involves placing needle tissue in individual vials and subjecting them to different levels of subfreezing temperatures. Electrolyte leakage is then measured to determine at what temperature most of the tissue dies.

The laboratory results were found to agree very well with most of our field observation. Figure 19 shows an injury index at -14°C. *Pinus caribaea* var. *hondurensis* was more damaged than var. *bahamensis*, as expected. *Pinus tecunumanii* from the San Cristobal plateau, Chiapas (*tecunumanii* HE, Mexico) was more cold hardy than high-elevation (HE) populations of *P. tecunumanii* in Guatemala and low-elevation (LE) populations in Honduras and as cold hardy as *P. patula* var. *longipedunculata* from Oaxaca. *Pinus patula* and *P. greggii* var. *australis* exhibited about the same degree of cold hardiness; trends that we see in the field. There were some surprises. *P. oocarpa* from northwestern Mexico was much more cold hardy than *P. oocarpa* from Honduras. Even though the results seem intuitive in that the Mexican provenances occur at fringe latitudes for the species, these northern populations tend to congregate in warm valley bot-

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toms in the Sierra Madre Occidental. We had thought that their ability to survive cold would be mitigated somewhat by the protection of the canyons and that they would be nearly as susceptible to frosts as their more tropical cousins.

We also found that *P. taeda* from North Carolina, Florida, South Africa, Paraná and Santa Catarina, Brazil and northern Argentina have frost resistance reflective of the environment in which they are grown. Whether these differences within a pure species are significant enough to influence cold hardiness patterns in hybrid progeny remains to be seen. Camcore plans to publish the results of the cold hardiness studies of the pure species and initiate a new series of studies with pine hybrids in 2009.



Gary Hodge measures freeze-induced electrolyte leakage from needle samples.

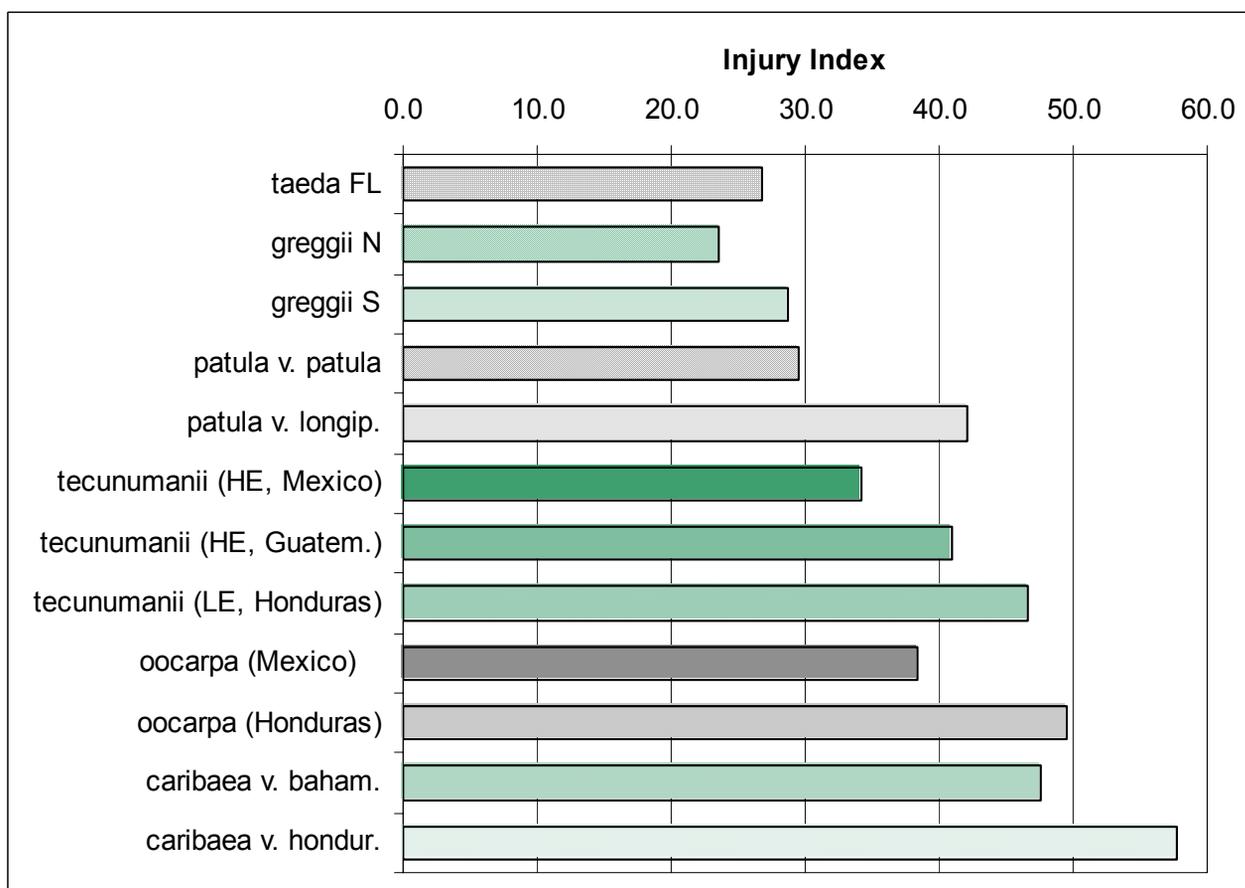


Figure 19. Injury Index for sub-tropical pine species following artificial freezing to -14 ° C.

Pitch Canker Report

Introduction

In 2008, Camcore conducted three different pitch canker resistance experiments at the USDA Forest Service Resistance Screening Center in Bent Creek, NC: 1) a comparison of 50 *P. oocarpa* provenances, 2) a comparison of 10 *P. greggii* provenances, and 3) an investigation of the heritability of pitch canker resistance of open-pollinated families of high-elevation *P. tecunumanii* from Colombia.

This report will summarize the results of those three studies. In each case, the methods were essentially the same as have been described in more detail in past annual reports. Briefly, the process involves wounding young seedlings, inoculating them with the pitch canker pathogen, and then assessing the amount of stem dieback 16 to 20 weeks later. A susceptible *P. elliottii* checklot (FA2) was included in all studies to ensure the viability of the inoculum.

P. oocarpa

This study included 50 *P. oocarpa* provenances that covered the entire range of the species, as well as 18 other seedlots from high and low-elevation *P. tecunumanii* (HE and LE, respectively), and *P. patula* vars. *patula* and *longipedunculata*. Seedlings were inoculated at 12 weeks of age, and stem dieback assessed at 12 and 20 weeks.

Results

P. oocarpa and LE *P. tecunumanii* were highly resistant with stemkill of 4.1 and 5.8%, respectively. HE *P. tecunumanii*, *P. oocarpa* var. *microphylla*, and *P. patula* var. *longipedunculata* were susceptible with stemkill values that ranged from 42 to 60%. *P. patula* var. *patula* and the *P. elliottii* control were highly susceptible with mean stemkill percentage above 70%. The ranks in stemkill percentage of the resistance and susceptible provenances of *P. tecunumanii* and *P. patula* were very similar to results obtained in our previous work (Hodge & Dvorak 2007).

Provenance variation in stemkill percentage within *P. oocarpa* (excluding var. *microphylla*) was small, but significant ($p=0.0001$). Values of 3% stemkill were common in the Cordilleras

of Honduras and Nicaragua in the southern part of the species' range. These values rose in a gentle clinal manner to a maximum near 8% in the Eje Volcánico Transversal in central Mexico before dropping slightly in the northern Sierra Madre Oriental at the extreme of the species' range. The highest dispersion in mean stemkill percentage within any group was for HE *P. tecunumanii* with extremes of Montecristo, El Salvador 12% and Pinalón, Guatemala 77% (Table 7). Full results of this study will be published in *International Journal of Plant Sciences* (Dvorak et al., In Press).

P. greggii

This study included 6 provenances of *P. greggii* var. *australis*, and 4 provenances of *P. greggii* var. *greggii*. The two varieties will be referred to as *P. greggii* South and North, respectively. In addition, the study included samples of four native provenances of *P. radiata* (Año Nuevo, Monterrey, Cambria, and Isla Guadalupe) and one commercial seedlot from Chile (CMPC Forestal). Lastly, seedlots of *P. tecunumanii*, *P. oocarpa*, and *P. patula* were included as controls. The seedlings were inoculated at 16 weeks, and measurements were taken at 20 weeks.

Results

The provenance and species means are summarized in Table 5. The control species all ranked as expected with *P. tecunumanii* and *P. oocarpa* the most resistant (3% stemkill), and the susceptible *P. elliottii* checklot (FA2) and *P. radiata* showing much more stem dieback (39% and 75% stemkill, respectively).

The *P. radiata* provenances averaged 75% stemkill, ranging from 62% (Año Nuevo) to 87% (Cambria). The CMPC commercial seedlot was similar to Año Nuevo, with 62% stemkill. In an earlier study (Hodge and Dvorak 2000) using 12-week-old seedlings, there was no variation among native provenances, and no difference between native provenances and Chilean commercial seedlots of *P. radiata*.

The most interesting result was that the *P. greggii* North seedlots were by far the most susceptible of all seedlots in this study, with 83%

SPECIES CHARACTERIZATION

Table 5. Stem kill (%) of provenance seedlots of *P. greggii* South, *P. greggii* North, and *P. radiata*.

Species	Provenance	stemkill (%)
tecunumanii (LE)	bulk	3
oocarpa	bulk	3
greggii S	Carrizal_Chico	8.9
greggii S	San_Joaquín	9.0
greggii S	Valle_Verde	12.8
greggii S	Jalamelco	12.9
greggii S	El_Madroño	15.6
greggii S	Laguna_Seca	21.6
patula	bulk	28.7
radiata	Año_Nuevo	62.3
radiata	CMPC	65.4
radiata	Monterrey	77.8
radiata	Isla_Guadalupe	84.5
radiata	Cambria	86.8
greggii N	Sierra_el_Tarrillal	73.3
greggii N	Loma_el_Oregano	81.4
greggii N	Ojo_de_Agua	87.5
greggii N	La_Tapona	91.9

stemkill, compared to 29% for the *P. patula*, 39% for the *P. elliottii* FA2, and 75% for *P. radiata*. There was some variation among the four provenances with Sierra el Tarrillal showing the most resistance. The *P. greggii* South provenances averaged 14% stemkill, ranging from 9% to (Carrizal Chico) to 21% stemkill (Laguna Seca). In the earlier study, *P. greggii* South was similar in resistance to *P. patula*, and slightly more resistant than *P. greggii* North (Hodge and Dvorak 2000). This study used 16-week-old seedlings compared to 12-week-old seedlings in the earlier study. These results suggest that *P. greggii* North may be substantially more susceptible to

pitch canker than *P. patula*, and approximately equal to *P. radiata* in terms of susceptibility.

***P. tecunumanii* (high elevation)**

This study was conducted by Nhora Isaza as part of her M.S. research. The dataset included 14 seedlots of *P. tecunumanii* (high elevation, HE) collected in the La Catana orchard of Smurfit Kappa Cartón de Colombia. In addition, there was a seed orchard mix of *P. tecunumanii* (low elevation, LE), *P. patula*, and bulk mixes of native provenance seedlots for HE and LE *P. tecunumanii*. The seedlings were inoculated at 16 weeks, and stemkill measured at 12 and 21 weeks.

Results

The species ranks in this study are exactly consistent with previous results reported in the literature: *P. tecunumanii* (LE) shows essentially no stem dieback when inoculated as a seedling, *P. tecunumanii* (HE) shows intermediate resistance, and *P. patula* is very susceptible. There was substantial genetic variation among the *P. tecunumanii* (HE) families for resistance to pitch canker infection, with the range in GCA predictions for stemkill from 12% to 63%. The most resistant *P. tecunumanii* (HE) families approach the resistance of low-elevation *P. tecunumanii*, while the least resistant families approach the susceptibility of *P. patula*.

Artificial screening of high-elevation *P. tecunumanii* families for pitch canker resistance appears very reliable. Heritabilities for infection response variables are high ($h^2 \approx 0.50$ or higher), and there is little family x experiment interaction. Any organization planting high-elevation *P. tecunumanii* commercially should consider screening their genetic material using this type of approach.

Progress in Hybrid Testing

This was a very successful year for the Camcore pine hybrid program. Fourteen new hybrid trials were established in Argentina, Brazil and South Africa (Table 6). The hybrids established in the field were *P. elliottii* x *P. tecunumanii*, *P. elliottii* x *P. caribaea*, *P. patula* x *P. elliottii*, *P. patula* x *P. greggii* S, *P. patula* x *P. pringlei*, *P. patula* x *P. tecunumanii*, *P. caribaea* x *P. tecunumanii* and *P. caribaea* x *P. oocarpa*. This brings the total to 21 hybrid trials established in the last two years.

The second batch of hybrid seeds produced by Camcore members were sown in nurseries in Argentina, Brazil, Colombia, South Africa and Venezuela in 2008. Germination of the hybrid seeds was not as good as the first batch. Seedlings will be converted to hedges to mass produce cuttings for distribution to members within each region. The new batch of pine hybrids include: *P. elliottii* x *P. greggii* S, *P. elliottii* x *P. taeda*, *P. greggii* S x *P. tecunumanii* (high elevation), *P. patula* x *P. tecunumanii* (high elevation), *P. patula* x *P. oocarpa* and *P. taeda* x *P. caribaea*. Field trials of these hybrids will be planted by members in 2009 and 2010. We again thank the regional coordinators (Rigesa, Bosques del Plata, Komatiland Forests, Smurfit Kappa Cartón de Colombia, and Smurfit Kappa Cartón de Venezuela) for their assistance in producing hedges from the hybrid seedlings.

Members in Argentina, Brazil, Chile, Colombia and South Africa collected seeds of hybrid crosses in 2008. The putative hybrid seeds produced will be sent to Camcore (Raleigh) through early 2009 and hybridity will be verified by molecular markers. A third batch of hybrid seeds should be sent to the regional coordinators for propagation by the end of 2009.

Camcore members in a number of countries will continue to attempt hybrid crosses with new shipments of pollen sent from Camcore (Raleigh). The source of pollen comes from members' trials and orchards and natural stands in Guatemala.



Ivone Fier (Klabin) with a *P. patula* x *P. greggii* hybrid seedling.

Table 6. Pine hybrid trials planted by Camcore members in 2007 and 2008.

Country	Member	Trials planted	
		2007	2008
Argentina	Alto Paraná SA	1	
	Bosques del Plata	1	1
Brazil	Klabin		2
	Masisa		2
	Rigesa	2	
Colombia	Smurfit Cartón de Colombia	3	
South Africa	Hans Merensky		1
	Komatiland - KLF		4
	Mond		1
	Mountain to Ocean – MTO		1
	PG Bison		2
Total		7	14



Christian Pedroso, Mónica Gelid, and Juan Shapovaloff in the Alto Paraná Camcore hybrid test at Iguazu, Misiones, Argentina.



Rute Berger in the Bosques del Plata hybrid trial established in Corrientes, Argentina in 2007. The trees are *P. caribaea* var. *hondurensis* x *P. tecunumanii*.

Research Update: Hybrid Verification with SNPs

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. Drs. Ross Whetten and Gary Hodge are the principal investigators.

In brief, the objective of the project was to identify species-specific molecular markers that would identify with high accuracy whether a putative hybrid of pine species AxB was in fact a true hybrid. Ideally, this would mean that we would have at least one SNP marker (and preferably more) that is present in 100% of the trees of species A and completely absent in species B, and another SNP marker that is present in 100% of the trees of species B and completely absent in species A. In the past few years, Camcore has attempted to identify markers like this using other types of molecular markers, specifically isozymes and RAPDs. Although we have had some success, we hope that the SNP markers will prove more powerful, and that a complete marker library for the whole suite of Camcore species will be possible.

There are a total of 18 species and varieties included in the study. DNA samples were taken from a total of 576 trees, with 20 to 30 individuals representing the native range of each species. Eleven genes were selected for sequencing: four genes related to lignin synthesis, three related to water processing, and four related to

signalling and cellular responses. PCR primers that amplify 400 to 500 base pair fragments for each of the eleven genes have been developed. In addition, a multiplex PCR protocol to amplify all eleven genes simultaneously has been developed. Preliminary data does show a number of candidate SNPs that may be useful to distinguish species. DNA from all 576 trees is now being processed by the Genome Sequencing Laboratory at NC State University. We expect final results of this study to be available by March of 2009.



Hugo España of Smurfit Kappa Cartón de Colombia with a putative natural *P. tecunumanii* x *P. patula* hybrid. A molecular marker system to test hybridity for these kinds of trees would be very useful.

Changes in Camcore

Carlos Gantz, CMPC Forestal Mininco left his position as Pine Tree Breeder to join another company. Carlos was a member of our technical committee for several years and a recipient of the Camcore educational stipend. We wish Carlos much success in his new job; he was a strong supporter of the program. He has been replaced by **Verónica Emhart**.

Mr. David, Vice-President, PT Sumalindo Lestari Jaya, received his Ph. D. in Strategic Planning.

Nhora Isaza successfully completed her MS project with Camcore at NC State and she returned to Smurfit Kappa Cartón de Colombia (SKCC). Nhora continues to be involved with the pine breeding and seed orchard programs at SKCC.

Julián Moreno was hired as the Tree Breeding Manager for PG Bison. Julián is originally from Mexico and received his Ph. D. in New Zealand. He will be a good addition not only to PG Bison but his expertise will also strengthen the Camcore program.

Kitt Payn successfully finished his Ph. D. work at NC State University and the University of Pretoria and is now the Pine Breeder at Mondi. Kitt's office is located at Mountain Home outside of Pietermaritzburg.

Alberto Ramírez was named as the Forestry Director at Smurfit Cartón de Venezuela (SKCV) to replace Alfonso Bello, who has left the company. Alberto has held the position of Forestry Director at SKCV before and has good knowledge of the Camcore program. We look forward to working with him.

Jaime Rodríguez, CMPC Forestal Mininco left the company for a position in forestry operations in Masisa, Chile. We wish Jaime the best of luck in his new position.

José Luis Romero was named Division Director of Forestry at Refocosta (Colombia). José worked for a number of years with Camcore and knows our program well. We look forward to working with him and the research staff at Refocosta.

Eloy Sanchez left Fomex (Mexico) to work with Chikweti Forests in Mozambique. Initially, Eloy's work dealt with the development of teak, but we understand his work activities will expand to include other assignments.

Terry Stanger, Project Leader, Eucalypts at Sappi Research has been named General Manager of Forestry for the company's new Mozambican project. Currently Terry's office is located in Johannesburg. We wish Terry much success in his new position.

Johan Vermaak left Mondi to become the Planning & Research Manager at PG Bison. Therefore, Johan is still in the Camcore family.

Byron Urrego, Director of Research, Smurfit Kappa Cartón de Colombia was also named as Director of Research, Smurfit Kappa Cartón de Venezuela. The dual appointment has given Byron the opportunity to better coordinate research activities between the two sister companies.

Jaime Zapata, Tree Improvement Researcher at Arauco-Bioforest, began his Ph. D. program at NC State University under Drs. Ross Whetten and Steve McKeand.

New Committee Members

The Advisory Board elected **Mr. David** (Sumalindo) and **Jan van der Sijde** to the executive committee beginning in 2009. **Rebeca Sanhueza**, eucalypt tree breeder (CMPC Forestal Mininco) was elected to replace Carlos Gantz on the technical committee; her alternate is **Verónica Emhart**. Also elected to the technical committee was **Mariana Schukovski**, Masisa, Brazil.

Graduate Programs and Training

Nhora Isaza, Smurfit Kappa Cartón de Colombia and **Kitt Payn**, Mondi, successfully completed their graduate research work at Camcore. Both were awarded partial Camcore stipends to fund their tuition and research during their stay at NC State University. Bill Dvorak and Gary Hodge served on Nhora's and Kitt's graduate committees.

Nhora's MS work was titled, "Flower production in *Pinus maximinoi* and *Pinus tecunumanii* in a tropical environment and artificial screening of high elevation *P. tecunumanii* for resistance to *Fusarium circinatum*". The results of her thesis are summarized in the sections "Increasing Flowering in Tropical Pines With GA_{4/7}" and "Pitch Canker Report" in this annual report.

Kitt Payn's Ph. D. work was titled, "Molecular genetic diversity and population genetic structure of the commercially important tropical forest tree species *Eucalyptus urophylla*." He did his course work at North Carolina State University and his lab work under the tutelage of Dr. Zander Myberg, University of Pretoria. Kitt's Ph. D. research examined the historic migration patterns of *E. urophylla* across seven islands in the Indonesia archipelago. A summary of his research results were highlighted in the 2007 Camcore annual report. He has published several papers on his research in the *Australian Journal of Botany* (AJB) and *Tree Genetics and Genomes* and has given a number of presentations at international meetings. He was awarded the AJB student prize for best research in 2007. Kitt gave a summary presentation of his research work to the Advisory Board at the annual meeting in Indonesia in October 2008.

Robert Jetton, leader for the Camcore hemlock project, also finished his Ph. D work entitled, "Biological Control, Host Resistance, and Vegetative Propagation: Strategies and Tools for Management of the Invasive Hemlock Woolly Adelgid, (*Adelges tsugae* Annand)." As mentioned in the last several Camcore reports, the hemlock woolly adelgid is an aphid-like insect that was introduced from Japan decades ago and is now destroying natural populations of both Carolina and Eastern hemlock. Robert's research work has been published in HortScience and two additional papers will soon appear in the *Journal of Entomological Science* and the *Journal of the North Carolina Academy of Science*.

Juan López, Camcore, continues his Ph. D. work on the economic returns of planting pine hybrids. Juan gave a presentation entitled, "Economic value of pine hybrids" at the annual meeting in Indonesia to explain to the Advisory Board members the methodology he plans to use in his Ph. D. research and the data that he needs to complete the research.

Andy Whittier, Camcore, completed a training certificate from the NCSU-ITAP web design program and is using those skills to make improvements and regular updates to the Camcore website.

Publications, Posters and Conference Papers

Publications

- Dvorak, W.S., 2008. Estamos más cerca de entender la ascendencia de las poblaciones de la “variante patula” en la Sierra Madre del sur, México? *Foresta Veracruzana* 10(1):59-66.
- Dvorak, W.S., G.R. Hodge and K.G. Payn, 2008. The conservation and breeding of *Eucalyptus urophylla*: A case study to better protect important populations and improve productivity. *Southern Forests* 70(2):77-85.
- Isaza, N.P., 2008. Flower Promotion in *Pinus maximinoi* and *Pinus tecunumanii* in a Tropical Environment, and Artificial Screening of High-Elevation *P. tecunumanii* for Resistance to *Fusarium circinatum*. Masters. Dissertation, North Carolina State University, 2008.
- Jetton, R.M., 2008. Biological Control, Host Resistance, and Vegetative Propagation: Strategies and Tools for the Invasive Hemlock Woolly Adelgid, *Adelges tsugae* Annand. Ph.D. Dissertation, North Carolina State University, 2008.
- Jetton, R.M., F.L. Hastings, and F.P. Hain, 2009. Arthropod diversity associated with old and secondary growth eastern hemlock (*Tsuga canadensis*) in the Great Smoky Mountains National Park. *J. NC. Acad. Sci.* In Press.
- Jetton, R.M., F.P. Hain, W.S. Dvorak, and J. Frampton, 2008. Infestation Rate of Hemlock Woolly Adelgid (Hemiptera: Adelgidae) Among Three North American Hemlock (*Tsuga*) Species Following Artificial Inoculation. *Journal of Entomological Science*. 43: 438-442.
- Jetton, R.M., W.A. Whittier, W.S. Dvorak, and K.M. Potter. 2008. Status of *Ex situ* Conservation Efforts for Eastern and Carolina Hemlock in the Southeastern United States. In: Proceedings of the Fourth Hemlock Woolly Adelgid Symposium The Eastern United States. February 12-14, 2008, Hartford, Connecticut.
- Jetton, R.M., W.S. Dvorak, and W.A. Whittier. 2008. Ecological and genetic factors that define the natural distribution of Carolina hemlock in the southeastern United States and their role in *ex situ* conservation. *Forest Ecology and Management* 255: 3212-3221.
- Payn, K.G., Molecular Genetic Diversity and Population Genetic Structure of the Commercially Important Tropical Forest Tree Species *Eucalyptus urophylla*. North Carolina State University, 2008.
- Payn K, W.S. Dvorak, B. Janse, and A. Myburg. 2008. Microsatellite diversity and genetic structure of the commercially important tropical tree species *Eucalyptus urophylla*, endemic to seven islands in eastern Indonesia. *Tree Genetics and Genomes* 4(3):519-530.
- Potter, K.M., W.S. Dvorak, B.S. Crane, V.D. Hipkins, R.M. Jetton, W.A. Whittier, and R. Rhea. 2008. Allozyme variation and recent evolutionary history of eastern hemlock (*Tsuga canadensis*) in the southeastern United States. *New Forests* 35: 131-145.
- Van Zonneveld, M.J., A. Jarvis, W.S. Dvorak, G. Lema and C. Leibing. 2009. Climate change impact predictions on *Pinus patula* and *Pinus tecunumanii* populations in Mexico and Central America. *Forest Ecology and Management*. In press.
- Whittier, W.A. and R.M. Jetton. 2008. Conservation of Native Hemlock Ecosystems in the Eastern US. *Forest Landowner Magazine*. November/December 2008: 30-33.

Posters

- Jetton, R.M., W.A. Whittier, W.S. Dvorak, and R. Rhea. 2008. Status of germplasm conservation of Carolina hemlock in the Southern Appalachian Mountains. Poster presented at the 51st Southern Forest Insect Work Conference. Chattanooga, TN.

Publications (cont.)

Josserand, S.A., B.M. Shamblin, K.M. Potter, C.J., Hairn, C.S., Echt, D, Nelson. Genomic Markers Carolina Hemlock, Eastern Hemlock, and Five Other *Tsuga* Species. Presented at the Forth Hemlock Woolly Adelgid Symposium, Hartford, CT, Feb, 2008. Abstract in Proceedings of the Forth Hemlock Woolly Adelgid Symposium, June 2008. Pg. 238.

Kaur, N., R.M. Jetton, J. Strider, A. Cohen, and F. Hain. 2008. Epicuticular Wax and Infestation Success: Possible Cause and Effect for Differential Susceptibility to Hemlock Woolly Adelgid Among Carolina Hemlock Provenances. Presented at the Forth Hemlock Woolly Adelgid Symposium, Hartford, CT, Feb, 2008. Abstract in Proceedings of the Forth Hemlock Woolly Adelgid Symposium, June 2008. Pg. 242-243.

Presentations

Jetton, R.M., A. Cohen, F. Hain, and C. Cheah. 2008. Alternative rearing strategies for predators of the hemlock woolly adelgid. Paper presented at the 51st Southern Forest Insect Work Conference. Chattanooga, TN.

Whittier, W.A., R.M. Jetton, W.S. Dvorak, and K.M. Potter. 2008. Status of *Ex situ* Conservation Efforts for Eastern and Carolina Hemlock in the Southeastern United States.

Shortcourses

Bill Dvorak and Gary Hodge participated in the third International Tree Improvement Shortcourse in Concepcion, Chile. The course was sponsored by the Universidad Austral, the NC State University Department of Forestry and Environmental Resources, and Camcore. There were 42 students in the course, including researchers and managers from forest organizations from throughout Latin America. Bill gave 3 lectures on genetic conservation strategies for forest trees, and overviews of hardwood and pine species suited for plantation forestry in the tropics and sub-

University Committees and Service

Bill Dvorak, continued as Vice-Chairman on the Panel of Experts for Forest Genetic Resources, FAO, Rome. The group met in Rome, December 2008 to discuss the contents of the upcoming work on the State of the World's Forest Genetic Resources. The report will be completed in 2013. Bill also continued his work as Associate Editor for *New Forests* and the *Southern Forests Journal* (formerly the *Southern Hemisphere Forestry Journal*) and as a member of the International Committee in the Department of Forest & Environmental Resources, NC State University. Bill received the College of Natural Resources/College of Agriculture Award for Service to the Environment & Society in a ceremony at NC State University in October.

Gary Hodge continued to serve as Associate Editor for the *Canadian Journal of Forest Research*, and reviewed articles for *Southern Forests, Tree Genomes and Genetics*, and *Annals of Forest Science*. He also served on various committees in the NCSU Department of Forestry and Environmental Resources. Gary was promoted to the rank of Full Professor in 2008.

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

tropics. Gary gave 3 lectures on the Camcore breeding program, selection indices and genotype x environment interaction. Other lecturers from NC State University and Camcore member companies included Department Head Barry Goldfarb, Bob Kellison, J.B. Jett, Bailian Li, Ross Whetten, Steve McKeand, Claudio Balocchi, Carlos Gantz, Rebeca Sanhueza, and Christian DeVeer.

In May, Gary Hodge gave a 1½ day short-course on BLUP to some of the Sappi tree improvement staff in Pietermaritzburg, South Africa.

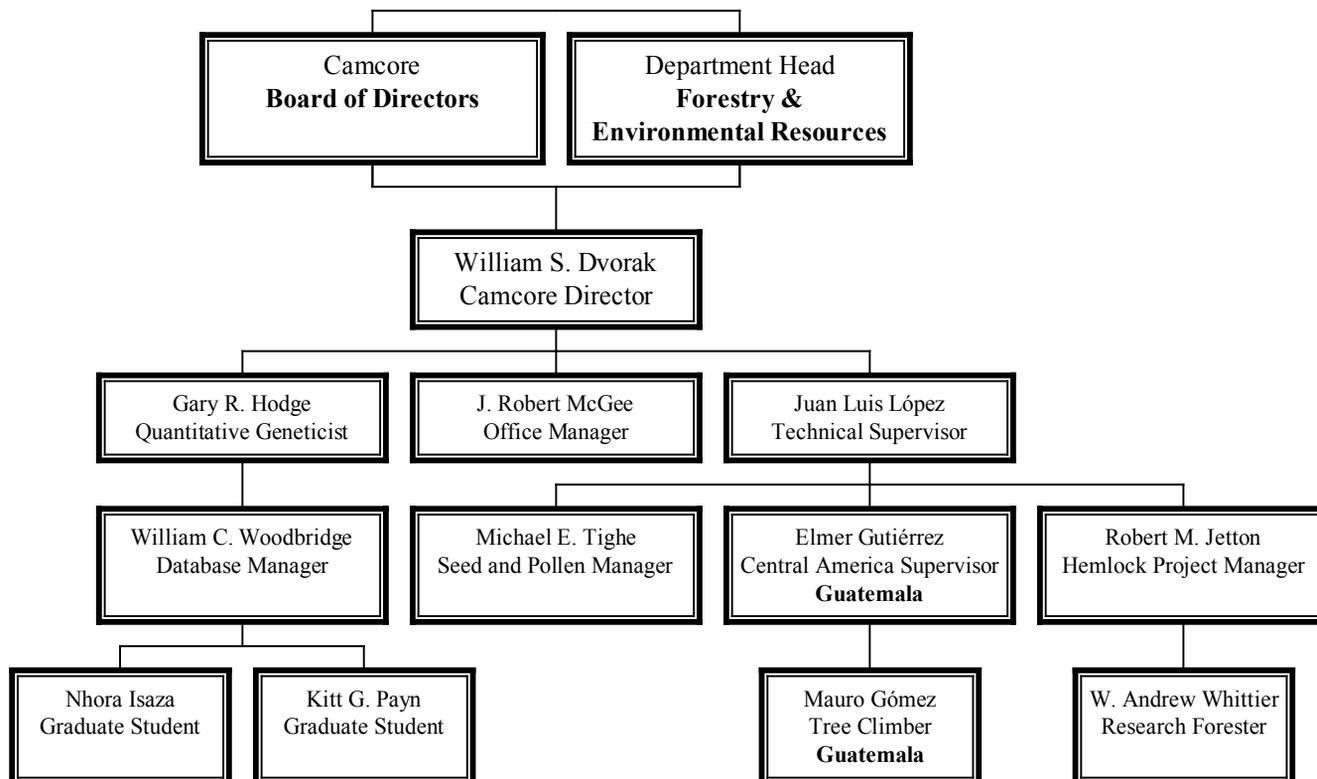
Passing of Friends

Errol Duncan, a Mondi employee for nearly 30 years and strong supporter of Camcore, died suddenly in January 2008. Errol was a key player in the tree breeding research team during the tenure of Neville Denison and was instrumental in assisting the company in the development of its operational eucalyptus clonal program in Zululand. Errol was also an important participant in the collaborative work between Mondi and the government forestry organizations of East Africa. Errol was known as an energetic, reliable, and dedicated employee, and was a good friend to all with whom he had contact. He will be greatly missed.



Marisa Fuentes Mussack, representative of Grupo DeGuate in Guatemala passed away in the month of November. Marisa is survived by her husband Mike and her daughter Mariel. Marisa earned her PhD degree in the Tropical Soils Department with Dr. Pedro Sánchez and Dr. Stan Buol at NCSU. Marisa was actively coordinating the efforts between Grupo DeGuate and Camcore while working as the Director of Corporate Social Responsibility of Camas Olympia, one of the Grupo DeGuate companies. We will miss Marisa's energy and enthusiasm, and her desire to promote forestry in Guatemala

Camcore Personnel



The 2008 Camcore Advisory Board

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Rudolf Rahn, Smurfit Kappa Cartón de Colombia
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Bill Dvorak, Camcore, USA
Gary Hodge, Camcore, USA
Juan Luis López, Camcore, USA
Carlos Gantz, CMPC Forestal Mininco, Chile
Ivone Satsuki Namikawa Fier, Klabin PR, Brazil
Glen Mitchell, Komatiland Forests, South Africa
Laercio Duda, Rigesa-Mead Westvaco, Brazil
Arnulf Kanzler, Sappi Forests, South Africa
Byron Urrego, Smurfit Kappa Cartón de Colombia
Robert Purnell, Weyerhaeuser Company, USA

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Robert Brown, Dean
J.B. Jett, Associate Dean for Research and Extension
Barry Goldfarb, Head, Department of Forestry and Environmental Resources



Young commercial Teak plantation established by Chikweti Forests in northern Mozambique. Camcore will begin working with Teak in 2009

Front Cover: Juan López of Camcore measuring trees of *Eucalyptus urophylla* in the state of Tabasco, Mexico. The measurements were used to assess the growth potential of *E. urophylla* for Camcore member company Forestaciones Operativas de México (Fomex). The plantation is owned by Leticia Manzur.