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2009 Annual Report

Taiwan Forestry Researh Institute

行政院農業委員會林業試驗所

九十八年度年報

行政院農業委員會林業試驗所 發行
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我們身處一個環境風險急遽升高的年代，面對全球暖化、極端氣候頻仍、海平面上升、物種加速滅絕等現象，一再挑戰著森林科學的角色與定位。而環境危機帶給人類的生存威脅，不論是水資源的匱乏，或是土壤沖蝕加劇，莫不讓人聯想到熱帶雨林的過度伐採、林地劣化、棲息地破壞、大量農工建地的競合，亟需回歸到理性、科學及決策的層次，才能降低大自然反撲及人類無知所造成的巨大衝擊。且看2009年所發生的一些自然與人為重要事件，或許能給吾人更多省思：

2009年8月莫拉克颱風3日內累積雨量高達2,965公釐，造成699人死亡及失蹤、4人重傷、房屋毀損不堪居住達1,622戶，重創台灣南部及東部，成為台灣近50年來最嚴重的風災。

2009年12月世界各國領袖齊聚丹麥首府哥本哈根，進行後京都時期的談判。這次會議原係設定全球溫室氣體減排目標與強制履約機制，以接續2012年即將屆滿失效的《京都議定書》，可惜在爭議中落幕，未能達成具有法律約束力的國際協約，只好將議題留待2010年11月在墨西哥市舉行的聯合國氣候變遷會議再行討論。

聯合國將2009年訂為大猩猩年(Year of the Gorilla)，以凸顯棲地破壞、疾病與盜獵對物種生存的威脅。聯合國也宣佈2009年為國際天然纖維年(Year of Natural Fibers)，以提醒世人重視天然纖維的價值，並鼓勵推動永續生產。2009年也是達爾文誕生200週年，以及其曠世巨著「物種起源(On the Origin of Species)」出版150週年。

有鑑於此，本所做為台灣林業試驗研究的專責機構，面對國內日新月異的森林與環境議題，如植物種原保育、生物技術開發、能源植物培育、竹材加工利用、混農林業經營等，業以更積極、迅捷的態度與方法，投注精力、累積成果，以提供決策及實務改進之參考。另一方面，為因應全球化的蛻變與挑戰，許多研究亦跨越了地理疆界，以更大的尺度審時度勢，如長期生態資料庫的建立、碳排放權交易模式設計、林木疫情監測與防治等，亦在本所研究團隊的努力下一步一腳印的建立基礎。

回顧2009年林業試驗所的研究工作，已由全體同仁協力完成81項試驗研究，為求相關成果能放眼國際、立足台灣，特修年報成集，俾供各界先進共同檢視本所過去一年的努力，並祈不吝賜教，冀能鑑往知來、精益求精，齊為台灣林業未來的研究方向提供更多指引。

行政院農業委員會林業試驗所

所長 黃裕星 謹誌

2010年10月1日

Preface

We are living in an age of rapidly escalating environmental risks. Faced with the phenomena of global warming, frequent extreme weather events, rising sea levels, mass extinction of species etc. the scientific capacity and role of our discipline, forestry, are repeatedly challenged. The environmental risks, regardless the scarcity of water resources, or the exacerbating soil erosion, are bringing with them threats to the existence of mankind, and remind us how we have overexploited the tropic rainforests, degraded forestland, destroyed habitats, and the large scale develop of land for agricultural and industrial purposes. Returning to a rational, science-oriented, and policy-directed state of forest management is urgently required so as to abate the revenge of nature and the huge impact wrought by the ignorance of mankind. Perhaps by looking at some important natural and man-made events happened in 2009, we can get a more profound insight and understanding of our actions and nature's reactions.

In August 2009, the typhoon Morakot struck Taiwan and dumped 2,965 mm of rain in 3 days, causing 699 persons to perish or disappear and 4 persons sustained serious injuries. A total of 1,622 units of houses were damaged beyond further residency. The typhoon brought serious harms to the south and east of Taiwan and was recorded as the most devastating typhoon in nearly 50 years.

In December 2009, world leaders gathered at the capital of Denmark, Copenhagen, trying to forge an agreement for the post-Kyoto era. The meeting was originally slated to install a target for the global greenhouse gas emission and an enforcing mechanism for the countries to comply with the target, so as to link up to the Kyoto Protocol which is due to expire in 2012. Unfortunately, the meeting ended in a contentious disarray, and was unable to achieve an international agreement with binding authority. All the issues have to await a meeting of the United Nations Climate Change Conference at Mexico City in November of 2010.

The United Nations has listed the year 2009 as the Year of the Gorilla, to emphasize the threats posed by habitat destruction, diseases, and poaching on the continuous existence of the species. The year 2009 was also slated by the United Nations as the Year of Natural Fibers to remind the world about the values of natural fibers and the importance of encouraging their sustainable production. Furthermore, the year 2009 was also the 200 anniversary of the birth of Charles Darwin, and the 150th anniversary of the publication of his renowned book "On the Origin of Species."

In view of the above, the Taiwan Forestry Research Institute, as the organization solely responsible for the forestry-related research, and facing with ever-changing issues of the forests and environments, such as conservation of plant geneplasm, biotechnological developments, cultivation of energy plants, conversion and utilization of bamboo resources, agroforestry management etc. staff of the institute are well-endeavored to actively engage the problems, using a timely method and manner to focus our capacity and accumulate solid achievements. These in turn provide a solid referential foundation for decision-making and practice-improvement in Taiwan's forest management policies. On the other hand, in order to cope with the transition toward globalization and the challenges it bring, many of our research projects have transcended the geographical boundaries. And we are engaging the issues at grander scales and longer time spans. Measures such as the establishment of databases for long term ecological research, modeling and design of carbon credit trading, monitoring and prevention of plant diseases and insect infestations etc. are also being gradually established through the efforts of our research teamwork.

Reviewing the research works of the Taiwan Forestry Research Institute, a total of 81 projects have been undertaken in 2009. In a bid to showcase our research achievements to a wider audience, and to consolidate our position in Taiwan, we've compiled the results in this annual report. Through the publication of this annual report, we welcome outside scrutiny of our research efforts in the past year and to put forth worthy comments and suggestions. These inputs shall allow us to review the past and set courses for the future in an ever-refining manner that together we can pool our wisdom to provide guidance to the future research directions of Taiwan's forestry.

Director General, Forestry Research Institute, Council of Agriculture, Executive Yuan

2010/10/01

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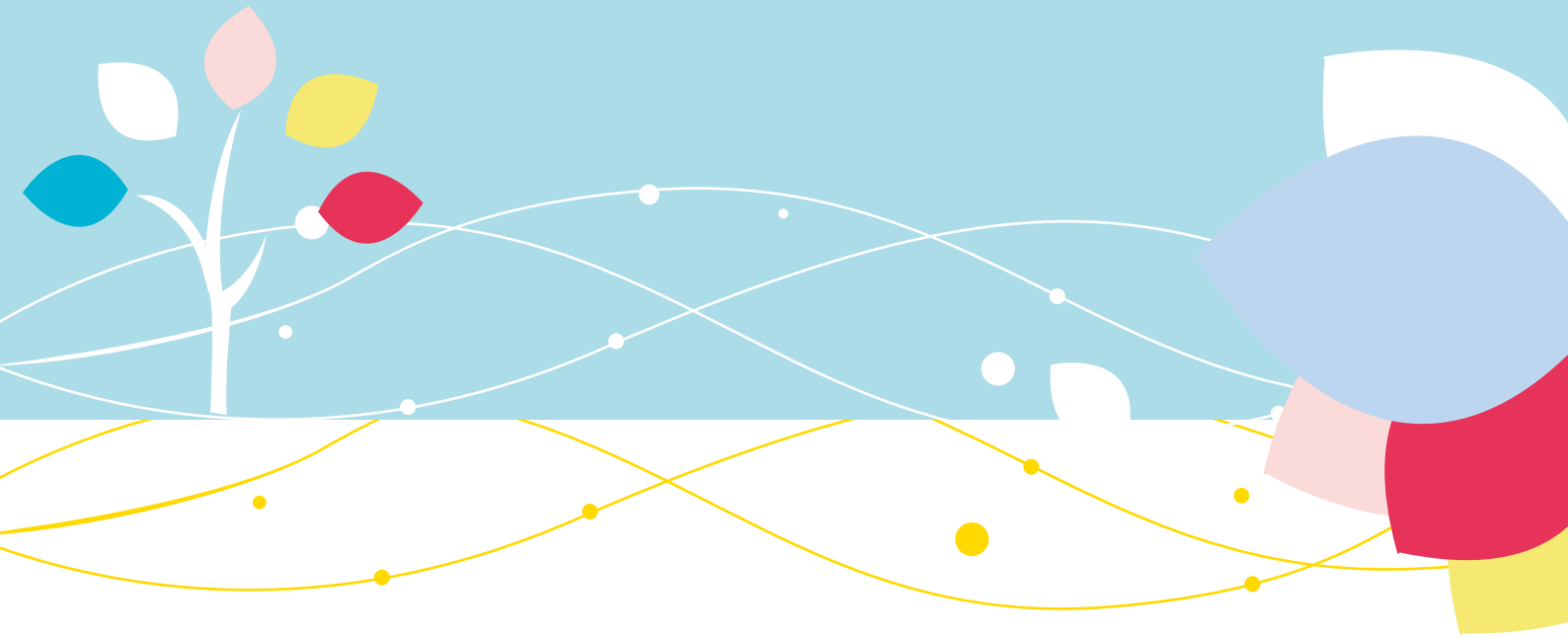
前言



農委會林業試驗所之前身創始於日據時期（西元1896年），迄今已逾一世紀。百年來，隨著時代更迭及社會需求改變，林試所歷經了數次組織架構調整，由最初的「台北苗圃」擴大成目前十個研究組別、四個行政室別及六個研究中心的規模，並不斷提昇相關試驗研究之設備及水準，累積出豐碩且多樣的研究成果。

本所以往年報的編輯，係依據各組室及研究中心之職掌及業務分類，有鑑於近年來跨領域合作及任務編組之計畫愈形重要，98年度年報爰突破以往體例，改以計畫領域為編纂軸心，並將研究成果逐項彙入，期能具體且完整地呈現過去一年的努力。本所98年度執行之試驗計畫共計81項，涵蓋五大領域，亦即農業生物技術研發領域（4項，佔5%）、農業科技研發領域（1項，佔1%）、農業政策研究及科技管理領域（6項，佔7%）、農業電子化領域（7項，佔9%）、森林及自然資源領域（58項，佔72%）；併同執行節能減碳研究團隊計畫（5項，佔6%）。前揭計畫又可細分為：開發生物技術與發展高科技農業3項，農業生技產業化發展推動方案1項，加強科技人才培育及國際合作1項，農業科技管理6項，推動農業電子化加值應用7項，建構國家生物種原庫2項，自然資源之基礎研究19項，生物資源之經營與利用31項，棲地之監測與經營管理2項，外來種生物監測與管理1項，航遙測之技術應用與林業資訊管理系統之建置3項，以及節能減碳研究團隊計畫5項。

除了推動試驗研究外，本所98年度亦先後達成以下施政績效：

一、在發展優質林業，提升國際競爭力方面：（一）推動「開發山胡椒植物活性組成分為機能性化妝品」、「優良與耐寒麻瘋樹品系量產技術之開發」、「牛樟組培苗生產樟芝段木技術之研發」、「市場導向之膠彩畫專用紙之研製」、「延長框組壁式木構造房屋使用耐久性技術之研發」、「台灣原生羅漢松科重要樹種種子保存與發芽技術」等6項產學合作計畫。（二）於福山研究中心設置試區，並完成25公頃樣區第二次樹木普查；於蓮華池研究中心設置試區，並完成25公頃樣區第一次木本植物普查；於恆春研究中心設置試區，並完成墾丁10公頃樣區第一次複查作業。（三）國際種子交換達到100國、600個單位。（四）發表論文832篇，其中研究期刊論文108篇（包括SCI有41篇，EI有13篇）、研討會論文161篇、專訊論文113篇。（五）完成植物園及標本館資料庫網頁國際化，並吸引146,600人次上網瀏覽。

二、在發展安全林業，保障消費者權益方面：（一）建立紅豆杉枝葉產品生產履歷1件。（二）完成林木病蟲害診斷和健康諮詢服務450件。（三）辦理木質材料檢驗與加工諮詢服務10,035件。

三、在發展休閒林業，提高鄉村生活品質方面：（一）辦理導覽解說及服務528,524人次。（二）辦理林業教育訓練4,702人次。

四、在發展生態林業，促進資源永續利用方面：（一）復育台東蘇鐵、台灣油杉苗木各419株、2,000株。（二）研究碳吸存樹種之吸碳能力2種。（三）培育及管理造林及綠美化苗木20,000餘株。（四）完成研究中心間植及複層林造林98.07公頃。（五）建立植物標本數位影像資料15,000筆。（六）建立昆蟲標本數位影像資料10,000筆。

五、在加強林業綜合發展，增進農漁民福祉方面：（一）辦理林道維護27公里。（二）辦理與綠色造林計畫相關之試驗研究及監測3案。

做為台灣官方林學研究機關的年度報告，本年報除了列舉98年度科技計畫、產學合作計畫之推動及成果外，也將當年之重要紀事、專題演講、出版品項、會計預算等資料附輯於後，以期彌補試驗計畫無法關照到的面向，提供本所過去一年整體工作之回顧與總評。

Introduction

The Taiwan Forestry Research Institute, Council of Agriculture, was founded during the Japanese occupation period (AD 1896), and more than a century has passed since then. With the changing time and different social demands, the TFRI has undergone several reorganizations and framework modifications in the interim. It morphed from the original "Taipei Nursery" into a full-fledged research outfit with 10 research divisions, 4 administrative units and 6 research centers. In the meantime, research facilities and capacity levels have been elevated constantly. As a consequence, the TFRI has accrued numerous and diverse research achievements.

In the past, annual report of the TFRI was organized according to the specialties and undertakings of individual divisions. However, in view of the increasing importance of interdisciplinary cooperative researches and mission-oriented study grouping, the 2009 annual report was thus endeavored to break the mold and using the project domains as the organizational axis of the report. Individual research results are then infused into the framework so as to present our research efforts in the past year in a comprehensive manner. There were a total of 81 projects carried out in the 2009 by the TFRI researchers, and 5 major domains were covered, these were agricultural biotechnologies domain (4 items and accounted for 5% of the total); agricultural technologies domain (1 item, or 1% of the total); agricultural policy research and science and technology management domain (6 items, or 7% of the total); agricultural electronics domain (7 items, or 9% of the total); forest and natural resources domain (58 items, or 72% of the total); and a special carbon conservation and energy saving task group (5 items, or 6% of the total). The above projects could be further grouped as: 3 items on developing biotechnology and high tech agriculture; 1 item on the promotion of agricultural technology industry; 1 item on strengthening talent training and international cooperation; 6 items on agricultural science and technology management; 7 items on the promotion of agricultural e-valued added applications; 2 items of establishing the national geneplasm depositories; 19 items on basic researches of natural resources; 31 items on management and utilization of bioresources; 2 items on monitoring and management of habitats; 1 item on monitoring and management of invasive alien species; 3 items on remote sensing technologies applied to the establishment of forest information management; and 5 items on energy saving and carbon mitigation research team.

In addition to promote researches, the TFRI has also achieved the following administrative achievements in 2009:

I. On the development of superior forestry and enhancing international competitiveness: (1) six items of academic-industrial cooperative research projects including: "Developing the active ingredients in *Litsea cubeba* into functional cosmetic products;" "Mass propagation of superior and cold resistant clones of *Jatropha curcas*;" "Cultivation of tissue culture derived *Cinnamomum kanehirae* plants to supply wood for the production of *Antrodia cinnamomea* fruiting bodies;" "Preparation of a glue-infused handmade papers;" "Development of technology in extending the service life of wood frame buildings;" and "Seed storage and germination technology of the important native Podocarpaceae species in Taiwan;" (2) A research plot was established at the Fushan Research Center and the 2nd all-tree survey of the 25 ha plot was completed. Another research plot was established at the Lienhuachih Research Center and the 1st all-tree survey was completed. Finally a 10 ha research plot was set up at the Hengchun Research Center and the 1st double check of the flora there was completed; (3) International seed exchanges were carried out with 100 nations and 600 organizations; (4) A total of 832 papers were published, of these, 108 were papers in research journals (including 41 SCI papers and 13 EI papers), 161 were symposium papers; 113 were bulletin reports; (5) Completed the internationalization of websites for the databases of botanical gardens and herbarium, and 146,600 hits were recorded for these sites.

Ⅱ. On the development of safe forestry and protection of consumer rights: (1) Established 1 case of a Taxus marei farm with comprehensive production records; (2) Completed 450 cases of forest tree insect and disease diagnostic and health inquiry services; (3) Provided 10,035 cases of woody material identification and processing inquiry services.

Ⅲ. On the development of leisure forestry and enhancing rural life quality: (1) Conducted 528,524 person-cases of guided eco-tours and services to the public; (2) Conducted 4,702 person-cases of forestry educational training.

Ⅳ. On the development of eco-forestry and promotion of sustainable utilization of natural resources: (1) Restored the endangered endemic populations of Cycas taitungensis and Keteleeria davidiana through cultivating their seedlings for 419 and 2,000 plants, respectively; (2) Studied carbon sequestration capacities of 2 species of trees; (3) Cultivated and managed 20,000 saplings for reforestation and greening of the environments; (4) Completed 98.07 ha of inter-planting and construction of dual-layered forests at the research centers; (5) Established 15,000 units of digital plant specimen images; and (6) Established 10,000 units of digital insect specimen images.

Ⅴ. On the enhancement of overall forestry development and promoting welfare to the farmers: (1) Conducted 27 km of forest road maintenance and rebuilding; (2) Conducted 3 cases of research and survey related to the "Green Reforestation" project.

As the official forestry research organization of Taiwan, this annual report lists the researches, the academic-industrial cooperative projects, and their achievements in 2009. In addition, the important events transpired, special lectures by the visiting scientists, published items, and accounting and budgets are also included at the end to cover the aspects not encompassed by the research projects, and to provide a comprehensive review and evaluation of the past year for our readers.

2009 Annual Report

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科技計畫推動及成果

木質素與纖維素專屬轉殖基因在桉樹的堆積

Gene stacking of *lignin*- and *cellulose* specific transgenes in *Eucalyptus*

鍾振德

本四年期之計畫擬定發展桉樹之基因堆積技術，期能培育出吻合產業需求，具有多重遺傳性狀改良之桉樹新品種，同時也將建立桉樹轉殖系之變種庫，將桉樹之分子育種研究工作帶入功能性基因體之新研究領域。於此第二年計畫，已經發展連續性基因轉殖，培育出帶有反義式Pt4CL1與順義式CAld5H轉殖基因之赤桉瓶苗，並將選用已轉殖順義式CAld5H基因之赤桉轉殖系，再轉殖SiRNA之CAD重組基因，已培養出帶有雙重轉殖基因之癒合組織。在共同轉殖方面，已培育帶有反義式Euc4CL1與順義式CAld5H雙重轉殖基因之赤桉瓶苗，並選用已轉殖順義式CAld5H基因，具有高S/G比之赤桉轉殖系，再同時轉殖2或3個SiRNA之CAD重組基因，已經培養出15個擬轉殖多重基因之癒合組織，其數量仍持續增加中。此外，已提早完成3個赤桉纖維素生合成系列基因之選殖，使本計畫之基因選殖數量提高成為5個不同的基因。在控制授粉之基因堆積技術發展方面，已經培育出帶有C4H與GUS雙重轉殖基因之赤桉×玫瑰桉×尾葉桉苗木，並針對已分別帶有Euc4CL1或CAld5H轉殖基因之赤桉與雜交桉，進行催花，已見其花芽之分化。至於木質素單體檢測技術之建立，則已建立熱裂解(pyrolysis)銜接GC-MS之木質素單體檢測技術，並應用於轉殖sense CAld5H基因不同轉殖系桉樹造林木之測定，結果證實轉殖sense CAld5H基因後，可以選擇到S/G比提高，而木質素與全纖維素總量沒大改變之轉殖系。

This 4-year research project was proposed to develop gene-stacking technology for the breeding of new *Eucalyptus* varieties in which multiple genetic characteristics are improved to meet the demand in industry. Preservation technology was also proposed to establish a mutant bank containing varied transgenic lines of *Eucalyptus* that will bring the molecular breeding into the new research area of functional genomics. In this year's project, gene stacking by sequential transformation was developed to raise transgenic *E. camaldulensis* plants with antisense Pt4CL1 and sense CAld5H transgenes. Transgenic *E. camaldulensis* plants previously transformed with a sense CAld5H transgene were sequentially transferred with a recombinant SiRNA of the CAD gene to produce transgenic callus or shoots with double transgenes. In addition to this, 5 cellulose synthase (CesA) genes will be cloned from *E. camaldulensis* for further co-transformation work in the following year. In a controlled pollination for gene stacking, transgenic seedlings with C4H and GUS transgenes derived from pollination between transgenic *E. grandis* x *E. urophylla* and *E. camaldulensis* were raised. Transgenic *Eucalyptus* previously transformed with either an antisense Euc4CL1 or a sense CAld5H transgene was induced to flower and to allow for more controlled pollinations. For rapid measurements of monomeric lignol of the transgenic wood, an analytical technique using pyrolyzer coupled with GC-MS was developed. We already confirmed that the sense CAld5H transgene could increase the S/G ratio and that the total amount of cellulose was not affected.

牛樟芝與喜樹鹼生產線之建立

Establishment production plateform of *Antrodia cinnamomea* fruiting bodies and camptothecin

張淑華

許多台灣的生技公司已成功的利用天然牛樟木頭的培養生產牛樟芝，但因天然母樹的保護，培養牛樟芝段木來源必須來自人工林。試驗顯示牛樟組培苗生長與存活率都高於扦插苗造林木，因此本計畫將發展牛樟組培苗的組培增殖體系，希望提高增殖率降低培養成本。同時也朝建立牛樟芝的試管培養、人工林牛樟枝葉與段木接種生產牛樟芝的生產平台進行研發。青脆枝是生產喜樹鹼以合成抗癌藥物的主要來源，曾經為生技公司創造出極高的產值。不過傳統經營過程是栽培5年後取其樹幹來萃取喜樹鹼，枝葉是被丟棄不用。我們已經選育出枝葉含喜樹鹼及其他高價值的衍生物含量的化學品系，利用組織培養量產這些品系的營養系苗，建立採穗園，建造組培苗與扦插苗的農場經營生產枝葉。本計畫將比較二種栽培法的成本與效率，同時發展利用枝葉採收的農場經營平台，分析採收新鮮枝葉與不同乾燥/粉碎處理產品之喜樹鹼與其衍生物成分的變異與產量，建立最佳生產枝葉產量與CPT類產品之經營模式。本年度，完成牛樟試管增殖數與組培苗出栽數的最佳組合，可每1.5月出栽1,500株，或配合栽植季節，4.5月出栽4,500株組培苗。利用UPLC-TOF鑑定出青脆枝葉片之9MCPT成分，分析來自5種源27家系新鮮葉片CPT與9MCPT濃度，CPT濃度為2,000至4,000 ppm，而9MCPT為900至2,000 ppm。

Production of *Antrodia* fruiting bodies in natural wood of *Cinnamomum kanehirae* has been developed by some biotech companies in Taiwan. Since natural trees of *C. kanehirae* are protected, wood from man-made plantation become the only source. We found that *C. kanehirae* plants derived from tissue cultures grew rapidly with a greater survival rate than those derived from cuttings.. Therefore, we tried to develop a mass production system for tissue culturing of *C. kanehirae* to increase its multiplication rate and reduce the production cost. We also tried to build a platform of *in vitro* culturing of *A. camphorate*; inoculation and fruiting bodies production on the harvested branches and logs of *C. kanehirae* from different ages of man-made plantations. In another study, *Nothapodytes nimmoniana* trees, a major source of camptotheicn (CPT), a precursor to synthesized anticancer drugs, have created substantial profits for some biotech companies in Taiwan. Process of the traditional management was to plant the trees for 5 years, and then harvested the trunks to obtain CPT, while branches including leaves were discarded. We selected several chemical races of the *N. nimmoniana* that contain high concentrations of CPT and its analogues, and develop a sustainable management system by harvesting the branches annually. In order to mass producing these superior clones, tissue culture is the best step. Once more clones are propagated *in vitro*; we established a scion garden to produce plants from cuttings. Plantations established using these 2 sources will be compared for their costs and efficiencies. In farm management, we will analyze variations and concentrations of CPT analogues in the fresh and differently dried/powdered branches to find the best yield of both biomass and CPT analogues. This year, we have established a suitable combination between the numbers of *in vitro* cultures and transplanted plantlets of *C. kanehirae*. We can transplant plantlets at a rate of 1,500 per 1.5 months, or 4,500 per 4.5 months, as the suitable planting season dictates. We have also identified the components of 9MCPT in *N. nimmoniana* leaves using a UPLC-TOF. CPT and 9MCPT in fresh leaves of 27 clones from 5 provenances were analyzed. The CPT concentrations ranged from 2,000 to 4,000 ppm, while the 9MCPT from 900 to 2,000 ppm.

高經濟林產物枝葉採收與後處理產業化平台之建構

Establishment of industrialized plantform for harvesting process of forest products with great value

何政坤

在產業化平台中，生產高品質的產品是一相當關鍵的技術。在台灣有許多具有經濟價值的林產品如生產紫杉醇的紅豆杉，生產喜樹鹼的青脆枝與喜樹，生產肉桂粉的土肉桂等。這些產品係將採收的枝葉經過乾燥粉碎成含水量低於10%的均勻小顆粒過程，然後再經萃取為目標成分。生產這些顆粒產品的過程為製造成本與品質的關鍵。本計畫利用太陽能轉化成熱能與電能來進行此一製程，以大幅降低成本及生產具有全球市場競爭力的產品。本年度完成建造一間由太陽能與電力供應的乾燥室，及每小時可粉碎1,250 kg枝葉的粉碎機。估計太陽能乾燥系統能減少電費約每處理1kg鮮枝葉11.2元台幣的費用。

Producing a good quality product is often the critical techniques in the establishment of its industrialization platform. There are many valuable forestry products in Taiwan, such as the taxol from *Taxus* plants, camptothecin from *Nothapodytes nimmoniana* and *Camptotheca acuminata*, cinnamon from *Cinanmoum osmphloeum*, etc. These products are made from harvested branches, dried and ground into small and even particle sizes with a low moisture content of < 10%, before being extracted to obtain the target components. Costs and quality of the particle products are very important in the process. In this project we used solar energy to convert heat and electricity to dry and grind the branches. This system will reduce costs and produce competitive products in the world market. This year, we have established an oasthouse heated by solar and electricity energy; and a powdering machine that can powder branches at 1,250 kg h^{-1}. We estimated that solar energy can reduce the electricity fee by about NT$11.2 kg^{-1} of the fresh branches.

台灣紅豆杉生產紫杉醇類商品化平台

Establishing production platforms of Antrodia camphorata fruiting bodies and camptothecin

何政坤

本計畫執行利用台灣紅豆杉以農場方式或以生物反應器方式生產紫杉醇類的產業化過程，提出促進商品化的方案。以化學品系生產紫杉醇的產業化平台-經由林試所與廠商的產學合作計畫的試量產試驗到廠商決定量產栽培過程-大致架構完成。為使產商更具有全球競爭力，持續開發含有高含量10-DAB的新化學品系相當重要，本計畫將集中在這些品系的農場經營及評估其經濟潛力。利用生物反應器生產紫杉醇的產業化平台，我們已發展出利用轉基因細胞在2-L生物反應器表現優異，並與廠商合作開發生物反應器量產評估，但因合作廠商投資大型生物反應器而失敗。由於丟棄式反應器已證明具有快速建造、節省時間、確效簡單等優點，細胞培養於此系統可能變成頗創新的紫杉醇生產方法。本年度經由每月取樣調查，選育出3個10-DAB含量高且穩定的品系。優良品系的扦插育苗體系，依據易獲得且便宜的人工介質盆栽試驗與健康品質的指標下建構完成，並完成1公頃栽培區的建立。收穫枝葉的處理根據目標成分的穩定度以試驗出最佳的作業方式。完成3細胞株5批次培養在攪拌式與波浪式反應器的試驗，仍需要更多試驗以試驗較佳的培養參數。

Iin this project, industrialization of the *Taxus sumatrana* production technologies either for farms or bioreactors to produce the anticancer taxoid drugs was carried out and a better protocol established. The industrialization platform of farming superior chemical races to produce taxol was near completion from a pilot test based on the cooperative plan between the Taiwan Forestry Research Institute (TFRI) and an industrial partner. In order to increase the competitiveness in the global marketplace, new chemical races with high 10-deacetyl baccatin III (10-DAB) contents should be selected and bred. This project focuses on farming these races and evaluating their economical potential. An earlier industrialization platform of producing the taxol via bioreactor failed as scale-up of our laboratory bioreactor by an industrial partner was not performing as expected, despite of the fact that transgenic cell lines were proven to perform well in our 2-L bioreactor. Since the disposable bioreactor has been proven to set up faster, reduce down time, and simplify validation; cell cultures in this system will become an innovative way to produce taxol effectively. This year, we have selected 3 chemical races with branches containing stable and high concentrations of 10-DAB after monthly analysis of the samples. The nursing system included rooting cuttings and pot test was established using reliable and cheap artificial medium and healthy plant quality. One ha of the trial plantation was established as well. Treatments for the harvested branches were tested to determine the best practices to preserve the desired chemicals. Five batches of 3 cell lines in both stirred and wave bioreactors were tried. The optimal conditions for both reactors still need more trials.

生態資訊服務系統建構與研究(96-98年)

Long-term ecological research on agricultural ecosystem and building the ecological information management system

林朝欽

台灣長期生態研究網自2004年與美國長期生態研究網、加州大學聖地牙哥高速電腦中心、聖塔巴巴拉分校的國家生態資訊分析與整合中心分別建立了合作管道，並且也由美國國家科學基金會（NSF）國際科技處得到部分經費補助，大幅提升台灣在建置生態資訊管理系統的能力。

本計畫持續進行新的生態資訊管理觀念與技術研究及國際合作，以改善目前生態資訊管理的瓶頸，並藉與美國及其他亞太地區之國家進行經驗交流之機會，發展生態資料交換之平台架構，建構以台灣為技術中心之亞太地區生態資訊整合與分享之機制與基礎。

過去三年分別在台舉辦生態資訊系統建構(96年)、及此系統應用在動態樣區資料(98年)國際研習會；並參與在美國舉行之生態資訊年會（96年）、前往澳洲及邀請澳洲專家來台(96年、97年)、在中國舉辦之國際長期生態整合系統論壇(97年)、美國長期生態科學家會議(98年)等活動達成國際合作之目標。透過上述活動，本計畫共撰寫7篇英文期刊報告(3篇EI、3篇SCI、1篇其他)、3篇中文期刊報告；國際研討會口頭報告12篇、國內研討會會口頭報告7篇；本計畫所提出之生態資訊系統架構已由農試所、國家公園、城鄉計畫之濕地研究、國科會生態分布領域採用。除在國內推展生態資訊研究與技術提供外，並保持與世界生態資訊研究接軌，除已獲參與國際正啟動的DataOne計畫外，並將成為國際生物多樣性與生態資訊整合GEOSS下之GEOBON示範案例。

Establishment of an ecological information management system (EIMS) is a highest priority issue, especially in the new era of information technology. Cooperation with US-LTER and learning experiences from their site management will help us saving time to set up similar information management system. Metadata is the ideal way in which these archived data can be rapidly accessed and discovered. In order to ensure the long-term availability and enhance the usability of ecological data, several partner groups from the ecological communities in the United States have collaborated with us since 1990 to define a standard format for documenting ecological data. This standard is called the Ecological Metadata Language (EML). EML, developed by the ecological communities and established as a standard for documentation, is a significant step forward in ecological research. It provides the means of editing and cataloging in the process of data archiving and retrieving. It is obvious that EML can fulfill the requirement of data legacy by providing sufficient documentation of necessary data for tomorrow's scientific use. We also planned and established the EIMS to support new research and application. Finally, we strive to promote our IM experience to other Asian countries, and play a leading role in Ecoinformatics.

圖一 2009年6月15－19於本所蓮華池研究中心舉行研習營。
An international information workshop of database management for dynamic plot.

數位化資訊在自然資源保育之應用

Application of digital information to natural resource conservation

林壯沛

本計畫目的在發展無線遠距資訊傳輸與GIS模擬技術，應用於水里溪上游集水區水文監測與沖蝕控制。並針對目前台灣之森林集水區經營與自然資源保育問題，辦理「森林集水區經營」研討會，奠立林業永續經營與自然資源保育工作的基礎。

2009年受颱風影響，6月到10月台灣本島降下豪雨，山區落石崩塌嚴重，影響蓮華池三號集水區之水文觀測。於大水過後，即刻清理量水堰淤砂409m^3，維護本所蓮華池試驗三號集水區氣象水文站儀器設施，持續長期氣象水文觀測與資料收集。

完成研判蓮華池地區之地形起伏變化，規劃設置傳輸中繼站AP與佈線，利用數位撥接、GSM、無線橋接技術，建立無線遠距之水資源監測系統，成功完成收集三號集水區遠端觀測資料傳輸。

針對臺灣自然資源保育問題，分別於6月與11月，舉辦「2009森林集水區經營」研討會與「2009年林道災害調查及復建工程」研習會，邀請大學教授與林試所專家講授森林生態與林道維護相關理念與技術，參加研討會與研習會分別為95人與63人。

Purpose of the project was to develop a wireless data transmission and a GIS simulation technology, and apply them to the hydrologic monitoring and sediment controlling of Suilichi upstream watershed. Also, in order to solve Taiwan's problems in natural resource conservation, a forest watershed management seminar was held. The results will be useful references for sustainable forest management and natural resource conservation.

From the passing typhoons, heavy rain will fall from June to October in Taiwan. These events cause falling stones and serious mudslides in the mountainous areas, which have already influenced current hydrologic observations at the No. 3 watershde at Lienhuachi. After the brook flood crested, namely carry on clearing up 409 m^3 amount of silt and sand in weirs and maintain instruments and facilities of Lianhuachi Watershed No. 3. Keep up long-term meteorological and hydrologic observation and data collecting.

After studying and judging topography of Lianhuachu, the AP points and cable of transmission had been planned and set up. Improvement hydrology instruments, using digital diary module, GSM data logger and wireless bridge/EAP technique to transport the data, it succeeded to collect the data from watershed No. 3.

To solve the Taiwan's problem of natural resources conservation, the 2009 forest watershed management seminar and the 2009 forest road disaster investigation recovery workshop had held in June and December. Invite the professors of universities and scholars of TFRI, teach forest ecology and forest road maintaince can correlated with knowing and technology. They are counted for 95 and 63 participants take part these workshops respectively. The result will be as the references of sustainable forest management and natural resources conservation.

圖一 黃所長主持「2009森林集水區經營」研討會開幕式。

Photo 1. Dirocter-General Huang presided opening ceremony of "2009 Forest Watershed Management Seminar".

珍稀蘭科植物分布模式之預測與分析

Modeling the species distribution of rare orchids in Taiwan

徐嘉君

本研究根據世界自然保育聯盟(International Union for Conservation of Nature, IUCN)所公布的稀有及瀕危植物等級分類標準，遴選32種台灣原生的珍稀蘭科植物，並收集各大標本館、文獻紀錄和植物學家的採集位點，建立物種分布資料庫433筆。此外以GIS軟體分析建置52個一公里解析度的台灣環境圖層，內容包含生態氣候、數值地形以及土壤分類。於32種原生珍稀蘭科植物中，選擇24種分布次數大於5點的物種用於建立物種分布模式。此外，為了減低相關性高的環境因子在建模過程中所發生的共線性的干擾，本研究先以相關性分析遴選Pearson's r < 0.75的環境因子作為建模使用。最後使用26個環境因子配合棲位模式軟體MaXent來建立物種分佈模式，並產生24幅台灣原生蘭分布地圖。再以GIS軟體疊合24種蘭花的可能分布範圍，產生台灣珍稀蘭科植物分布熱點地圖。本研究結果顯示，雖然現有保護區及國家公園範圍已涵蓋部分分布熱點，仍有許多熱點區域座落於保護區範圍之外，期能藉由本研究之結果提供相關管理單位作為未來制訂保育政策時的參考。

Base on the IUCN's criteria on rare and endanger species, we selected 32 orchid species for this study. Database including 433 collections of 32 species were established, and a map of Taiwan with 52 environmental factors of 1-km grid resolution were constructed. Only species with more than 5 occurrence records were modeled. Furthermore, to minimize the collinearity effects from correlated factors during the model building, we applied a correlation test to select the independent environmental factors. Finally, 26 factors were used for building the species distribution models (SDMs) of 24 species by a niche modeling tool MaXent. The 24 SDMs were then overlaid to obtain a hot spot map of the rare orchids. The resulting map was then compared with the present conservation areas in Taiwan. Eventually, we made conservation suggestions on rare orchid species in Taiwan based on results of this research.

先進生態資訊管理整合平台之研究與建置

Research and building an integrated platform of advanced ecological information management

陸聲山

本計畫之核心目標，主要為林業試驗所與研究中心間提供一種新的研究環境，透過網際網路提供了進階資料的取得、儲存、管理、整合、挖掘與其他有關計算與資訊處理程序的服務。研究人員可以藉由最大的資料流通、整合相關的生態學知識，在複雜的時間與空間尺度上，促進與提升進一步的合作。藉尖端科技基礎設施建置完備與共享，將可促進新世代生態學的發展，使科學應用得以整合跨國界、跨領域、共享長期生態研究的專業知識，確保珍貴資料的長久安全保存與唾手可得。預期效益能提供我國長期生態研究網先進的資訊平台，持續獲得穩定可靠的研究資料，迅速累積可觀的研究能量。利用生態巨量資料儲存系統以擴展林試所研究成果，使得資料之再利用及創造更珍貴的價值得以實現。透過專業講習會提昇專業技能，使台灣之生態研究居亞洲領導地位，與世界接軌達資訊即時共享。

The goal of this project was mainly to provide a new kind of platform to researchers in the Taiwan Forestry Research Institute (TFRI) and its research centers. The researchers will have easy access to the database and can obtain all the cumulative relevant information through the internet. The main works of this project include the following: First, to plan and establish a cyberinfrastructure (CI) as an integrated platform to support new applications and research. Second, to offer a stable and advanced platform for ecological networking. Third, to promote the experience from establishing the CI to other Asian countries and play a leading role in the regional Ecoinformatics. The anticipated benefits can provide advanced information platform for long-term ecology research network in our country. We can continue to access the stable, reliable research original data, and rapidly accumulating considerable research resources for tomorrow's scientific use.

數位化森林景觀美學評估之研究

Digital Appraisal of the Forest Landscape Aesthetics

汪大雄

本計畫整合地形、植物、建築物之空間與時間之數位資料，建立森林景觀美學之評估與設計準則模式，以六龜試驗林為對象，進行針、闊葉林林相景觀美學之分析、評估和比較，以期了解針、闊葉林相所呈現之森林景觀美感。設計並建置森林景觀美學之模擬系統與網站，以整合性之森林景觀數位化處理技術，支援森林景觀之規劃、設計、預測、模擬與解析。結果顯示受測者對台灣杉人工林景觀美質之偏好高於闊葉林景觀；層次性、顏色偏好對兩種森林類別之景觀美質均有顯著影響。不同的是，自然性對人工林景觀美質有影響；而統一和諧性對闊葉林景觀美質有正向顯著影響。利用Google SketchUp建立3D地形、樹種及建物模擬物件資料庫，並進行扇平森林生態科學園區3D模擬，並以Google Earth呈現模擬結果。

This study collected the digital data of space and time by integrating topography, plants and buildings of the Liukuei Experimental Forest to establish an evaluation and design model of forest landscape esthetics. Based on analyzing, evaluating, and comparing the forest landscape aesthetics between coniferous and hardwood forests there, it is expected to lend understanding to variables of forest scenic beauty displayed by various forest types. Furthermore, with the digital techniques of generating forest landscapes, a design and simulation system could be setup. Through the internet communication, forest landscape aesthetics studies of the planning, design, prediction, simulation and analysis of forest landscapes can then be supported. Results showed that the respondents preferred the scenery of coniferous *Taiwania* plantation to that of broadleaf forest in the ranks of SBE (Scenic Beauty Estimation), both "gradualism" and "preference of light intensity" of formal aesthetics had positive effects on the scenic beauty and provided valid prediction in both investigated forest types. "Naturalness" did show positive effect on the scenic beauty of the *Taiwania* plantation, but, on the other hand, "harmony" had positive effect on the scenic beauty of the broadleaf forest. Finally, a 3D simulation model was created via Google SketchUp to visualize the forest landscape at the Shanping Ecological Garden.

扇平生態科學園經Sketchup模擬套入Google Earth 後之3D景觀。

3D simulated landscape of Shanping Ecological Garden by Google SketchUp and displayed via Google Earth.

推廣二維條碼在休閒農業之服務應用示範計畫

Application of 2-D barcode to serve recreational agriculture

許原瑞

創新農業數位內容的價值，並結合生態農業及休閒農業之加值應用，藉由設備傳輸二維條碼技術，整合農業生態園區與現有的農業數位內容，創造活潑、便利的園區數位生態導覽模式，促使農業數位內容得以發揮多樣化的價值與功能，將農業帶入民眾生活化的應用層次，發揮農業兼具生產、生活及生態的現代化價值。

本計畫完成嘉義植物園(http://cytfri.tfri.gov.tw/index.php)於農業數位生態館網站，將嘉義植物園之數位內容資料與功能合併於農業數位生態館網站，提供豐富、快速更新的導覽內容，增進園區生態旅遊的導覽品質與深度。可提供加入會員、登入會員、取得導覽行程建議、線上即時查詢動植物資料、印製二維條碼紀念標章貼紙、導覽行程規劃及會員管理功能等。

參訪民眾可透過具有二維條碼功能之個人行動電話或植物園區內建置無線導覽系統，由本園區提供之手持PDA讀取植物名牌上之條碼，認識植物。另外參訪民眾可利用建置之導覽機認識嘉義植物園，並可自行建立導覽紀錄，作為個人資料及知識之累積。

本系統之利用可整合農業眾多的生態數位資料庫，創新農業數位內容的加值應用，使農業數位內容成為最佳的生態、休閒與教育的參考資料來源之一。國內的教育單位可由本計畫所衍生的參訪行程紀錄及資料下載，得以追溯校外教學成果。並透過所發行之生態終生學習護照，促使學校機關更樂於將農業生態園區納入校外教學的行程之一，達到結合農業生態資源與教育的效益。

In order to create innovative digital content values for the agriculture sector, value-added services from organic and recreational agriculture were combined. The subordinate institutions of Council of Agriculture: the Forestry Research Institute, Agriculture Research Institute, and Fishery Research Institute, all have digitized their core contents respectively to ivcrease the usage. However, currently, the digitized contents are dispersed at different locations, and their usage value is limited. Therefore, we proposed to apply a mobile computation technology to transmit 2-D barcode messages that integrated information on organic agriculture parks and current digitized agricultural contents. A brisker and more convenient digital ecological introduction of the parks could thus be accessed. It will provide various digitalized agriculture contents in terms of value and function, lending to a more relevant connection between the people and the agriculture sector, and redefine the modern meaning of agriculture not only per crop cultivation but also lifestyle and ecology.

Innovating the digital value of agriculture by means of the 2-D barcode transmission technology allows integrating the agri-eco-farm activities and the digitized agriculture archives, creating a vivid and convenient introduction to farming, and extending the multiple values and functions of agriculture such as living and farming to the users.

The propose of the project is to establish a net site of Chiayi Botanic Garden (http://cytfri.tfri.gov.tw/index.php) in the digital eco-library of agriculture which supports a briskly updated and broad spectrum introduction of the botanic garden. Upon online registration and login, a virtual tour guide will be provided and species information on a certain animal or plant will appear. Besides, online printout of a souvenir sticker and membership administration are also availiable. A wireless guiding system such as a cell phone with onboard barcode reader or a PDA (personal digital assistant) could provide the visitor all the aforementioned services. Visitors could also acquire the information of the Chiayi Botanic Garden through a tour guide where in the garden to set up a personal visit record. The system integrated serveal agri-ecological data banks and enhanced application of digitized data and making it a very useful source of ecology, recreation and education for the user. The visiting record of schools could be downloaded for the school outing achievement. And through the use of a throughout-life study passport project which encourages schools and offices to participate in visiting agir-eco-farm, the combined benefits of acquiring agri-ecoresource and education could be attained.

林產物與苗木生產履歷系統之建立

Traceablilty system for branch products made from Nothapodytes

陳怡蒨

本計畫將建立青脆枝良好農業生產規範（TGAP）及產銷履歷資訊系統。本系統將顯示每批次產品之詳細資料，包括：栽培地區、產量、農藥使用、喜樹鹼濃度、含水量等。此一履歷平台已建構在林試所網站，網址為http://trace.tfri.gov.tw。

A Taiwan Good Agricultural Practice (TGAP) certufucate and a traceability system for products made from branches of *Nothapodytes nimmoniana* crops in Taiwan will be established in this project. This system will show detailed information on the process of each batch of products, including production area, production yield, chemical pesticides used, the camptothecin concentration, water content of products, etc. The traceability system has been setup in the web site of Taiwan Forestry Research Institute as http://trace.tfri.gov.tw.

無線感測器網路應用在紫斑蝶棲地之保育監測

Application of Wireless Sensor Network (WSN): Monitoring overwintering habitat of Euploea butterfly

趙榮台

林業試驗所於2005年至2008年在高雄六龜選擇三處紫斑蝶越冬棲地，採用自動化監測儀器，建立感應器網路，收集棲地氣候數位資料與蝴蝶影像資料，並透過網際網路查詢、分析監測資料，以便在沒有人為干擾及降低調查成本的狀況下瞭解紫斑蝶越冬的行為、生態和棲地需求。然而，由於感測器架設的地點固定，無法全面掌握紫斑蝶動態，而且因野外天候條件變化多端，致使感應器網路的傳輸資料經常中斷甚或遺失。因此自2009年起執行「無線感測器網路應用於紫斑蝶棲地之保育監測」計畫，擬以行動式系統結合感測器、無線通訊、資訊軟體、野外電腦硬體技術，整合出一個從自動化蒐集資料，到建立資料、倉儲、搜尋、使用、分享、分析等能力的資訊管理系統，作為從事長期、跨領域、共同分享資源與資料的示範性生態研究。

本年度計畫之主要成果包括：(1)現勘、選定東部地區的樣區，樣區位於台東縣大武鄉大武溪上游之姑子崙溪與茶茶牙頓溪匯合台地，紫斑蝶於每年十一月至次年二月在此區越冬，族群穩定。(2)在選定的樣區規劃並完成建置六座氣象塔，分別安置溫度計、濕度計、風速風向計及日照計等感測器，自動收集現場氣象資料。(3)完成採購三台網路大量儲存設備，其中一台置於本所，另兩台分別置於六龜研究中心與太麻里研究中心。資料每日儲存至當地之儲存設備中，並藉由網路同步連線至本所製作異地備份，以提升資料儲存安全性。(4)完成維修、保養、或校正六龜棲地已設置的各種感測器，汰換老舊或已損壞儀器。(5)完成架高、改善、保護六龜棲地森林內部的實體線路，使原先布設於森林底層的線路，免於人為干擾、地表水氣或鼠類噬咬，致使線路中斷的風險。

Meteorological data (temperature, relative humidity, wind speed and direction, radiation) and images of overwintering Euploea butterflies (Family Danaidae) were collected by automatic monitoring equipments set in 3 locations at Liuquei, Kaohsiung County from 2005 to 2008. The digital data collected in the field was then transferred through ADSL, microwave, internet and stored in a digital station at Liuquei. Users could query and analyze these data through internet interface. This sensor network offered an opportunity to better understand the characteristics of the overwintering habitats and habitat requirement of overwintering butterflies without disturbing the fragile overwintering butterflies. However, the fixed sensors made it impossible to monitor the dynamic overwintering butterflies. In addition, the sensor network was frequently damaged by human being, wildlife and poor weather condition. Data transfer may be interrupted or even lost as a result. Therefore, we initiated a new project, "Application of Wireless Sensor Network (WSN): Monitoring overwintering habitat of Euploea butterfly," combining sensors, wireless connection, information software, outdoor hardware technique and date storage to establish a long-term, cross-scale, cross-field, source and data sharing model for ecological research. The result of the first year included (1) Selected plots in Dawu site, Taitung County after survey and assessment. Euploea butterflies generally move in theses plots in November and move out in February next year. The overwintering population is fairly stable in Dawu site; (2) Built six towers in Dawu site. Sensors which measure temperature, moisture, wind speed/direction, and radiation were deployed on each tower; (3) Setup 3 Network Attached Storages (NAS) in headquarter of Taiwan Forestry Research Institute in Taipei, Taimali Research Center in Taitung County and Liuquei Research Center in Kaohsiung County respectively. NAS will be linked for data storage and backup to guarantee the safety of data storage; (4) All sensors in Liuquei site were either maintained, repaired, and/or calibrated. Equipments not well functioned in Liuquei site were replaced; (5) Cable lines in Liuque site were moved 1m away from the trail and lifted 1m above the ground to prevent them from the damage by human beings, ground moisture and rodent chewing.

森林野生物種質保育與利用

Collection, preservation and utilization of genetic resources from the endemic plant species

簡慶德

台灣野茉莉有生理的休眠，種子播種後第5個星期開始發芽，5個月後發芽率低於10%。種子用激勃素GA_3或GA_4處理，然後播種，發芽率可從10%增加至60%以上。台灣鐵杉種子能耐乾燥及零下低溫儲藏，為正儲型的種子，而長尾柯種子顯示為非正儲型的種子。研究棋盤腳族群發現，族群基因流傳並不暢通，不同島嶼間已明顯呈現分化現象。棋盤腳樹族群總體之基因歧異度較低的原因，推測應經歷長期或嚴重的瓶頸效應所致，故除了採取就地保育之措施來保存現有族群外，更應進行遷地保育措施。福氏石松基因圖庫新增19種類似功能性基因之25條cDNA序列資料，另外經由PCR擴增獲得覆葉石松(224-227 bp)、垂枝石松(224 bp)、寬葉石松(223-240 bp)、台灣石松(220-222 bp)、及福氏石松(223-228 bp)，共5種石松之內含子。利用葉綠體DNA三個轉錄間片段atpB-rbcL、petG-trnP和trnL-trnF片段序列，進行捲斗櫟之族群遺傳與親緣地理研究，初步比對結果發現三個葉綠體DNA轉錄間片段之樹狀關係分析皆呈現多分枝群。

Seeds of *Styrax formosana* and *Styrax matsumuraei* have physiological dormancy. Fresh seeds germinate poorly. Seeds treated with gibberellic acids (GA_3 or GA_4) promoted germination, and germination percentage increased to 60%. Seeds of *Tsuga formosana* exhibited orthodox storage behavior. However, seeds of *Castanopsis carlesii* exhibited recalcitrant storage behavior. Genetic variation and phylogeny of the coastal plant, *Barringtonia* species showed a lower genetic variation by the ISSR assay, suggesting that *ex situ* conservation for this species is required. We found 19 functional genes from the native plants of *Lycopodium*. Preliminary determination of genetic variation and phylogeny of *Quercus pachyloma*, Fagaceae, showed some variation among the populations.

台灣森林物種基因條碼及種質基因庫之建立與保存利用

Establishing DNA barcodes and preservation and utilization of genetic resources of forest species in Taiwan

朱麗萍

利用葉綠體DNA三個轉錄間片段atpB-rbcL、petG-trnP和trnL-trnF片段序列建立台灣原生茶科植物的基因條碼資料。98年度共計採集茶科9屬29種72單株樣本，完成葉綠體DNA三個轉錄間片段，獲得71條完整之序列，序列長度在atpB-rbcL為827 bp到847 bp之間、petG-trnP為434 bp到465 bp之間和trnL-trnF為419 bp到438 bp之間，將三片段合併分析，解析能力可以達到屬階層解析。

台灣粗榧種子有形態生理的休眠，需要經由暖溫和低溫之組合層積處理，打破種子休眠。經過一年的研究，初步資料顯示有些組合處理的種子之發芽率較高，但仍未有一組處理的結果讓人滿意，即大部分種子仍處於休眠狀態，本研究仍在進行中。高海拔冷杉種子沒有休眠性，種子一個月內可以發芽完畢，推測高海拔冷杉生育地之冬天溫度低，種子在11-12月成熟掉落後因溫度太低不會發芽，因此種子有沒有休眠對冷杉樹種並不重要，種子在春天氣溫回升後開始發芽。阿里山十大功勞種子有形態的休眠，即胚發育不完全，需要等到胚發育完全後種子才會發芽。從各種不同的溫度處理之種子發芽率看來，阿里山十大功勞種子只有形態休眠，沒有生理休眠，因為種子在一個月內發芽完畢。

調查南部地區三個樣區 (四湖防風林、六龜扇平及嘉義石卓) 的木材腐朽菌、結果顯示三個樣區中，六龜扇平與嘉義石卓較相似，四湖防風林可能為低海拔海岸林與另外兩區差異較大。四湖防風林的木材腐朽菌多以生長在木麻黃上熱帶與亞熱帶的種類為主，如 *Coriolopsis aspera*, *C. neaniscus*, *Ganoderma australe*, *G. tropicum*, *Hexagonia tenuis* 和 *Trametes hirsuta*等。六龜扇平及嘉義石卓的木材腐朽菌種類相似，如 *Microporus affinis, Stereum ostrea*, *Ganoderma australe*, *Trichaptum biforme*, *Trametes hirsuta*等。這三個地區共通較常見的菌類以 *G. australe* 和 *T. hirsuta* 為主。採集的木材腐朽菌標本多已做培養分離，共獲得40多株純培養菌株。

The DNA barcode data of Theaceae family plants established using their chloroplast DNA transcribed spaces showed that the lengths of atpB-rbcL, petG-trnP and trnL-trnF segments were 827-847bp, 434-465bp and 419-438bp, respectively, among the 71 complete sequences collected.

The seeds of *Cephalotaxus milsoniana* and *Mahnia oiwakensis* showed low germination rates due to their morphological dormancy, but seeds of *Abies kawakamii* in high altitude could germinate within one month after harvesting. Besides, we found that *Ganoderma australe* and *Trametes hirsute* were the most common wood decay fungi investigated, judging from the data of more than 40 strains separation, in the Szehu shelterbelt, Liukuei Shanping, and Chiayi Shizhuo.

森林生物分類研究與典藏

Systematic studies and storage of forest creatures

邱文良

一、標本館典藏

1. 植物標本館：保存標本330,000份，新增23,600份，數位化210,000份；與國外標本館交換標本共20次；提供國內外學者查閱標本212次及植物分類文獻調閱23次；發表新記錄及歸化植物共8篇報告。
2. 木材標本館：更新電腦資訊系統之木材基本性質資料61筆、木材鑑定服務226件、木材性質相關諮詢服務2,764件、蒐集外國產木材標本25種、國產木材標本製作261片及雷射雕刻材種名稱1,837片。
3. 昆蟲標本館：標本製作1,798隻，資料庫資料增修15,533筆；針插標本鑑定13,163隻，浸液標本鑑定478隻。網站新增13,437份標本影像。完成全館標本箱樟腦粉添加工作，15,441瓶浸液標本酒精更換。

二、複合群分類研究

1. 二型鳳尾蕨複合群：以cpDNA及核DNA基因片段測試，發現測試之11個分類群中，都共同擁有Y基因系群，另一組則分別為X1,X2,X3,或X4系群；各分類群分別為二、三或四倍體，且均行無配生殖。
2. 桃葉珊瑚複合群：由形態觀察及核醣體基因之研究，顯示地理隔離已造成基因的分離；歸群樹亦可分為桃葉珊瑚及鳳凰山珊瑚兩群。
3. 大花細辛複合群：由cpDNA及核糖體DNA分析所建構的親緣關係樹，顯示台灣的種類可分成兩群：一為大花細辛複合群與白斑細辛；另一群是下花細辛與八重山細辛。由此可見台灣本群植物至少是兩次起源的。
4. 布勒德藤複合群：以葉綠體及1組核基因序列測試，結果顯示小金石榴與毛布勒德藤複合種群關係可明顯區分，後者呈現毛布勒德藤、圓葉布勒德藤與布勒德藤三個單系群。
5. 木芙蓉複合群：發現二新種，擬分別命名為「太魯閣木芙蓉」與「太麻里山芙蓉」。
6. 十大功勞複合群：發現二新種，擬命名為「大禹嶺十大功勞」與「奮起湖十大功勞」。
7. 台灣黃芩複合群：由cpDNA片段序列顯示，布烈氏黃芩與其他種類有較多的差異，其他種類則成為另一個分支。都蘭山的田代氏黃芩和里龍山與大埔的南台灣黃芩形成一分支。而利稻的田代氏黃芩、里龍山的台灣黃芩以及浸水營的台灣黃芩則無法區分。
8. 斑葉蘭複合群：研究結果顯示台灣之斑葉蘭植物共20種；並確認兩種同物異名、7種誤用學名及一新記錄種「波密斑葉蘭」。

[執行：王瀛生、王震哲、呂勝由、邱文良、陸聲山、趙榮台、蔣鎮宇、謝宗欣、鐘詩文]

1. The Herbarium and other collections

1.1. Plants: 330,000 sheets of specimens were deposited, 23,600 sheets mounted, and 210,000 sheets digitalized. Duplicates were also exchanged with 20 oversea herbaria. Specimens were checked 212 times and literatures 23 times by researchers. Eight papers regarding to the new record or naturalized plants were published.

1.2. Woods: 61 records of wood properties were built in the database; 1837 wood pieces were laser-carved; 286 wood specimens were collected; 226 identified and 2764 wood property inquires were serviced.

1.3. Insects: 1,798 specimens were collected and mounted; 15,533 records and 13,437 images were archived; 13,163 pinned and 478 liquid-soaked specimens were identified. Alcohol of 15,441 liquid-soaked specimens was replaced and camphor of all boxes was replaced.

2. Species-complex studies

2.1. *Pteris cardieri* complex: The cpDNA *atp*B-*rbc*L and *rbc*L and nrDNA *PgiC* sequences analyses showed there were 11 taxa. They all shared a "Y" haplotype and another haplotype came from either X1, X2, X3, or X4 lineage. They were diploid, triploid, or tetraploid, and all reproduced by apogamy.

2.2. *Aucuba* complex: The phylogeny tree derived from morphology and nrDNA (ITS-1, ITS-2) revealed two clades, *A. chinensis* and *A. chinensis* var. *fongfangshanensis*. Geography separation also led to genetic differentiation of taxa within the clade.

2.3. *Asarum macranthum* complex: The phylogeny tree derived from cpDNA (*trn*L-F, *mat*K, *pet*D) and nrDNA (ITS) showed 2 clades, *A. macranthum* + *A. albomaculatum* and *A. hypogynum* + *A. yaeyamense*, in Taiwan. Results also revealed that there were at least 2 speciation origins of this complex in Taiwan.

2.4. *Bredia* complex: The phylogeny tree derived from cpDNA (*trn*L-F, psbA-*trn*H and *rps16*) and nrDNA (ITS) has 2 highly supported clades, *B. gibba* and *B. hirsuta*. The latter included 3 monophyletic groups of var. *hirsuta*, var. *rotundifolia*, and var. *scandens*.

2.5. *Hibiscus* complex: Two new species were found and tentatively named *Hibiscus tarokoensis* S.Y. Lu *et* S. W. Chung *sp. nov.* and *Hibiscus taimaliensis* S.Y. Lu *et* S. W. Chung *sp. nov.*

2.6. *Mahonia* complex: Two new species were found and tentatively named *Mahonia tayulingensis* S. Y. Lu *et* S. W.Chung *sp. nov.* and *Mahonia funchifuensis* S. Y. Lu *et* S. W.Chung *sp. nov.*

2.7. *Scutellaria* complex: The phylogeny tree derived from cpDNA *atp*B-*rbc*L sequences revealed 2 clades, *S. playfairii* and another one (B) which included the other taxa of this complex. The *S. tashiroi* of Dulan and *S. austrotaiwanensis* of Lilong and Dapu in clade B formed a branch. However, the *S. tashiroi* of Lidau and *S. taiwanensis* of Lilong and Chingshuyin were not distinguishable.

2.8. *Goodyera* complex: Results showed there were 20 species in this complex native to Taiwan. Among them, 2 synonyms, 7 misidentified names were corrected, and one new recorded species, *G. bomiensis* Lang was confirmed.

[This research was conducted by: Wang YS, Wang JC, Lu SY, Chiou WL, Lu SS, Chao JT, Chiang TY, Hsieh TH, Chung SW]

台灣油杉保育之研究

Study on the conservation of *Keterleeria davidiana* var. *formosana*

鍾振德

台灣油杉不連續分布於台灣本島之南北(大武與坪林)兩端，族群稀少，結實率低，為積極保育之固有樹種。台灣油杉母樹非常少，在坪林僅約108株，樹勢漸老弱，所生產的種子不佳，每毬果可孕性種子97%以上均屬空粒，致天然下種苗稀少，繁殖不易。本計畫透過花粉保存與扦插方式保育母樹，其中已成功扦插繁殖53株母樹，花粉經過乾燥與低溫冷藏可以超過四年，而且花粉發芽率沒有下降，新鮮花粉授粉到母樹，具飽滿種子比率為94.6%。大武no. 298花粉儲藏4年花粉發芽率73.5%，授粉至大武種源嫁接盆缽苗，具飽滿種子毬果母樹間差異大，0-100%具飽滿種子，飽滿種子平均發芽率為5-44%。本計畫之發芽種子已培育成苗木2,000餘株。

Keteleeria davidiana var. *formosana* is an indigenous tree presents only in the northern (Pinglin) and southern (Dawu) parts of Taiwan. These trees have already been listed as one of conservative tree species and protected by the government due to their scarcity and low rate of seed setting. The mother trees are few and there are only 108 in Pinglin. Moreover, their vigor is decreasing which coupled with few regenerated offspring in nature are caused by their low quality of seed production, as - more than 97% seeds per cone are empty. This research project proposes to conserve these mother trees using pollen preservation and branch cuttings. Fifty-three mature mother trees have already been propagated by branch cutting. There was no decline in the pollen viability level after 4 years of low temperature and freeze drying preservation. Fresh pollens were used to pollinate different seed parents and the ratio of sound seed is 94.6%. After 4 years using low temperature preservation of pollen, the Dawu No. 298 pollen produced germination rate of 73.5%. The stored pollens were used to pollinate different seed parents and the ratio of sound seeds varied from 0 to 100%. The germination rates of sound seeds were from 5 to 44%. In this year, we've already produced more than 2000 seedlings.

台灣產石櫟屬(殼斗科)植物之保育與應用研究

The conservation and utilization of *Lithocarpus* (Fagaceae) species in Taiwan

邱文良

以台灣產16種殼斗科石櫟屬植物進行其分類學研究及稀有植物等級之評估，並選取其中有利用潛力之小西氏石櫟與后大埔石櫟，進行其遺傳變異、授粉生物學、及化學成份分析研究，進行小西氏石櫟與南投石櫟種子之發芽研究，以及鬼櫟之嫁接實驗。完成結果分述如下：

1. 本屬16種植物之花粉皆為長橢圓形且有三溝孔，屬內花粉之大小及表面飾紋上差異不大，但可做為屬間分類的參考；葉表皮毛形態差異可分為五大類；染色體數皆為2n=24。
2. 利用葉綠體DNA atpB-rbcL、trnL-trnF和trnP-petG非編碼區之序列，分析小西氏石櫟和后大埔石櫟二種石櫟屬植物之遺傳變異。結果顯示兩者皆呈現低基因型岐異度和低核苷酸歧異度現象；兩者具共有的基因型，但亦皆具各特有的基因型。
3. 小西氏石櫟日間訪花昆蟲的種類數量多於夜間，共7目，以鞘翅目的數量和種類最多，雙翅目次之。后大埔石櫟的訪花昆蟲紀錄有5目，以鞘翅目的數量最多，白天訪花昆蟲數量多於夜晚，前者以鞘翅目的大吸木蟲和金花蟲、膜翅目的蜜蜂、雙翅目的蠅類為主；後者以鱗翅目的蛾類為主。
4. 小西氏石櫟與后大埔石櫟之殼斗之抗氧化活性、原花青素與黃酮類含量、海蝦之毒性致死率均較葉子及枝條高。
5. 小西氏石櫟與南投石櫟種子均具休眠性，新鮮種子需經剝皮處理才發芽，發芽後一年之存活率達86.2%；以25/15℃及20/10℃為較佳之種子儲存條件，至1.5年後可發芽。後者發芽後一年之存活率僅18.7%，但種子不耐儲存。子彈石櫟、加拉段石櫟和三斗石櫟之新鮮種子都不具有休眠性。
6. 鬼櫟嫁接試驗結果顯示，冬春兩季是接穗存活率較高之季節，春季接穗存存活率約有58%，其成活株中有56.75%在抽穗展開枝葉後開花，目前僅呈現雄花開放，各株花期不一從7月持續至11月。此外亦已培育小西氏石櫟之砧木100株，可供後續嫁接試驗。
7. 完成16種石櫟屬植物稀有等級之評估，其中嚴重瀕臨滅絕(CR)1種(台灣石櫟)、瀕臨滅絕(EN)3種(大武石櫟、浸水營石櫟、南投石櫟)、易受害(VU)3種(柳葉石櫟、後大埔石櫟-VU、細葉三斗石櫟)、接近威脅(NT)4種(子彈石櫟、台東石櫟、油葉石櫟、鬼櫟)，其餘5種為安全等級。

[執行：江友中、朱麗萍、呂勝由、洪昆源、范義彬、黃怡菁、陳舜英、鄭育斌、鐘詩文]

Taxonomy of 16 *Lithocarpus* species (including 3 varieties) native to Taiwan was studied and their rareness statuses were evaluated. Among these, *L. konishii* and *L. corneus*, being potentially useful in the future, were selected to study their genetic diversity, pollination biology, and chemical components. Seed germinations of *L. konishii* and *L. nantoensis*, an endangered species, were investigated, and grafting of *L. castanopsisifolius*, another potentially useful species, was studies. Results showed that pollen morphologies were not very different among species in the *Lithocarpus* genus, but could be distinguished among different genera. The trichomes on the leaf surfaces were classified into five types. Each species in this genus was diploid (2n = 24). Based on sequences of *atp*B-*rbc*L, *trn*L-*trn*F, and *trn*P-*pet*G, the genetic diversities of *L. konishii* and *L. corneus* were low; both of them shared some haplotypes and with some specific ones. There were 7 orders of insects visiting flowers of *L. konishii*, mostly Coleoptera and then Diptera. Five orders of insects were found on flowers of *L. corneus*. More of them were found in daytime (mainly Helotidae and flea-beetle of Coleoptera, Apidae, and Muscidae) than in the night (mainly moth). Amounts of anthocyanin and flavonoid, activities of anti-oxidant, and fatal rates toxicity to marine shrimps were all high in cupules than in leaves or branches of *L. konishii* and *L. corneus*. Fresh seeds of *L. konishii* and *L. nantoensis* would not germinate unless their skins were removed. Seeds of *L. konishii* under 25/15°C and 20/10°C could germinate after 1.5-year of storage. However, the seeds of *L. nantoensis* were not suitable to be deposited under the tested conditions. Average survival rates of seedlings of *L. konishii* and *L. nantoensis* were 86.2% and 18.7%, respectively, in a one year culture. The rates of grafting survival of *L. castanopsisifolious* were significantly higher in winter and spring than it did in other seasons. During the spring, successful grafting rate was 58%. And 56.75% of them started flowering but only male ones were observed. According to the IUCN criteria, one species were evaluated as critically endangered, 3 species endangered, 3 species vulnerable, 4 species near threatened, and 5 species of least concerns.

[This study was conducted by: Chinag YC, Ju LP, Lu SY, Hong KY, Fan YB, Huang IC, Chen SY, Cheng YP, Chung SW]

六龜試驗林不同海拔森林鳥類多樣性與林相組成及林下植被關係之研究

Relationship between the composition and understory of forests and avian community diversity at different elevations in the Liukuei Experimental Forests

陳永修

本研究於2009年3~10月間在六龜試驗林區進行每個月各一輪的鳥類多樣性調查，同時進行樣區內林相組成與植被結構之測量；此外，於7月份繁殖季末期進行鳥類繫放工作，藉以獲得群聚組成物種的族群數量；另一方面，也利用扇平地區既有之無線網路資源建置自動錄音感測系統，發展動物聲學相關之應用研究。適逢 8 月份莫拉克颱風侵台，提供了一個難得的機會對照干擾前後鳥類群聚變動之契機。鳳崗山樣區的研究結果顯示，颱風過後共記錄到24科59種鳥類，保育類占15種。比較大尺度干擾前與干擾後鳥類群聚的狀況，顯示出無論是在平均出現的鳥種數或者平均豐富度上，兩者均無顯著的差異。繫放結果方面，共標放了83隻次不同的個體，分屬6 科11種，其中以繡眼畫眉捕獲數量最多。在植被調查上，完成25個樣點之植群測量，並建置初期的植被名錄與簡易檢索表，並且針對干擾過後的異常物候現象持續進行監測。自動錄音感測系統的部份，已經完成前測實驗並建置初步的聲音檔案資料庫，以期後續階段更進一步的整合與發展。

Inventories of bird diversity, and vegetation compositions and structures were respectively conducted in the Liukuei Experimental Forest monthly from March to October in 2009. Bird banding was also carried out at the end of breeding season in late July to obtain information on the hetero-specific population parameters of bird communities. Meanwhile, an auto-sensing recording system was built on the basis of existing wireless networks of Shanping Workstation for the development of applied bioacoustic research. With the severe impact of Typhoon Morakot to Taiwan in August, variations in bird assemblages between two periods were compared. After the typhoon, point count census recorded 24 families of birds, including 15 conserved species among a total of 59 species in the Fengkangshan study area. Large scale disturbances did not significantly decrease the mean numbers of either species or individuals. As to the banding work, there were 11 species of 6 families captured, amounting to a total of 83 birds, of which grey-cheeked fulvetta (*Alcippe morrisonia*) predominated. Measurements of vegetation characters within the 25 sampling points were completed; and a brief checklist with an identification key were established for further uses. The unusual phenology after the disturbance was monitored persistently. Furthermore, pre-tests of the auto-sensing recording system were done and an initial sound database was ready for advanced integrations and exploitations.

森林蛾類族群分布暨重要優勢闊葉樹種之食葉性蛾類種調查及其能量消耗評估

A survey of the forest moth community distributions; the leaf foraging moth larvae of dominant tree species, and evaluation of their energy consumptions

沈勇強

本計畫在98-99年進行蛾類成蟲之研究，執行燈光誘集並製作成蟲標本，目的在建立林試所所屬5個林區的蛾類相資料庫，探討蛾類隨季節、方位、海拔等因子變化之影響，並進行同一地區及不同地區蛾種及族群組成變化的比較。98年於5個林區各執行12次燈光誘集，總計拍攝成蟲生態影像7,897張，並上傳至Flickr網站供後續鑑定及建立資料庫之用。製作成蟲標本6,923份，完成飼育及鑑定之幼蟲總計16科90屬106種，拍攝幼蟲影像計303張，包括可能的新種4種，台灣新紀錄種6種。建立各林區蛾類相初步名錄，並對危害林木之蛾種加以討論。

The project proceeds with a study of adult moths from the period from2009 to 2010. The studying areas include Taimali, Fushan, Lienhuachi, Henchun and Liukuei. The purposes of the project is to establish the moth fauna database of the TFRI forests, exploring the factors variations such as season, direction, altitude and vegetation that affect the moth fauna, comparing the compositions to the different collecting sites in the same area or to the different areas. Moth collecting by light attraction had been implemented once a month in 2009; and a total of 7,897 photos of living adult moths had been taken and uploaded to the TFRI website "Flickr" for future identification. We have made 6,923 mounted adult specimens so far in this study. Larvae of a total of 106 species including 16 families and 90 genus have been reared and identified, of these, 4 species are new to Taiwan and 6 species are Taiwan new records. A total of 303 ecological photos of the larvae have been taken and also uploaded to the Flickr. The primary list of the moths and caterpillars with their host plants had been established. Some caterpillars that caused severe damage to their hosts have been investigated and discussed.

上傳於Flickr網站之蛾類幼生期圖庫。

Photos of adult moths and their larvae have been uploaded to the TFRI website "Flickr" .

台灣八角茴香屬植物分類及保育之研究

A systematic study and conservation of the genera of Illiciaceae of Taiwan

呂勝由

依據林祁(2001)研究，八角屬植物分為白色花瓣、葉中肋上凸的八角節（Sect. Illicium）與紅色花瓣、葉中肋下凹的八角茴香節（Sect. Cymbostemon）兩大類群。本研究初步認為台灣本屬植物約可區分為五個分類群，其中白花八角、大武八角及東亞八角屬於八角節（Sect. Illicium），紅花八角及粉紅花八角（新稱）屬於八角茴香節（Sect. Cymbostemon）。

本研究發現大多數之白花八角心皮數較東亞八角心皮數少，但兩種之間單株的心皮數仍有重疊之處；因此林祈(2001)以心皮數（白花八角心皮數7-8枚，東亞八角心皮數11-20枚）單一特徵作為二者區別之特徵，仍有鑑定錯誤之虞。而本研究以八項形態特徵（心皮數、果尾尖、果柄、最大果徑、果側高、葉長、葉寬、葉柄），利用數值分析，可將產於台中縣鞍馬山一帶之白花八角及東亞八角，共計10個單株明顯區分為2個分類群。其餘分類群待基本資料補齊後再一併分析。而研究發現僅見於大雪山林道24K之粉紅花八角只見開花不見結果，疑似雜交種，此有待進一步研究。

花粉SEM觀察結果，形態上的差異在於萌發溝於極面匯合與否。紅花八角與粉紅花八角的花粉為叉狀合流溝粒，大武八角、白花八角與東亞八角的花粉為三溝粒，可將紅花類群與白花類群明顯區分。

從trnL-trnF及ITS兩序列可將台灣產八角茴香屬植物與日本東亞八角區分，但trnLtrnF無法區分台灣之紅花及白花類群；而ITS只可將紅花及白花類區分開來，但種間無法進一步區分。從DNA分子技術分析研究結果顯示：台灣產的東亞八角不同於日本產的東亞八角，將進一步做形態學方面的比較研究。

According to Lin (2001), the genus *Illicium* (Illiciaceae) should be revised and he suggested two sections: The sect. *Illicium* (with white petals and keeled leaf midrib) and the sect. *Cymbostemon* (with reddish petals and impressed leaf midrib). In this research, we suggested that the 5 known *Illicium* taxa in Taiwan could be divided into these two sections (Sect. *Illicium*: *I. daibuense*, *I. philippinense*, *I. tashiroi*; Sect. *Cymbostemon*: *I. arborescens* and an unknown *Illicium* sp. with pink petals).

Lin (2001) also suggested that carpel number is a diagnostic character for *I. philippinense* and *I. tashiroi*. Our research result reveals that carpel number of *I. philippinense* in most individuals is usually fewer than that of *I. tashiroi*, but the range of carpel number in both *Illicium* overlapped. Carpel number thus seems to be not a diagnostic character for these two taxa in Taiwan. In this research, 8 morphological characteristics (carpel number, follicle apex, follicle pedicel, follicle diameter, follicle height in lateral view, blade length, blade width and stipule) and 10 OTUs in the Anmashan, Taichung County. were measured and analyzed by a numerical analysis. These 10 OTUs could be divided into two groups. Quantative analysis of all *Illicium* spp. in Taiwan would proceed in the future. The *Illicium* sp. found only in a Dasheshan forestry road seems to be a hybrid because it flowers but never set fruit. Hybridization of this *Illicium* sp. should be researched in future.

Pollen morphology of the *Illicium* spp. in Taiwan was observed by a scanning electronic microscope (SEM). Ditches in the pole faces were diagnostic characteristics of the pollen grains of *Illicium* spp. in Taiwan. Pollen grains of *I. arborescens* and *Illicium* sp. were syncolpate. Pollen grains of *I. daibuense* , *I. philippinense* and *I. tashiroi* was tri-colporate.

Based on a cladistic analyses of trnL-trnF and ITS sequences, the Taiwan *Illicium* spp. and Japan *I. tashiroi* could be differentiated into 2 clades. Results of the trnL-trnF sequences could not differentiate members in the 2 sections of *Illicium* spp., however. Results of ITS sequences could differentiate the Taiwan *Illicium* spp. into the 2 sections, but could not divide these taxa clearly. Based on these results, we suggest that Japan and Taiwan *I. tashiroi* are different species and further taxonomic research is necessary.

都市公園綠地遊客對鳥類之影響研究

Effects of visitor disturbance on birds in urban parks and green areas

葛兆年

本研究目的主要在探討遊客對都市綠地鳥類的影響。我們利用台北植物園限定開放時間之園區的特殊經營管理方式來進行研究。首先比較樣區開放前、開放後調查到的各樣區鳥種數、隻次、Shannon-Wiener index、Shannon-Wiener Evenness index與各鳥種隻次之差異，並檢定上述變數與噪音值、靜態遊客數、動態遊客數和總遊客數的線性相關程度。結果顯示台北植物園園區實施局部時間開放的管理方式，確實影響鳥類的分布。靜態遊客數對鳥類活動影響微小，但動態遊客數可能對整體的鳥類多樣性具有負面影響。遊客產生的聲音音量不明顯，反而是植物園區外道路交通產生較大噪音值，但其對植物園區內的鳥類影響不明。本研究結果顯示，台北植物園區的限時開放措施確實會影響鳥類對棲地的使用，進一步說，在清晨時段實施園區關閉措施，應有利於鳥類順利進行日常生活所需之活動項目，如平時的覓食、領域維護、休息等活動及繁殖時期的求偶、產卵、育幼等活動，有助於其族群之維持、生存及繁衍。另一方面觀察台北植物園遊客對此一管制措施，皆能有非常良好的配合。本研究認為這項良好的管制措施仍應繼續維持下去，並建議可以考慮推廣此作法至其他公園綠地。

The main purpose of the study is to assess the influence of pedestrians on bird communities in urban green areas. We used a plot- close policy in Taipei Botanical Garden to study the difference between bird communities with or without pedestrians.

Certain parts of the Taipei Botanical Garden were closed before 8:30 in the morning. We compared bird communities in these parts before and after 8:30 to assess the effects of the plot closure on the bird's use of habitats. We compared each for the bird richness, abundance, Shannon-Wiener index, Shannon-Wiener evenness index and number of each species between the closed and open plots. Besides, we tested the linear-correlations between each of the above variables and each of the disturbance factors such as noise level, number of static pedestrians, number of moving pedestrians, and number of total pedestrians. Our results showed the plot-closure policy actually influenced the distribution of birds. Bird richness obviously has a negative relationship with number of moving pedestrians, while there was no significant relationship between each of bird community variables and number of static pedestrians. The noise from pedestrians was less disturbing than that from the outside traffic. There were no significant relationship between noise level and each of the bird community variables. The plot closure policy of the Taipei Botanical Garden actually affected habitat use of the birds, and we suggest that the policy should be continuously maintained to help the population of wild birds. We suggest that the early morning plot closure policy may be extended to other urban green areas as well.

台東蘇鐵復育研究

Study on the restoration of *Cycas taitungensis*

朱麗萍

台東蘇鐵專一性多形性微衛星體基因座之發展和以ISSR DNA標記進行台東蘇鐵族群結構探討，分析鹿野溪各林班地、海岸山脈和林試所內保育栽植種子苗之族群遺傳結構與多型性。ISSR DNA標記顯示台東蘇鐵族群變異主要存在族群內而非族群間。鹿野溪各林班地族群在PCA分佈圖所呈現空間分布可區分開，而海岸山脈呈現分散情形，種子苗則呈現分布於鹿野溪23林班地。

台東蘇鐵保留區年均溫21℃，最冷為2月10.6℃，最熱月分為7月29℃，受光量林外為127 μE 遠高於林內之17.9 μE。二月初葉芽開始綻放，新芽抽出初期生長快速，葉芽三天可以抽長10 cm以上，至第10天已經超過30 cm，從綻放到完成可達120-140 cm，此時溫度約為18-21℃。雄株於4月初出現，5月初可完全抽長。利用野外定時影像捕捉設置，發現保留區新芽綻放一年有兩次，分別為2-3月與8-9月，今年雌雄株數高於去年，分別有雌株14株，雄株45株，比率為1:3，雄株有3株連續兩年都開花的現象。今年共採得7株母樹結實，占雌株比率1/2，共計339粒種子。

台東蘇鐵種子有形態的生理休眠，胚小需4個月以上的時間使胚在種子內成長。保護區內台東蘇鐵種子不同種源間之發芽率變異大，如96年採的種源93-1514平均發芽率可達77%，93-1781平均發芽率可達50%，93-1098平均發芽率0%，93-2885平均發芽率70%，93-2670平均發芽率42.3%，懸崖1-3號平均發芽率分別為83%、87%和75%，種源93-2885發芽率亦佳，種原95-1514的種子播種後需要17週以上。97年採的編號1號和4號發芽率分別為62.4%和44.4%。採自私人農場之新鮮種子，在30/20℃、25/15℃和25℃溫度下之發芽率分別為56.7%、57.5%和60.0%。GA3處理的新鮮種子之發芽率為64.2%。5℃低溫層積和裸藏6個月後之發芽率分別為40.0%和28.3%，顯示種子儲藏6個月後有下降的趨勢。此外，本年11月初已運送台東蘇鐵種子苗517株至台東林區管理處繼續培育。

以97年底收集的未成熟台東蘇鐵種子作為試驗材料，進行30/20℃變溫處理，每4週取胚培養，計28週。結果顯示變溫處理對種子、雌配子體的大小，沒有顯著影響，處理20週後，胚顯著變大，且開始發育成子葉期胚。利用胚培養方法，可使大於0.5 x 0.3 cm(長x寬)之胚，培養10天即可發芽長成小苗。胚培養小苗的芽體與成熟樹吸芽可利用微體繁殖方法，在試管內增殖。培養雌配子體、胚、子葉、葉片可誘導產生癒合組織，且部分胚與雌配子體的癒合組織可進一步分化成原胚組織。

The development of specific polymorphism microsatellite loci on *Cycas taitungensis* and the research on *Cycas taitungensis* population using ISSR DNA are discussed. Plants collected in the Luye River Forest Compartments, Coastal Range, and seedlings in a Taiwan Forestry Research Institute nursery showed that variations existed within population rather than among populations according to the results of ISSR DNA. In addition, we observed that buds occurred twice a year in the nature reserve. As for the physiological dormancy, the germination rate of *Cycas taitungensis* seeds could be improved by GA3 treatment and cold moisten stratification (64.2% and 40.0% respectively) and calluses were formed through sucker mircopropagation.

福山闊葉林長期動態研究

The long-term dynamic research of the Fushan natural broad-leaved forest

王相華

依據全球森林動態樣區之研究協定，為了解森林植物社會組成結構在時間與空間上的變化過程，本計畫於25公頃的福山森林動態樣區進行第二次每木調查工作。結合兩次調查所得資料，有助於吾人探討臺灣天然闊葉林內樹木之死亡、新增、生長等動態過程。

本年度已完成全區之樹木複查、樹木調查資料庫之建置與資料驗證、除錯作業。資料分析結果顯示，樣區森林在五年之間減少四個樹種，樹木則增加了424株(其中新增15,869株、死亡12,976株，另有2,469個存活植株已無胸徑大於1 cm的枝幹)，胸高斷面積也增加了2.1 m^2/ha。整個林分的總體年死亡率約為2.61%，年新增率為3.15%，而年生長率則為1.71%。從個別樹種的死亡率與新增率來看，不同樹種的死亡與新增情形變化甚大，死亡率與新增率較高的樹種均以偏好在較開闊環境的先驅樹種以及位於森林下層的灌木種類為主。此外，樹種的死亡率與新增率之間呈現出顯著的正線性相關性，這反映出福山森林內的樹種具有更新棲位上的分化，有助於維持此地森林的樹種多樣性。

According to the protocol of worldwide Forest Dynamic Plots (FDP), and in order to understand the temporal and spatial processes of forest community composition and structure, we conducted the second tree census of the 25-ha Fushan FDP in this project. Combining the data from the 2 censuses, we analyzed the mortality, recruitment, and growth rates of the tree demography and examine the dynamics of the Fushan natural broad-leaved forest.

The full tree census of the 25-ha plot, compilation of census database, and verification and debugging of the data were completed in this year. Based on the data from the plot, there were increases of 424 tree individuals in abundance and 2.1 m^2/ha in basal area of trees, respectively, but there was a loss of 4 tree species within the plot as well.

The annual mortality rate and recruitment rate throughout the forest were 2.61% and 3.15%, respectively. And the mean annual growth rate was 1.71%. However, these rates greatly varied among different species. Pioneer and understory shrub species tended to have higher mortality and recruitment rates. Besides, there was a significantly positive linear correlation between the mortality and recruitment rates among the 110 tree species, which revealed a regeneration niche of tree species in Fushan forest and may contribute to maintenance of the tree diversity.

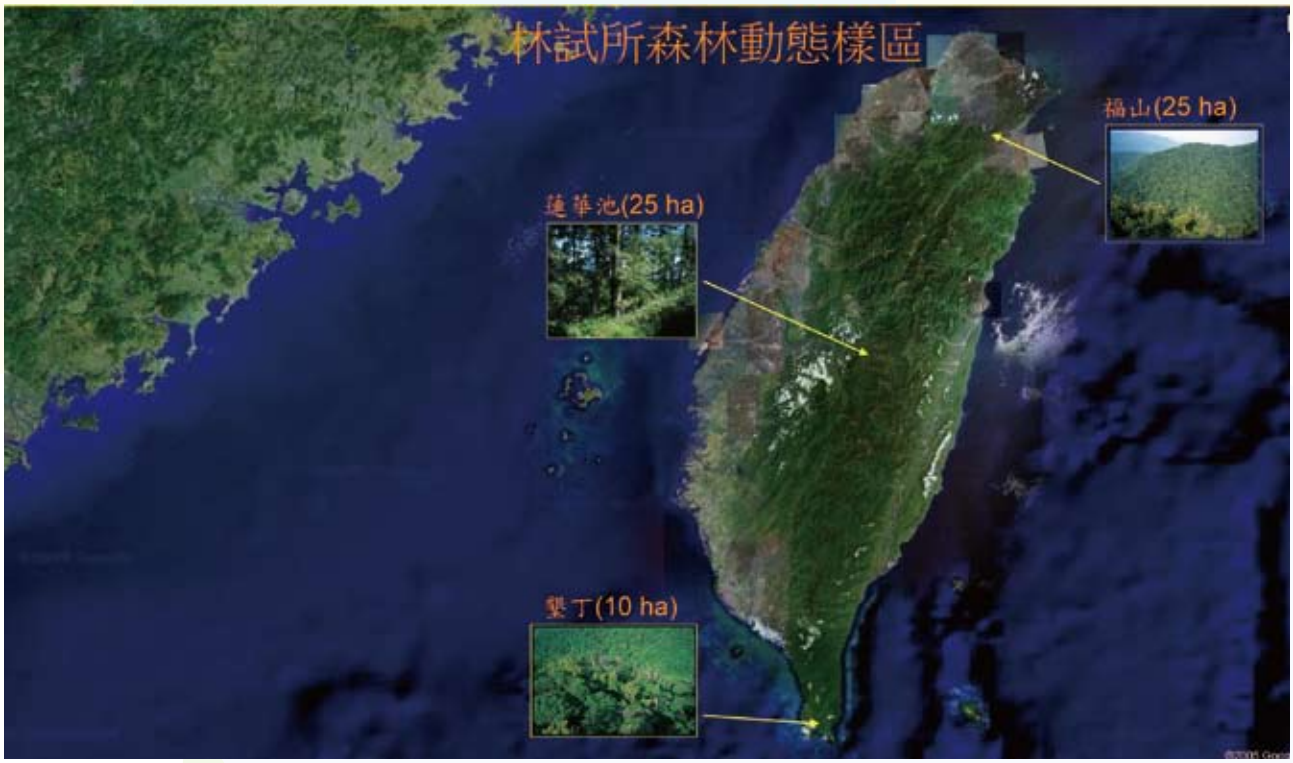
墾丁闊葉林長期動態研究

Natural regeneration potential of the Kenting tropical coastal broadleaf forest

沈勇強

本計畫為完成墾丁高位珊瑚礁自然保留區10公頃長期動態樣區之第一次複查工作。初步分析結果顯示，樣區內木本植物種數由原有的105種減少為第一次複查的102種，合計減少4種，新增1種。植株密度由第一次的4,211株ha^{-1}（不包含白榕與正榕）減少為3,892株ha^{-1}，胸高斷面積也由第一次調查的41.4 m^2ha^{-1}減為39.9m^2ha^{-1}。在兩次調查期間樣區內新增樣木5,603株，死亡10,427株。

A 10-ha forest dynamic plot, 400 x 250 m, was set up at the Kenting uplifted coral forest in 1996~2001, and it was re-inventoried in 2008. Among the 105 woody species recorded in the first survey, 4 were not seen in 2008. In the same period, 1 new immigrant species was recorded. The tree density of the first survey was 4,211 trees ha^{-1}, which has decreased to 3,892 trees ha^{-1} in 2008. The basal area of the plot decreased from 41.4 m^2 ha^{-1} to 9.9 m^2 ha^{-1}.There were 5,603 recruits and 10,427 dead trees during the two census periods.



林業試驗所之3處森林動態樣區。

Three forest dynamic plots are operated by the Taiwan Forestry Research Institute.

蓮華池闊葉林長期動態樣區調查與研究

A study on the Lienhuachih broadleaf forest dynamic plot

黃正良

依據CTFS長期進行永久樣區研究所發展而成之作業模式，進行木本植物普查，於蓮華池天然林內設置一處25公頃(500m×500m)之森林動態學研究永久樣區。調查項目包含每一棵樹的物種名稱、胸高直徑(DBH)與每一棵樹木的位置，調查結果區域內共計有144種木本植物，分屬於39科，86屬；其中DBH在1 cm以上的木本植物株數共計153,268株(6,131株/公頃)。

就全樣區各科重要值指數而言，以樟科、殼斗科、茜草科最為優勢。統計數量最多的種類者為茜草樹，次多者為柏拉木。全樣區平均每公頃底面積為34.77 m^2。南投石櫟底面積最大，佔全部底面積的8.38%，黃杞及鵝掌柴分別位居第二(8.12%)及第三(7.23%)。以重要值IV(相對密度及相對底面積加總)而言，樣區內最優勢的種類分別為茜草樹8.34%及柏拉木5.50%，其次為鵝掌柴5.41%，前30名物種累計可達83.06%。總體而言，優勢組成集中於少數物種，而株數稀少之種類增加樣區物種的多樣性。

各種類徑級分佈呈現4型，分別為L型，倒J型、波動型及鐘型。前3型共98種，表示此森林大部份的物種有足夠的幼苗，更新良好。以生物多樣性而言，與台灣其他低海拔動態樣區比較，蓮華池動態樣區最為豐富；另與世界上島嶼動態樣區比較，其多樣性值低於其它熱帶的樣區，卻和波多黎各動態樣區相當。

The Lienhuachih Forest Dynamics Plot (FDP), measuring 500 m by 500 m square, is located in central Taiwan. Surveillance data on the plot, collected following a unified method adopted for the worldwide FDP network, were analyzed for floristic composition, size-class structure, and species diversity. In total, the censussed trees and shrubs belonged to 144 species in 86 genera and 39 families. The most dominant families were the Fagaceae, Lauraceae, Rubiaceae, Euphorbiaceae, and Melastomataceae. In total, 153,268 (6,131 ha^{-1}) individuals were recorded, and the total basal area was 34.77 m^2 ha^{-1}. Of the 144 species, the most abundant were *Randia cochinchinensis* and *Blastus cochinchinensis*. *Pasania nantoensis* had the highest basal area (8.38%), followed by *Engelhardtia roxburghiana* (8.12%) and *Schefflera octophylla* (7.23%). Calculation of the importance value (IV, incorporating relative values of abundance and basal area) showed that *R. cochinchinensis*, *B. cochinchinensis*, *S. octophylla*, *Cryptocarya chinensis*, and *E. roxburghiana* were the most dominant species with the highest IV values in the plot. The sum of the 30 top species' IV reached 83.06% of the whole. Although the first 2 species were understory shrubs and very dominant due to their large number of individuals, certain numbers of rare species did increase the floristic diversity of the plot. Based on the species composition, the forest is characteristic of the *Machilus-Castanopsis* forest zone of Taiwan, there are certain dominant understory species and 2 pioneering species in the major canopy composition.

For the size-class structure, 102 species showed 4 patterns of size-class distribution: L-shaped, inverse J-shaped, fluctuating, and bell-shaped. The former 3 patterns accounted for a total of 98 species, including a great number of small-sized individuals, imply that most current species in this study site can display good recruitment with rich resources of saplings. The woody plant richness of the Lienhuachih FDP is the highest among the low-elevation FDPs in Taiwan. Compared to other Center of Ttropical Forest Science forest dynamics plots on the islands, Fisher's alpha diversity (ha^{-1}) index of the subtropical Lienhuachih FDP was similar to that of the Luquillo FDP in Puerto Rico but much lower than that of other FDPs in the tropics.

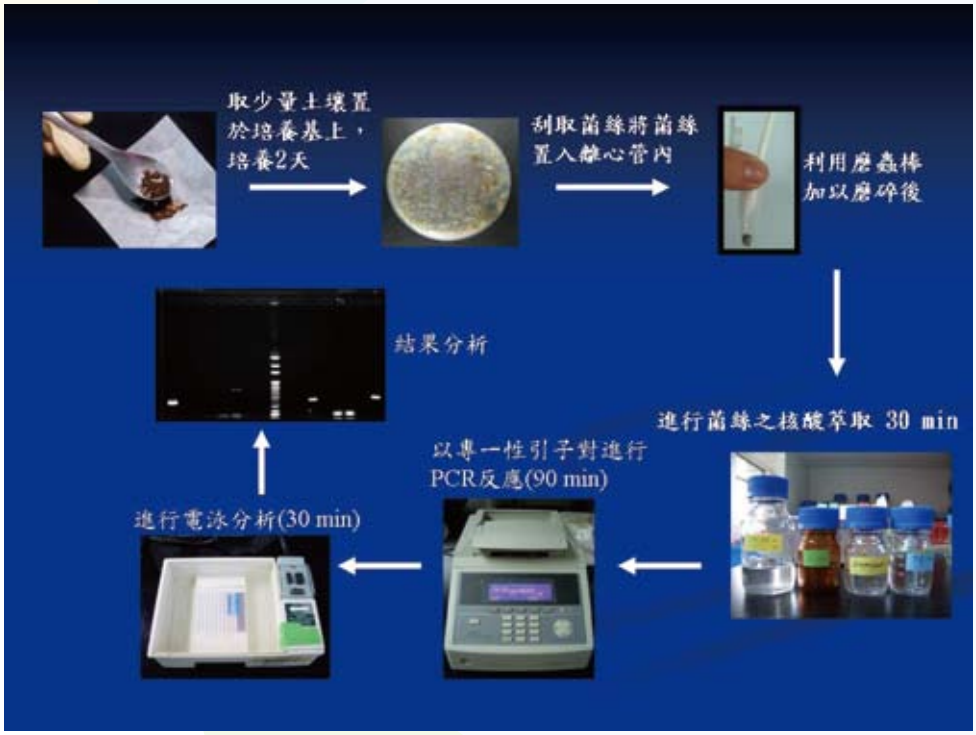
健康林苗生產流程建立

Establishment of a healthy tree nursery system

吳孟玲

98年選定的重要造林樹種苗木共有烏心石、土肉桂、牛樟、紅豆杉及楓香。期中完成4種樹種(烏心石、土肉桂、牛樟及楓香)重要疫病蟲害種類的調查，期末完成剩餘4種樹種(桉樹、瓊崖海棠、白千層及紅豆杉)之重要疫病蟲害種類調查，並已完成資料收集及8種樹種病蟲害資料庫建立。本計畫另建立苗期各重要疫病害分子診斷技術。目前已完成對立枯絲核菌（*Rhizoctonia solani*）、腐霉病菌(*Pythium spp.*)、疫菌(*Phytophthora spp.*)及鐮孢菌(*Fusarium spp.*)聚合酶連鎖反應快速檢疫方法之建立，並更進一步利用分子診斷技術直接檢測土壤中重要林木疫病菌，及比較傳統及商業純化核酸方式的差異。初步結果已於98年度中華林學會論文發表。

The seedlings selected as important tree species for afforestation in 2009 were *Michelia formosana*, *Cinnamomum osmophloeum*, *Cinnamomum kanehirai*, *Taxus sumatrana*, and *Liquidambar formosana*. The investigation of the important types of diseases or pests in 4 tree species (*Michelia formosana*, *Cinnamomum osmophloeum*, *Cinnamomum kanehirai*, and *Liquidambar formosana*) was completed in the midterm; the investigation of the important types of diseases or pests in the remaining 4 tree species (*Eucalyptus spp.*, *Calophyllum inophyllum*, *Melaleuca leucadendra*, and *Taxus sumatrana*) was finished in the final. In addition, the data collection has been completed, and database of pests and diseases for the 8 tree species has been established. Our research also established molecular diagnostic techniques to all major pests and diseases at the seedling stage. We currently have developed the diagnostic techniques against *Rhizoctonia solani*, *Pythium spp.*, *Phytophthora spp.*, and *Fusarium spp.*, as well as completed the establishment of polymerase chain reaction (PCR) method for rapid quarantine. In order to detect the 4 pathogens of damping-off disease at the same time, we searched and designed the primer pairs specific to these pathogens and these primers could act at the same annealing temperature, 56℃, in PCR. In specific tests, each primer pairs could amplify only the correct DNA fragment of a target pathogen. Damping-off is the most common disease of seedlings, this new technique has already been used to detect pathogen in seedling roots and soil, and diagnosed damping-off disease for healthy forest seeds and seedlings. Moreover, we compared the differences between traditional and the new DNA purification methods. Preliminary results were published in 2009 Quarterly Journal of Chinese Forestry.



檢測土壤疫病菌流程SOP。

The SOP of the diagnostic techniques against soil diseases or pests.

林木病蟲害之診斷與諮詢研究

Integrated management of studies on the diagnosis and consultation of tree diseases and pests

莊鈴木

林木健康檢查開放性服務窗口，提供林木病因診斷諮詢以達到防治目的。林木疫情鑑定與資訊中心資訊網(http://health.tfri.gov.tw)，98年度林木疫情中心共完成病蟲害診斷鑑定服務工作500件，其中病害204件(40.8%)、蟲害110件(22%)、及其他原因(包含生理因素及物理因素)186件(37.2%)。病害以褐根病83件佔全部案件的16.6%，佔病害案件的40.68%，而蟲害以介殼蟲25件佔全部案件的5%，蟲害案件的22.7%為主。病蟲害服務之分佈區域以台北市70件為首，其次為台北縣59件。其經由網路通報件數約占全部服務案件的70%，達成單一窗口服務簡化的目標。本年度林木疫情電腦資訊軟體及網頁有持續的更新，且病蟲害資料皆已完成資料庫更新建立，讓使用者瀏覽時更加方便及友善，並將針對重大的林木病蟲害，開發有效的診斷試劑，以提升鑑定服務的效率。此外，更辦理病蟲害講習活動共11場。

In this project, a “Diagnosis Center of Forest Diseases and pests” has been set up to provide information and services of forest health management-related issues to the public. In addition, we’ve also renewed the database of forest pests on the website. A total of 500 cases of forest diseases or pests were identified since 2009, which contains 204 cases of plant diseases (40.8%),110 of insects (22%),and 186 of physiological agents (37.2%).

Among the plant diseases, 83 cases were brown root rot that made up 16.6% of the total cases and 40.68% of total plant diseases. Nevertheless, there were 25 scale insects cases that occupied 5% of the total cases and 22.7% of the insect cases. In regional distributions, Taipei city which had 70 cases, was the leader, followed by 59 cases in Taipei County. The cases reported through internet communications accounted approximately 70% of the overall services and this achieved the objectives of a simplified single-window service. This year computer software for forest diseases and website information continued to be updated, and the database on pests has been established and updated that will allow users to browse the web more conveniently and friendly. In connection with the major forest pests and diseases, we not only continued to develop more effective diagnostic reagents to enhance our service efficiency, but also held 11 pest workshop activities.

林木疫情鑑定與資訊中心網站首頁。

The front page of the website of the Diagnosis and Information Center of Forest Diseases and Pests.

珍貴及受保護林木健康性評估與管理之研究

Health evaluation and management of precious and conserved trees

張東柱

選擇受保護樹木為樣木，作為定期檢測的對象，進行樹木病蟲害的調查及檢測，並瞭解病蟲害對樹木健康性及樹幹材質的影響。應用樹木外觀健康性評量標準，評估樹木的健康活力，並調查樹木生長及環境間關係。應用不同的非破壞性技術評估受保護樹木的樹幹內部的腐朽空洞狀況。瞭解樹木的腐朽作用機制、樹木生長及環境的關係、樹木健康性評估及診斷腐朽空洞的非破壞性方法。

本計畫研究15個地區12種樹種133株樹木，除了野外現場調查之外，亦需進行實驗室的腐朽菌培養鑑定及材質基本檢測試驗，質化判斷及專業責任，並撰寫回覆報告，所有的檢測樹木皆為各地機關團體列管的受保護樹木，都具有文化或歷史價值。目視樹木外觀健康診斷評估樹木健康性的標準具有應用性價值，可陸續應用與改善；腐朽菌的調查發現白腐菌在闊葉樹較多，褐腐菌在針葉樹較多，褐根病沒有一定的樹種對象，發病是從根部開始往樹幹上方危害，使材質逐漸劣化。

Management and tending of protected tree is necessary in Taiwan, and there are no standard of evaluation for various tree disease, tree vitality, and tree risk rating. For this practice purpose, this study aims to explore the effects of various fungi on the living trees, to investigate tree health rating by visual tree assessment, and to display 2D profile of stem cross section on decay or damaged standing tree by nondestructive techniques. The experimental sites were selected from street trees, parking lots, and plantation plots. The sampled trees included precious and protected standing trees. Results of the research could provide information for set up management, and evaluation of tree health.

The investigative results of this year covered 133 trees (12 tree species) from 15 different plots. We made suggestions on various diseases, visual tree health inspection, and tree risk diagnosis methods for protected trees. The nondestructive techniques of tree risk diagnosis used included the first diagnosis measures (visual, hitting, and contact methods) and the second diagnosis measures (ultrasonic wave, electrical resistance, and increment core sampling, etc.). The experimental results often discovered other problems from the protected trees. Therefore, further research is need.

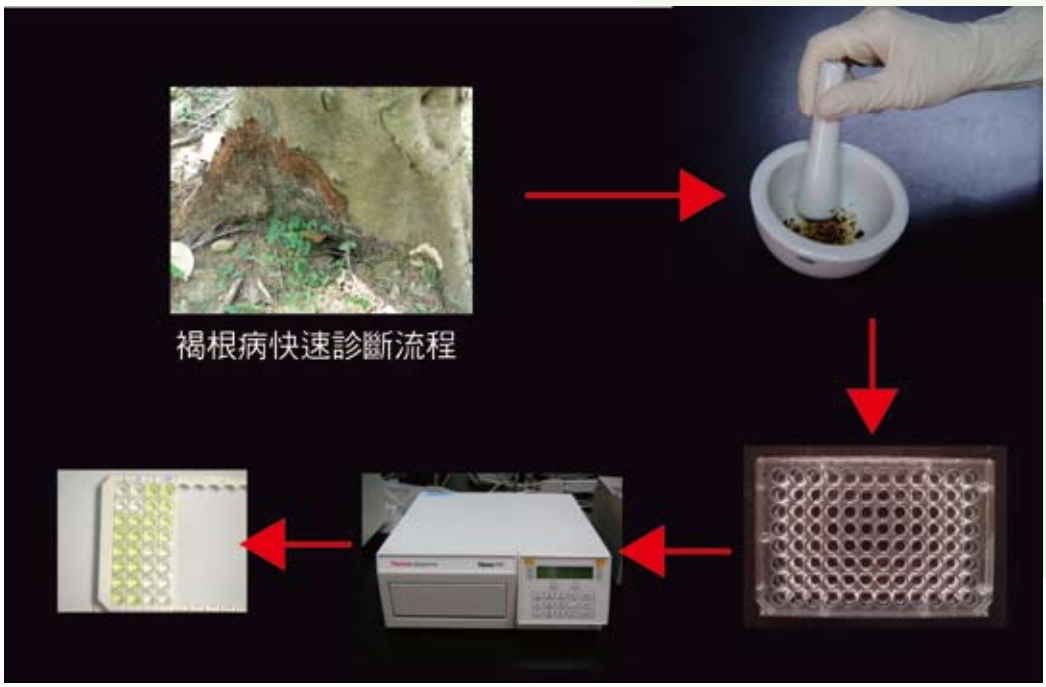
林木褐根病之簡易型驗菌試紙之研發及防治研究

Research on the preparation of a diagnostic strip and control of the tree brown root rot disease

吳孟玲

樹木褐根病(brown root rot disease)是台灣重要樹木病害之一，由病原真菌*Phellinus noxius*所引起，其寄主範圍極廣，台灣每年許多珍貴樹種皆因此而枯死，並有逐年擴大趨勢。樹木罹病初期不易以外部病徵診斷，為掌握防治先機與日益增加之診斷與檢測所需，本研究應用融合瘤(hybridoma) 技術，開發對褐根病菌具專一性之單元抗體，再利用酵素連結免疫吸附法(enzyme-linked immunosorbent assay = ELISA)，提供一套褐根病快速診斷方法。目前共篩選出14株對褐根病菌反應高，且對健康植物組織與其他相似真菌*Ganoderma sp.*與*Phellinus gilvus*反應低之專一性融合瘤細胞株。經單株化由其中選出高力價細胞株 (編號P-10-5) 生產抗腹水，抗腹水之力價測試可達到10-15。由抗腹水純化之單元抗體應用於田間病樹快速檢測，僅需0.5克根部組織即可檢查有無褐根病菌感染。未來本單元抗體將進一步製成膠金標誌套組(colloidal gold-labeling kit)，以提供更方便、不需儀器，而能立即於田間診斷之樹木褐根病檢測試劑。

Brown root rot caused by a pathogenic fungus, *Phellinus noxius*, is one of the most devastating diseases of forest trees in the world. Many valuable trees are destroyed by this pathogen every year in Taiwan. This disease is not easy to diagnose by its induced external symptoms especially in the early infection stage. This study was dedicated to develop monoclonal antibodies against *P. noxius* with the ELISA for rapid and sensitive diagnosis of brown root rot. In total, 14 clones selected from the cell lines of *hybridoma* showed positive for *P. noxius* in the ELISA tests whereas they were negative for the other similar species of fungi such as *Ganoderma* spp., and *Phellinus gilvus*. Among these 14 cell lines, a clone named "P-10-5" showing the best sensitivity and specificity was chosen to produce ascetic fluid and its titer can reach to 10-15. The monoclonal antibody derived from P-10-5 was further purified from ascetic fluid and used in the diagnosis of brown root rot. Our results in this paper demonstrated that only 0.5 g of diseased root tissue was enough to obtain the reliable data for the diagnosis in the ELISA tests. This monoclonal antibody will be further applied to the preparation of colloidal gold-labeling kit for more convenient diagnosis of brown root rot in the field.



單元抗體免疫酵素反應應用在褐根病快速診斷之流程。

The application of the monoclonal antibody immuno-enzyme reaction on fast diagnosis of brown root rot diseases.

以集水區觀點探討森林對空氣污染物之緩衝效能

Air pollutant buffering capacities of forest in a watershed

陸象豫

酸雨的主要成分為二氧化硫及氮氧化物，此等污染氣體是以懸浮微粒的狀態輸送，在都會區會對人體健康造成影響，同樣也會傳送到森林區域而影響到森林生態系。本研究乃在探討森林集水區對水溶性空氣污染物的交換作用，以明瞭森林對空氣污染物之離子交換功能。試驗地點為臺北縣文山林場，將所收集的林外雨、穿落水、土壤水及溪水樣品，攜回水質試驗室分析pH、電導度、懸浮值、陰陽離子及凱氏氮等，期以此等科學數據提供森林生態系對空氣污染物緩衝效能之佐證。

初步結果顯示，酸性的雨水經過林冠(穿落水)及土壤層，成為溪水後被中和變成弱鹼性。雨水所含的離子以Ca^{+2}、Na^{+}、H^{+}及HCO_3^-為主，顯示此區的雨水受塵土及海鹽的影響極大；至穿落水則H^{+}大部份被交換吸收，並淋溶出大量的K^{+}；土壤水及溪水皆以Na^{+}和HCO_3^-為主，SO_4^{-2}因常與Ca^{+2}結合並以$CaSO_4$的形式流到溪流中，因此提高Ca^{+2}在溪水中之濃度。HCO_3^-能做為溪流水的酸中和能力和地區性土壤礦物風化程度的指標，故也證明此森林對酸沉降具有緩衝效能。

The 2 major ionic contents of acid precipitation are SO_2 and NOx, which are transported by suspended solids. Those air pollutants will not only affect people's health but also the well-being of forest ecosystem. The aims of this project are to study ion exchanges between precipitation and forest ecosystem, and to understand the buffering capacity of forest ecosystem on air pollution. Bulk precipitation, throughfall, soil solution, and stream water were collected in the Wenshan Forest District and analyzed for their pH, conductivity, solid, cations, anions, and nitrate to investigate the attenuating ability of forest ecosystem on air pollutants. Those scientific data are believedto provide good information for identifying the buffering capacity of forest ecosystem on air pollutants.

The primary results indicated that the acid precipitation in the study will be neutralized after passing through canopy and soil layers and transfer to alkaline when it drained into stream as streamflow. The major ions of acid deposition were Ca^{+2}, Na^{+}, H^{+} and HCO_3^- which are the results of heavy dusts and sea salt depositions in this area. A lots of H ion were exchanged and absorbed but K^{+} were leached out after passing through canopy. The major ions of soil solution and stream water were Na^{+} and HCO_3^-. SO_4^{-2} always combing with Ca^{+2} transported into stream in the type of $CaSO_4$. For this reason, it caused an increasing of Ca^{+2} content for stream water. HCO_3^- could be considered as an index about the ability to neutralize acids in streamflow and the degree of weathering for mineral soils. It also proved that the forest in the study area have the ability of buffering acid precipitations.

森林防火樹種選育與防火林帶建造研究

Selection of fire prevention species and building of vegetative fuel break system

林朝欽

燃料防火線建造的主要目的是為切斷燃料連續性，以達成阻斷森林火災傳播危險，因此必需定期清除地表之可燃物以達到阻斷林火傳播之功能；但由於許多林地長期裸露產生土壤衝蝕問題、地表清除原生植物後造成外來物種入侵機會、景觀的考慮、以及森林火災常發生團火 飛越防火線等因素，造成燃料防火線系統功能不如預期。恢復燃料防火線植生，改成具有防火、水土保育及林產功能的防火林帶觀念逐漸被提出及推行，此類具有植物覆蓋的防火線被稱為防火林帶或林帶防火線。

1968年起林務局執行聯合國補助之林相變更計畫，大甲溪事業區為林相變更計畫造林區之一，主要造林樹種為台灣二葉松，之後為德基水庫水源涵養亦加強造林，雖混有其他樹種但仍以台灣二葉松為主，目前於大甲溪事業區人工造林地約11,600公頃，有鑑於大面積松林面臨森林火災危險，造林地內分別建立永久防火線，防火線寬度分為：5、10、15、30及50m五類，防火線每年需花費約二千萬元於乾燥季前清除地表燃料。但1968-2006年間有68次森林火災發生在設置有防火線之林班間，其中燒越防火線之紀錄有11次。因此，東勢林區於1990年起試行於防火線上栽植闊葉樹，試圖建立防火林帶以有效防範大面積火燒的擴展。目前大甲溪事業區已有8個林班建立防火林帶，本研究擬依據防火樹種之燃料性、生物與生態性、造林性檢測各栽植的防火樹種，並選育較能阻絕林火之種類，配合育林技術提出建置防火林帶之技術與操作實務。

The main purpose of building the fuel break system is to prevent the danger of fire spread when it ignites. It is necessary to frequently remove all above-ground fuels from the fuel breaks to keep them functioning properly. However, due to long term soil erosion, invasion of alien species, landscape and spotting fire concerns for the fuel break system, replant of vegetation in the current fuel break system is thought to not only prevent fire hazards but also increase productivity of forestland. Therefore, the vegetative fuel break system is promoted and adapted as an alternative of fire management tool.

Species selected to replant on the fuel break system are those having properties of fire resistance which can delay the ignition of fire. In 1968, a forest conversion project sponsored by FAO was executed in Taiwan by the Taiwan Forest Bureau. The Dajashi area was one of the forest districts of that project to convert the original hardwood forest into stands of a fast growing Taiwan red pine. A total of 11,600 ha were planted in the area. In order to prevent forest fire danger, a fuel break system has been implemented since 1970. There are 5 categories of fuel breaks, ranging from a width of 5 m to 50 m. Annually, the cost of cleaning the above-ground fuels costs about NT$ 2 million. However, there were 68 fire outbreaks in the area during 1968 to 2006. Among them, 11 burned cross fuel breaks. Thus, changing the fuel break system to a vegetative fuel break system has been proposed and tested. The main purpose of this study is to select suitable species for build the vegetative fuel break system. Based on evaluation of the fuel break system and the post-fire surveys, the study will review and list the chosen species, and collect the seeds of the species to be use. Once the seedlings are bred, we will test these species in the experiment forest of Taiwan Forest Research Institute. The final goal will be preparation of a handbook to guide the practice of build vegetative fuel break system.

防火樹種育苗情形。
Seedlings of selected fire prevention speries.

海岸林飛砂防治之研究

Study on the prevention of shifting sands in coastal windbreak forests

陳財輝

飛砂起動機制主要由風速、風向、砂粒粒徑大小及砂體含水率特性影響，據此定砂作業主要為減緩風速並固定、攔阻砂源。飛砂接近地表的移動模式為滾動及跳躍兩種，其活動範圍皆在1m以下，而長久以來海岸地區廣泛架設堆砂籬作為抑制移動性飛砂危害的方法。本計畫著重於海岸移動性飛砂起動機制的探討，以及堆砂籬防治飛砂之有效性觀測，並同時進行室內風洞試驗與現地觀測。

在現地實驗方面，以苑裡濱海為試區，架設BSNE垂直集砂器及多層風速計等進行觀測。假設間距10m的堆砂籬，其每1 m斷面有堆砂10 m^3功效，於東北季風期間進行觀測，堆砂籬之攔砂量為87.62%，平均單位面積(m^2)之攔砂量為8.71 m^3，據此獲得在間距10m，攔砂功效為87.62%。若從砂丘最高點為界分為迎風面與背風面兩邊作探討，迎風面最先獲得飛砂，當迎風面砂丘幾乎堆滿至堆砂籬所能定砂之高度，多餘之飛砂則會逐漸往背風面移動，因此背風面的堆砂時間與堆砂量，相較於迎風面較晚且較少；經量測砂丘迎風面之攔砂功效高達98.57%，而背風面之攔砂功效為74.92%，若背風面定砂功效低於20%時，應再行評估是否施設堆砂籬。

現地以BSNE垂直式集砂器，收集高度0.1~1.5 m範圍之飛砂量，因1.5 m以上飛砂量已幾乎沒有，將0.1~1.5 m飛砂量進行積分，求得結果代表0.1 m以上之總飛砂量為20.21 g，0.1m以下則由風洞試驗進行，求得總體飛砂量推估式為：$Q=14.4858\times(U_{0.25})^2\div[(g\times d_{50}\times\sigma\div\rho\times w)-0.1208]\times d_{50}\times U_{0.25}\times\sigma$

另室內砂粒物性實驗結果得知，在樣區後龍、苑裡、大安及大甲濱海地區土壤質地皆為砂土，其密度介於2.62至2.67 g/cm^3之間；粒徑分布則在0.25~0.42 mm者最多；含水率皆在1%以下。風洞測定砂粒粒徑介於0.15~0.84 mm時，其起始風速為5.5~7.0 m/s，又粒徑在0.15 mm以下之砂粒，其起始風速為5 m/s；當砂粒含水率低於1.22%時，飛砂量達到最大值；含水率由1.24%遞增至1.84%時，飛砂量急遽遞減；而含水率達4.35%時，對砂粒起動之抑制作用達到最大值。

Mechanism of initiating shifting sands is dominated by wind speed, wind direction, grains size of the sands, and surface sand moisture content etc. In view of these, the sand stabilizing operations expect to slow down the wind speed, regulate the pass through amount of shifting sand, and block the sand source. The close to the surface aeolian sand motion modes are creep and saltation, the both activities are less than 1 m. Sand fixing hedge has been using at Taiwan's seacoasts to inhibit the aeolian sand hazard.

This study focuses on the discussion about initiating mechanism of coastal aeolian sands, and survey of the effectiveness of sand-fixing hedge. We used wind tunnel experiments and field survey in the approaches.

The field experiments set BSNE sand collector and multi-layer anemometer for survey at the Yuanli coast. We assumed that a 1 m cross section of sand-fixing hedge spaced 10 m apart would fix ca. a 10 m^3 dune. During the northeast monsoon wind season, the sand-fixing hedge can fix aeolian sands up to 87.62%, the average unit area fixed aeolian sands for 8.71 m^3. According to the results, efficiency of a 10 m pitch about the sand-fixing hedge was 87.62%. From the highest point, a dune is divided into windward and leeward sides for the discussion, the windward side carries off sands first, when the windward side of dune is stacked up to full heights, the excess shifting sands will gradually move to the leeward side. Therefore, the amassing time and amount of aeolian sands at the leeward side are both later and less than the windward side. According to our surveys, the efficiency of fixed sand is 98.57% on the windward sand dune, and that on the other side is 74.92%.

The field study applied BSNE sand collectors for gathering sand samples at the heights 0.1~1.5 m above ground, and there are few sands above 1.5 m. We integrated the sand amounts of 0.1~1.5 m range; the results represented the total above the 0.1 m level was 20.21 g; whereas the sand amounts below the 0.1 m level was assessed using a wind tunnel experiment. The function of the aeolian sands is:

$Q=14.4858\times(U_{0.25})^2\div[(g\times d_{50}\times\sigma\div\rho\times w)-0.1208]\times d_{50}\times U_{0.25}\times\sigma$

Results of the indoor experiments show that 4 plots at Houlong, Yuanli, Da-an and Da-jia on the coastal areas are all sandy soils. Their sand densities were between 2.62 and 2.67 g/cm^3. The particle diameters were mostly between 0.25~0.42 mm. The soil moisture contents were all below 1%. Results of wind tunnel experiments indicated that when particle diameters of the sands were between 0.15 and 0.84 mm, the initiating wind speed for sand motion was 5.5 to 7.0 m/s, and when the particle diameters of sands were smaller than 0.15 mm, the initiating wind speed for sand motion was 5 m/s. When moisture content of the sand particles was less than 1.22%, the aeolian sand amounts reached maximum; and at moisture content from 1.24% to 1.84%, the aeolian sand amounts decreased rapidly. When moisture content reached 4.35%, the preventive function for the amounts of shifting sand motion reached a maximum.

墾丁熱帶海岸林天然更新復舊潛力之研究

Study on the restorative potential through natural regeneration at the Kenting tropical coastal forest

王相華

本研究對墾丁地區現存熱帶海岸林木本植物組成及土壤種子庫進行調查，瞭解可供天然更新之潛在材料組成、數量，用以評估採天然更新方式復育受銀合歡入侵海岸林之可行性。相較於老熟林，次生林之植株密度較高、胸高斷面積較低，且多為銀合歡、稜果榕、黃槿、構樹等偏陽性樹種，鮮少有棋盤腳、蓮葉桐等典型海岸林之大型優勢喬木。墾丁熱帶次生海岸林內有密度極高(234株/m^2)的原生先驅樹種土壤種子庫，如稜果榕、血桐、構樹、山黃麻等，可提供為更新之天然材料。

This research focused on the investigation of forest trees and soil seed bank compositions at the Kenting tropical coastal forest. The purpose was to understand the potential of restoring the *Leucaena leucocephala* invaded coastal forest through the means of natural regeneration. Comparing to the primary coastal forest, the secondary forest is higher in tree density and lower in tree basal area. The secondary forest is mainly composed of pioneer trees, such as *Ficus septica*, *Hibiscus tiliaceus*, *Broussonetia papyrifera*; and a few dominant tree species of the primary coastal forest, such as *Barringtonia asiatica* and *Hernandia nymphiifolia*. The Kenting secondary coastal forest has very high density of pioneer tree soil seed bank (234/m^2), which could be good materials for natural regeneration at the sites.

由土壤種子庫萌發的大量陽性木本植物幼苗。
Many seedlings of pioneer woody plants germinated from the soil seed bank.

再生紙張品質的改良及紙張性質之研究

Study on improving the quality of paper made from recycle fibers

何振隆

本年度完成廢紙及瓦楞紙版之芯紙板回收-利用-再生過程中纖維性質及紙張性質之變化研究，以做為後續纖維及紙張性質改良，並使用鹼、酵素、嵩高劑及紙力增厚劑等處理方法，以期達到增強或改善紙張性質，進而提高再生纖維的使用範圍、時間等以延續纖維之生命週期與減少利用原生紙漿之多項目的。纖維經過回收後之力學性質，除撕裂強度外，其餘強度性質均為呈現下降之勢，此為纖維性質產生表面角質化緣故，導致活性羥基含量減少，因而減少纖維與纖維間結合性，使廢紙、裱面紙板及瓦楞芯紙之保水值分別下降42、45及39%。由化學組成來看，兩種紙之全纖維素含量大幅下降，且羥基含量亦減少，使紙力下降。因此為了使纖維改質，故以鹼、酵素、嵩高劑及紙力增厚劑等處理方法：

1、鹼10~20%及以70~90℃熱水處理30分鐘做為改質條件，可使保水值增加，更可使紙品成為高嵩度且物理性質提昇之紙板。
2、使用三種酵素LDI、CS及LBR以3 U/g絕乾漿重，能使紙張力學性質提升，但酵素用量若提高至5 U/g絕乾漿重時，反而使纖維遭受破壞而使纖維強度下降。在酵素的處理功效上以LDI處理的紙漿纖維在各項力學強度的表現上最好。
3、嵩高劑及紙力增厚劑添加於此三種紙漿均無法達到改善紙張性質之效果。此結果對於國內造紙業者技術之提昇，貢獻非常大。

This year, we completed the study on the changes in fiber properties and paper properties from recovered wastepaper and OCC board in cycles of recycling and reuse. The information served as the basis of subsequent paper property improvements. Alkali, enzymes, bulking agents and strengthening agents were applied to the recycled stocks to achieve strengthening or property improvement purposes. The results might help extend wastepaper use, prolong its life cycle and reduce virgin pulp requirements. Except for tearing strength, recycled paper strength properties all showed decreasing trends. This was caused by hornification of the fiber surface, leading to reduced hydroxyl groups and diminished bonding. The water retention value of waste printing and writing paper, liner and corrugating medium decreased 42, 45 and 39%, respectively. Holocellulose content of both recycled paper types showed marked decreases, and hydroxyl groups were also reduced, causing paper strengths to decrease. Improvement measures using alkali, enzymes, bulking and strengthening agents produced the following results:

1 Treating with 10~20% alkali and 70~90℃ temperature for 30 min increased water retention value and produced a higher bulk paper and physically enhanced paperboard.

2 Three enzymes of LDI, CS and LBR at 3 U/g dry pulp dosage caused paper tensile strength to increase. If a 5 U/g dosage was used, however, cellulose was damaged and strengths decreased. Performance of LDI enzyme allowed superior paper strengths to develop.

3 Bulking and strengthening agent were unable to achieve the desired paper strengths improvement.

These results are expected to contribute to the technical upgrading of the domestic papermakers.

竹材品質對燒製竹炭之影響

Effects of bamboo quality on the charcoal manufacturing

黃國雄

本研究之目的在探討竹材年齡與生長部位對竹炭性質之影響，試驗中以4種年齡(1至4年生)與4種生長部位(高度0.5、3.0、6與10 m)之麻竹為試材，將其鋸製成長度14 cm之竹片，利用實驗室小型機械窯於炭化溫度500-900℃燒製竹炭，溫度上升速度設定為100℃/h，至所定之炭化塭度後持溫時間為1h。燒製前先將竹材以105℃乾燥至絕乾並秤其重量，完成燒製後再秤取竹炭重量並計算收炭率。為了瞭解炭化溫度對竹炭性質之影響而進行測試，項目包括表面電阻、pH與真密度等。由試驗結果得知竹炭之收炭率隨炭化溫度之增高而明顯減少，表面電阻受竹材年齡與竹桿高度之影響不明顯，但受炭化溫度之增高而明顯減小， pH受竹材年齡、竹桿高度與炭化溫度之影響不明顯，真密度為1.45-2.20 g/cm^3，在任一竹材年齡或竹桿高度下，其真密度均隨炭化溫度之增高而明顯增大。

The purpose of this research was to investigate the effect of bamboo quality, including age, and growth position, on the properties of bamboo charcoal. Ma bamboo with 4 different ages (1~4-years-old) were cut to 14 cm length from different positions at 0.5 m, 3.0 m, 6.0 m and 10.0 m heights along the culms for charcoal making in an experimental kiln. The carbonization temperatures were set from 500 to 900 ℃ in a 100℃/h temperature rise rate. The pH, electric resistance, and true density of the resulting charcoals were measured to understand their properties. The electrical resistance of bamboo charcoals was not obviously affected by the age or height along the bamboo culms, but was affected by the carbonization temperatures. The pH of bamboo charcoal was also not obviously affected all factors. The true density of bamboo charcoal, in the range of 1.45~2.20 g/cm^3, showed obvious differences with the temperatures of carbonization.

竹材之乾燥與保存研究

Study on the drying and preservation of bamboo wood

李銘鐘、周群

行政院六大新興產業其中農業精品發展包括竹製精品。木竹材加工利用首重材料之乾燥。本研究共進行4窯次四年生麻竹之高溫乾燥及傳統乾燥。第1窯次高溫乾燥麻竹試材生材含水率(39-107%)，經17.0小時乾燥後含水率降至(2-24%)，電力消耗114度，乾燥速率3.31(Mc%/hr)；第2窯次傳統乾燥麻竹試材生材含水率(28-64%)，經69.5小時乾燥後含水率降至(2-26%)，電力消耗288度，乾燥速率0.61(Mc%/hr)。第3窯次高溫乾燥麻竹試材生材含水率(62-112%)，經22.5小時乾燥後含水率降至(1-18%)，電力消耗142度，乾燥速率3.28(Mc%/hr)。第4窯次傳統乾燥麻竹試材生材含水率(38-67%)，經75.5小時乾燥後含水率降至(2-26%)，電力消耗328度，乾燥速率0.62(Mc%/hr)。

1%蘇打熱水處理之麻竹試材經乾燥後強度較差。麻竹材質變異大，故乾燥後試材含水率差距大。

Exquisite bamboo products are one of the 6 new refined agricultural products industries promulgated by the Executive Yuan. Seasoning of the material is of primary importance in processing wood and bamboo. Four kiln-drying schedules were conducted on ma bamboo to examine effects of high-temperature and traditional drying. Moisture content of green ma bamboos used in the first high-temperature kiln drying was between 39~107%, which decreased to 2~24% after 17.0 h of drying with an electricity consumption of 114 kWh and a drying speed of 3.31 Mc%/h. Moisture content of green ma bamboos used in the second traditional kiln drying was between 28~64%, which decreased to 2~26% after 69.5 h of drying with an electricity consumption of 288 kWh and a drying speed of 0.61 Mc%/h. Moisture content of green ma bamboos used in the third high-temperature kiln drying was between 62~112%, which decreased to 1~18 % after 22.5 h of drying with an electricity consumption of 142 kWh and a drying speed of 3.28 Mc%/h. Moisture content of green ma bamboos used in the fourth traditional kiln drying was between 38~67% which decreased to 2~26% after 75.5 h of drying with an electricity consumption of 328 kWh and a drying speed of 0.62 Mc%/h. Strength of the ma bamboo treated with a 1% hot soda solution was inferior after drying. The large strength variation in the untreated ma bamboo induced large variation of moisture content in the dried specimens.

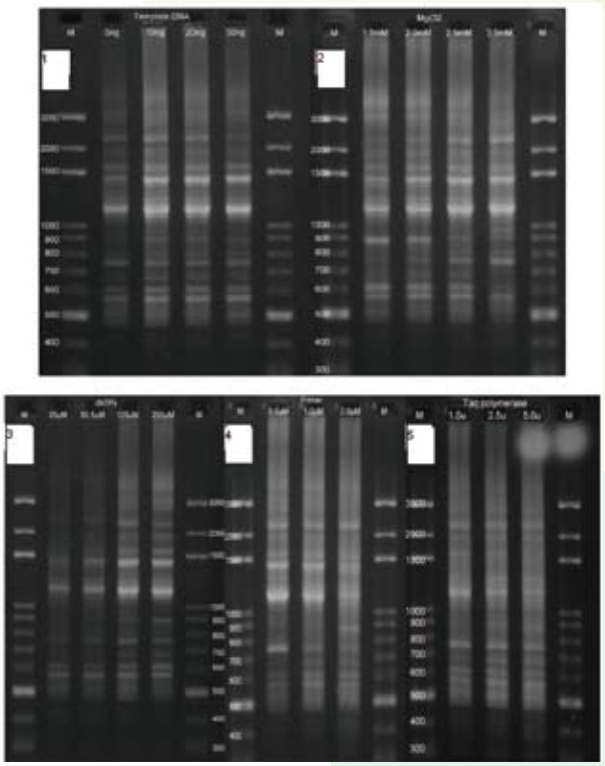
品系分子標誌選拔及基因選殖

Molecular markers and gene cloning for Camellia oil tea trees

蕭棠文

本計畫欲利用分子鑑別技術探討國內油茶栽培品系，共收集92株小果種栽培樣品、3株短柱山茶野生種、6株細葉山茶野生種、6株大果種栽培樣品，另外也收集2株日本山茶及2株茶梅作為對照組。樣品葉片利用AxyPrep Multisource Genomic DNAMiniprep Kit （Axygen, XG）試劑組抽取DNA，透過限制酵素TaqI作用核DNA之ITS、葉綠體DNA之trnDT及trnLF片段之分析，發現大、小果種油茶之間並無差異性。此外亦以條件最適化之RAPD配合9個引子進行試驗，結果發現雖然RAPD可以區別各別樣品，卻不見區別大、小果種油茶之分子標誌，後續試驗將繼續嘗試其他引子並新增ISSR等試驗以達鑑別品系之目的。

In this study, we utilized molecular techniques to identify *Camellia tenuifolia* and *C. oleifera*. We chose an AxyPrep Multisource Genomic DNA Miniprep Kit to extract *Camellia* leaf tissues in order to recover quality DNA. According to our study, digestion of the ITS, trnDT and trnLF fragments using restriction enzyme TaqI did not reveal polymorphism among samples. We further used RAPD to differentiate the 2 *Camellia* species. After optimal reaction conditions were established, we conducted 9 RAPD reactions. Although there were polymorphisms in samples, there were no distinct bands to differentiate the 2 *Camellia* species. We will continue to work on it in order to find molecular markers capable of distinguishing *Camellia* tenuifolia from *C. oleifera*.



油茶葉片DNA 之RAPD 最佳條件篩選試驗。1.為模板DNA 添加量。2.為$MgCl_2$ 添加量。3.為dNTPs 添加量。4.為引子添加量。5.為Taq DNA 聚合酵素添加量。

Screening test for optimal RAPD reaction for leaf of *Camellia tenuifolia* and *C. oleifera*. 1. DNA; 2. $MgCl_2$; 3. dNTPs; 4. Primer; 5. Taq.

竹材栽培、採收、分級處理技術規範

Establishing technical norms of cultivation, felling and classification treatment for bamboo wood

陳財輝

竹林具有快速生長及容易繁殖的特性，且台灣之栽培面積大，前幾年竹產業沒落，以致多數竹林呈現荒廢狀態。最近竹炭及竹醋液等加工利用產業提供竹林加工新用途，為提昇竹炭、竹醋液生產所需竹材原料品質，有關竹林之栽培，伐採收獲及分級技術等需儘速加以研訂，所以本試驗分為竹林生長調查、竹材性質測定及竹材分級標準試定三部分進行。

在竹林生長調查部分，桂竹林試區設在石門水庫集水區及南投蓮華池，而孟宗竹則設在南投惠蓀及嘉義石棹。石門水庫集水區桂竹林分密度介於15,700～18,767 culms ha^{-1}，胸徑分佈於4.7～5.9 cm，且高齡級之竹株較多，顯示竹林已開始老化，應適度疏伐老齡竹材，以維持林分的生產力，生物量累積在40.99～81.68 ton ha^{-1}之間。蓮華池桂竹樣區密度介於18,000~20,000 culms ha^{-1}，胸徑大小則多數分佈在2~3 cm之間，竹高則不超過7.5 m，生物量介於14.5至23.7 ton ha^{-1}之間。由上可知石門水庫集水區桂竹林生長狀況優於蓮華池，此與生育地之環境因子有關。

惠蓀林場孟宗竹密度為7,933 culms ha^{-1}，地上部稈乾量為57.87 ton ha^{-1}；阿里山石棹孟宗竹則為8,344 culms ha^{-1}，而地上部稈乾量則為171.34 ton ha^{-1}。由此可知石棹之孟宗竹林分生長發育較良好，但二地之齡級株數比例皆有竹齡越小，株數比例越少之衰退老化趨勢，故需適度擇伐老竹與不良竹，提供充足空間給幼竹生長，方可提升此兩地孟宗竹林之生產力。

竹材性質測定係利用萬能材料機進行抗拉強度試驗，結果發現桂竹1年生根莖最大荷重為869 kgf，2年生根莖最大荷重935 kgf，3年生根莖最大荷重927 kgf，而枯死根莖最大荷重為356 kgf。顯示3年生之竹材根徑，可承受較大之拉力。

竹材分級標準係依竹稈長度大小整齊、竹稈外表整潔、外觀有無龜裂、擦痕缺點等，以及竹稈頭徑與末口徑大小、節間長、竹稈重量及病蟲害等不同性狀，試訂孟宗竹林竹稈之分級標準。目前市場孟宗竹材交易調查，竹材尺寸大小，可分為長度10尺(頭部直徑3, 4寸)及14尺(3, 4, 5寸)等5種規格。根據本試驗之調查結果將桂竹竹材分為優、中、劣三等，優等者其稈的直徑>5.5 cm，稈材顏色濃綠色，外型通直；中等者稈的直徑4.5~5.5 cm，稈材顏色綠色，外型略微通直；劣等者稈的直徑<4.5 cm，稈材顏色偏黃褐色，有藤蔓纏繞或彎曲。在孟宗竹的部分，桿材直徑優等為>10 cm，中等為8~10 cm，劣等為8 cm，其他外型與桂竹相同。

The properties of bamboo forest are fast-growing and easily reproducing. There are many bamboo cultivation areas in Taiwan. In past years, the bamboo industry is in decline, causing many cultivated bamboo forests to be abandoned. Recently, bamboo converting industry such as bamboo charcoals, and vinegars provide some new purposes. In order to promote the quality of bamboo materials used in the bamboo charcoals and vinegars production, studies on the cultivation, harvesting, and classification of bamboos are necessary. Therefore, this study was separated into bamboo growth investigation, bamboo property tests, and bamboo classification.

In bamboo growth investigation, experiment plots of the makino bamboo (*Phyllostachys makinoi*) were located in the Shihment Reservoir watershed and Lienhuachih. The moso bamboo (*Phyllostachys pubescens*) plots were located in Hui-Sun Experimental Forest Station and Shi-Zhuo, Chiayi. Density of makino bamboo in the Shihment Reservoir watershed was between 15,700~18,767 culms ha^{-1}. The diameter distribution was between 4.7~5.9 cm, and high frequencies of old bamboos were found on most sites, indicating that the bamboos on those sites were senescent. It should be thinned to remove the old culms in order to maintain the productivity of the stand. The biomass accumulation was between 40.99~81.68 ton ha^{-1}. Stand density of the makino bamboo at Lienhuachih was between 18,000~20,000 culms ha^{-1}. The diameter distribution was between 2~3 cm and the hight of bamboo was < 7.5 m. The above-ground biomass was between 14.5~23.7 ton ha^{-1}. According to the results, we knew that the makino bamboo forest at the Shihment Reservoir watershed was in better conditions than those growing at the Lienhuachih plots.

Density of the moso bamboo at the Hui-Sun forest was 7,933 culms ha^{-1} and the culms biomass was 57.87 ton ha^{-1}. Density of the moso bamboo at Shi-Zhuo of Alishan was 8,344 culms ha^{-1}, and the culms biomass was 171.34 ton ha^{-1}. According to the results, moso bamboo stands at Shi-Zhuo were better than those at Hui-Sun. But age classification ratios of the 2 sites were having the same trend; i.e., when the age was younger, the biomass ratio was less. This trend indicated that the bamboo forest was becoming degenerated. Therefore, moderate selective harvesting of old and bad bamboos to provide spaces for junior bamboo growth is needed. The results suggested that the practice could promote bamboo forest production at the 2 locations.

A universal material testing machine was used to test the bamboo tensile strength properties, The results indicated that maximum loadings of the 1, 2, 3-year-old, and dead bamboo rhizomes were 869, 935, 927, and 356 kgf, respectively; indicating that the 3-year-old bamboo rhizome could tolerant the highest pulling force.

Bamboo classification was based on the following criteria: evenness of culm lengths; surface cleanliness; presence or absence of defects such as crack, and scratch mark; diameters of the tops and bottoms of culms; length of the internode; weight of the culms, and presence or absence of disease and insect infestation etc. Stand classification of mono bamboo was carried out according to the market rules which entailed separating bamboo culms sizes into five grades: the 10-footers (with 2 head diameter grades of 3, and 4 inches) and 14-footers (with 3 head diameter grades of 3, 4, and 5 inches). We also classified the makino bamboo culms into three grades: the best, medium, and poor. The best ones have diameters > 5.5 cm; culm color of deep green; and is straight. The medium ones have diameters of 4.5~5.5 cm; a green culm color; and is roughly straight. The poor ones have diameters < 4.5 cm; yellow or brown culm color; often have vines wrapped around and curved. In moso bamboos, diameters of the best ones > 10 cm; the medium ones are 8~10 cm; and the poor ones < 8 cm. The other characteristics are similar to those of the makino bamboo.

竹材成熟度與材質評估之研究

Evaluation of bamboo maturity and material properties

李銘鐘

本研究以應力波法進行立地麻竹稈之音速檢測，第三季檢測各年生應力波音速均有增加之趨勢。麻竹生材比重未滿一年生平均0.67、二年生平均0.74、三年生平均0.79和四年生平均0.79。麻竹生材試材(含水率100%以上)破壞強度(MOR)以三年生平均985 (kgf/cm^2)最大。麻竹氣乾材(含水率13%)破壞強度(MOR)以三年生平均1449(kgf/cm^2)最大。各年生麻竹氣乾材音速均較麻竹生材試材音速大，增加百分比為未滿一年生平均52.6%、二年生平均65.6%、三年生平均21.2% 、四年生平均35.3%和五年生平均37.9%。四年生氣乾桂竹稈打音振動檢測同株桂竹每段音速。音速由第1段漸增，第2、3段持平，第4、5段音速漸減。應力波檢測4年生氣乾同株桂竹每段需以同側量測，方能避免因不同側而造成之誤差。竹農依竹稈色澤和側枝節數判斷竹齡，但雖同一立地各年生竹材之生長受各氣候因子影響，生長量不一致，強度不一。今以應力波法及打音法可正確分辨出竹材立稈生材之非破壞性強度，可提高竹材之利用價值及竹農之收益。

Non-destructive testing was conducted on ma bamboo culms on site. The sound velocity by the stress wave method in fall increased with bamboo age. Average specific gravities of green ma bamboo were 0.67, 0.74, 0.79, and 0.79 for culms < 1-, 2-, 3-, and 4-year-old, respectively. Both 3-year-old green, and air-dried ma bamboo (moisture content > 100%, and 13%, respectively) have the highest average modulus of rupture (985, and 1449 kgf/cm^2, respectively). Sound velocity of air-dried ma bamboo in each age group was greater than those of green ones. The percentage increases were 52.6, 65.6, 21.2, 35.3, and 37.9% for < 1-, 2-, 3-, 4-, and 5-year-old ma bamboo, respectively. Tap-tone vibration test was conducted on different sections of the same air-dried makino bamboo culms. Results showed that sound velocity increased height-wise gradually from segment 1 to 2, maintained through segment 3, then decreased in the segments 4 and 5. The same side of each segment of air-dried, 4-year-old makino bamboo was tested using a conducting stress wave test to avoid variation due to different sides. The age of bamboo can be judged by bamboo farmer according to culm color, and node number in branches. Growth and strength of bamboos in the same stand, however, were affected by the climate. Stress wave and tap-tone vibration tests can accurately distinguish the non-destructive strength of green bamboo culms on site. These add values to bamboo and create profit for bamboo farmer.

竹材材質處理技術規範

Material treatment technical specification of bamboo wood

王瀛生

竹藝品之品質與竹材原料息息相關，面對大陸龐大竹林資源及廉價工資的競爭，擬以認證手段建立材質處理之標準條件，確保竹材原料品質，鼓勵業者經營專業備料廠供應下游加工廠，配合優質設計及經營效率，盼能區隔大陸廉價量產產品。加工竹原料材材質處理之認證準則如下：

1. 竹材表面除污除油處理是竹材加工品質保障的第一關卡，尤其以製作竹管家具或少量精製加工作品時，更需注重竹材表面的完整性。以手持瓦斯噴燈除污除油時，據稱蟲蛀機會較低。為兼顧量產效率而以大型蒸煮槽採自動進料處理者，遭蟲蛀機會反而較高。桂竹本具備較不易蟲蛀特性，如確保竹齡在4年生以上，其蟲蛀機會將更低。
2. 漂白處理係將除污除油處理後，其表面需更加白皙均勻者，進一步以雙氧水煮沸約1小時再取出氣乾。如處理材料為供外銷加工產品，則須進一步監測雙氧水殘餘量是否在安全範圍內。
3. 高溫蒸汽處理者雖可達預期褐色處理效果，但仍須注意含水量的控制，否則仍有再遭蟲蛀機會。
4. 煙燻處理是日本人極為喜愛的傳統處理方法，竹青光澤度佳，色澤持久自然。先經長時間氣乾，再進窯煙燻處理者，色澤較淡。以生材直接進窯煙燻處理者，色澤較深。前者相對較耐蟲蛀。
5. 高溫低氧炭化處理竹材與煙燻處理竹材相較，前者竹青光澤度較差，竹青與竹肉色澤較一致，較耐蟲蛀。
6. 紋飾處理常見於竹管家具、器具製作，近年來，紋飾處理已漸不流行。
7. 車鏇處理僅見於筆筒、花器製作，屬個人技術層面，惟未經妥善乾燥處理者，極易龜裂。
8. 噴砂處理早已普遍應用於業者噴製設計圖案及表面精緻處理之利器，惟金剛砂殘留表面之清除，宜加留意。供噴砂處理之竹材宜採氣乾或窯乾材，避免以生材為之，可得較佳之噴砂處理效果。

Standard treatment procedures of surface cleaning, high temperature and low pressure steaming treatment, smoking treatment, high temperature hypoxic charring treatment, figure marking, rotary cutting, and sand blasting of the makino bamboo materials were established to offer manufacturers the know-how on handling high-quality raw materials, and ensuring the quality of products following the protocols. The protocols also allow reduction of material costs, improve product competitiveness establish an international brand images of exquisite handicraft bamboo products, and effectively differentiate the products from the low-priced items produced in China or southeast Asia.

桂竹圓竹表面除污及除油處理。
Surface cleaning of Makino bamboo culms.

孟宗竹竹片及圓竹煙燻處理。
Smoking treatment of the culms and sliced culms of moso bamboo.

造紙功能性奈米添加劑之開發研究

Development of functional nano-additives for papermaking

王益真

本年度進行添加奈米絹雲母塗布紙研製之後續工作。進行以奈米絹雲母修飾乳膠後再配製塗料之系列試驗，對乳膠添加量1%以下即已使乳膠及塗料之保水性降低、低與高剪力黏度升高。前此鑑於直接添加奈米絹雲母為顏料配方一部份時造成操作性困難，本系列試驗則顯示修飾乳膠未能有效改善之。後續將添加不同劑量分散劑至塗料配方並觀察其效果。進行以含浸法添加奈米銀與奈米二氧化鈦製備殺菌紙與光觸媒機能紙之開發，目前結果顯示以奈米銀製備之抗菌紙有殺菌效果。

This year we undertook the subsequent work of applying sericite nanoparticles to paper coating. We modified binder latex with nanosericite first, then prepared coating color with the modified latex. At nanosericite dosage of ＜1%, the water retention properties of the latex and color showed drastic decreases; while the low- and high-shear viscosities of the color increased dramatically. We modified the addition procedure since last year's work indicated that directly incorporating nanosericite to the pigment fraction caused operational difficulties. This series of study indicated that by modifying the binder first did not effectively improve the problem. Perhaps by distributing the nanosericite to different color formula fractions could overcome the difficulty.

Nanoparticles of silver and titanium dioxide were incorporated in test papers by impregnation method and at present, and only the nano-silver paper showed bactericidal efficacy.

濕端添加聚電解質複合物於紙張強度與功能開發之研究

Studies on the application of polyelectrolyte complexes to papermaking wet-end for strength and functionality developments

徐健國

本試驗以改善OCC的強度性質為主要目標，主要以陽性PAM及澱粉配合陰性PAM及澱粉，藉由改變各種濕端條件及添加模式，以期達到顯著增加OCC強度的目的，同時考慮濾水性質、成本及操作的方便性。試驗結果顯示在定量添加6種PAM及澱粉時，去年以PS 1280及tapioca澱粉效果至為突出，今年之結果以陽性PAM之PERCOL 182對紙張抗張強度、破裂強度、耐摺力有最佳促進效果，兩性PAM之Hercobond 6350及PS1280次之，陰性PAM之PERCOL 155其抗張指數僅高於陰性澱粉，但破裂指數卻是最低；而撕裂指數又以PS 1280最高。

對濾水性的影響隨聚電解質種類及添加量而異，PERCOL 182明顯提高游離度，Hercobond 6350次之，PERCOL 155明顯減低游離度。當固定陽性PAM及陽性澱粉而變化兩性或陰性PAM及澱粉添加量時，紙張強度依各聚電解質有所不同。抗張指數以PERCOL 182或陽性澱粉在0.1%對漿濃度時，PS 1280、Hercobond 6350及 PERCOL 1%時為最佳，但在考慮經濟成本下，在陽性澱粉及PERCOL 155添加量為0.75/0.25時亦可提升紙張之抗張指數。撕裂指數以陽性澱粉及PS 1280添加至0.25/0.75及0/0.75時為佳，但在考慮成本下，則以陽性澱粉及陰性澱粉添加至0.75/0.25及0.5/0.5為最適化添加比例。

The study aimed to improve the paper strengths of OCC-based secondary papers. We used cationic polyacrylamides (PAMs) and starch in conjunction with anionic counterparts and by varying the wet end conditions and adding modes in order to achieve significant strengthening the OCC paper. In addition, drainage performance, cost and operational convenience were evaluated. The results indicated that at fixed dosages of the 6 PAMs and starches, PS 1280 and tapioca starch were the top performers last year. This year, however, Percol 182 (cPAM) appeared to enhance tensile, bursting and folding endurance the most. It was followed by an amphoteric PAM, Hercobond 6350 and PS 1280. Anionic PAM, Percol 155 allowed a slightly higher tensile vs. anionic starch, but had the least bursting indices. For tearing strength, PS 1280 was the best.

As for the drainage performance, the genre and dosage of the polyelectrolytes added exerted different influences. Percol 182 notably increased pulp freeness, it was followed by Hercobond 6350; whereas, Percol 155 notably reduced pulp freeness. When fixing cationic PAM and starch dosages but changing the amphoteric or anionic PAM and starch dosages, paper strength varied according to different polyelectrolyte types. For the tensile indices, Percol 182 or cationic starch at 0.1% to the dry pulp; or PS 1280, Hercobond 6350, and Percol 155 at 1% showed the best performances. With cost consideration, at a cationic starch to Percol 155 dosage of 0.75: 0.25%, tensile strength was effectively increased. For the tearing strength performance, cationic starch and PS 1280 added at the 0.25: 0.75%, and 0: 0.75% gave the best results. With cost considerations, however, dictated a cationic vs. anionic starch dosages of 0.75: 0.25% or 0.5: 0.5% as the most-optimal addition.

製紙功能性化學藥劑之開發研究

Studies on the development of novel functional addifives papermaking

葉若鋆

本計畫擬與業界合作，探討特定製紙功能性添加劑的製備技術，以其為紙業發展籌謀。本年度工作重點在於開發防油紙，選擇環保安全的非氟素化學藥劑，塗佈於原紙上以提高其防油效能。測試不同防油劑，包括聚乙烯醇、羧甲基纖維素、澱粉、蠟乳劑、甲殼素以及氟素防油劑等的防油效果，氟素防油劑在低塗量下即有良好的防油效果，聚乙烯醇以鹼化值較高的類型具有較佳的防油性能，澱粉、羧甲基纖維素、蠟乳劑則不適用於單獨使用，未能發揮防油效果，改以混合配比方式施用，結果顯示以聚乙烯醇與羧甲基纖維素混合最具防油效果，Kit值8，展開係數S皆小於1.68，接觸角角度大於15度。

In this study, we plan to work with the industry to develop functional additive technologies to empower the specialty papers sector. This year, we worked on developing an environmentally friendly non-fluoro greaseproof paper by selecting safe chemicals to coat on base paper and to endow a greaseproofing functionality. Different greaseproofing agents were tested, including polyvinyl alcohol (PVA), carboxymethyl-cellulose (CMC), starch, wax emulsions, chitosan and fluorochemical greaseproofing agents. Fluorochemical agents showed good greaseproof performance even at low dosages. PVA with higher alkalinity showed better greaseproofing capacity. Starch, CMC, and wax emulsion alone were not adequate and had no greaseproof performance. When these were mixed at various proportions, the results indicated that PVA and CMC mixture showed the best greaseproofing performance, having kit value of 8 and spreading coefficient < 1.68 and a contact angle > 15 degrees.

以奈米纖維素微晶製作複合層材之研究

Study on the preparation of nanocomposites using nanocrystalline cellulose

王益真

奈米技術興起成為21世紀材料的主流。生物材料，特別是纖維素，具價廉、供應廣、比強度高、耗能低、生物可分解與相容等優異特性，適合發展輕質而高性能之生物複合材料。林產利用之永續必須衍生新穎高附加價值的產品，故與大葉大學合作以奈米纖維素微晶開發「綠色」生物/奈米複合材以取代/補充既有石化聚合物複合材料。本年度計畫以最適之製備奈米纖維素酸水解條件，研究結果以 60% 硫酸濃度、 1:10 固液比、 20 分鐘為酸水解製備奈米纖維素之最佳條件，奈米纖維素得率達 54.43%，產物呈短棒狀，粒徑分布集中於 100 nm。並將奈米纖維素與絹雲母進行製備複合材分析其性質。預期研究結果有助新產品開發、既有產業轉型、增加競爭力。研究顯示，酸水解後之奈米纖維素易產生絮凝現象，經超音波震盪後雖能使奈米纖維素呈現懸浮狀，但發現若僅以超音波震盪，奈米纖維素水溶液還是容易絮凝，造成粒徑尺寸會隨時間增加導致實驗誤差。故除利用超音波震盪外，另添加 1% Tween 80 非離子性的溶液作為分散劑，有助於奈米纖維素良好分散。

Nanotechnology has become the mainstay of 21st material science. Biometerials, particularly cellulose, is superiorly endowed with cheap, widely available, high specific strengths, low energy consumption and biodegradability. The material is suitable to develop light-weight and high-performance composite materials. We plan to cooperate with the Dayeh University and using nanocrystalline cellulose (NCC) to develop "green" bionanocomposites to replace or supplement the existing pet-rochemical-based composites. This year, we use the optimally prepared nanocrystalline cellulose which entailed a 60% sulfuric acid treatment at 1: 10 liquor to material ratio and 20 min hydrolysis time to obtain NCC at 54.4% yield. The products were rod-shaped and had particles size ~100 nm. Composites with polylactic acid (PLA) and nanosericite were successfully prepared. The results also showed that acid hydro-lyzed NCCs tended to reaggregate, although ultrasonic treatment could disperse them briefly, adding 1% Tween 80, a non-ionic surfactant, was shown to stabilize the NCC dispersions.

木構造建築物溫溼度變化與耐久性評估

Research on variation of temperature and relative humidity and related durability in wood-frame structures

周群

以往探討木屋對溫濕度之效應，未能考慮不同地點之影響，本計畫分五地監測木屋及鋼筋水泥建築之溫濕度，以了解氣候環境及建材之影響，並研擬改善方案來加強木屋的效應。已完成五地之溫濕度監測器之設置，數據分析至98年10月止。一般而言，每日最低溫發生在早上6時至8時，最高溫在下午2至4時，相對濕度則反之。福山溫度最低，六龜最高；相對濕度以台北及六龜較低，福山、蓮華池、及扇平因屬山區則較高。室內溫度高於室外，相對濕度則反之。混凝土基礎構造之地板下溫度高於挑高構造者，相對濕度則相差不大，溫濕度之變異係數較小。木構牆壁內之相對濕度變化極小，石膏板牆壁內之相對濕度變化則近於室外者。並於98年3月底前在台北、福山、蓮華池、及扇平，於各地木屋屋頂共設置7台排風機，作為改善措施，並以18個溫濕度監測器，來探討排風對溫濕度之效應，數據分析至98年10月止。

初步結果顯示木屋屋頂排風可略降低溫度，但在台北並不明顯，在屬山區的福山及蓮華池則降幅增大；排風對濕度之影響不明顯，惟排風對濕度之增加幅度在山區較大。有天花板之屋頂溫度較無天花板者高，室內溫度一般則較低；至於屋頂溫度則普遍高於室內者。有天花板之屋頂濕度較無天花板者低；至於屋頂濕度則普遍低於室內者。

The effects of outside climate on the indoor temperature and relative humidity of a wood structural unit have not been properly researched in Taiwan. This study investigated the effects of climate and building materials on the indoor temperature and relative humidity. Improvements to enhance the conditioning of temperature and relative humidity will be proposed to get a better performance. Monitoring sensors were installed at 5 locations in Taiwan to record temperature and relative humidity data until October, 2009. The data were then analyzed. In general, the lowest temperature occurred at 6 to 8 am each day, and the highest at 2 to 4 pm. Relative humidity showed the opposite trend. Fushan has the lowest monthly temperature except from June to September. The lowest relative humidity occurred in Taipei, and was followed by Liukuei. Fushan, Lienhuachih, and Shanping have relatively higher relative humidity due to their mountainous locations. Relative humidity at Fushan exceeded 85% and showed a small coefficient of variation, indicating a long duration of humid climates. Results showed that indoor temperature was higher than that of the outdoor, whereas relative humidity has an opposite trend. The temperature under flooring with concrete foundation was higher than that with a stilted floor. Ddifferences in relative humidity, however, were not significant. Variation of relative humidity inside a wood-frame wall was extremely small. The largest variations of temperature and relative humidity were observed above the ceilings. Exhaust fans were installed to improve the conditioning of temperature and relative humidity. Data obtained from April to October, 2009 and analyzed indicated that installing 2 exhaust fans under roof could slightly decrease temperatures.Magnitude of reduction was not as significant in Taipei as those at Fushan and Lienhwachih. Exhaust fans did not significantly affect the relative humidity.

人工樟櫧林木材形質改良與中小徑木開發利用之育林技術研究

Study on the timber improvement of Laurceae-Fagaceae plantation and utilization of its small-mediate logs

游漢明

調查闊葉混合人工林造林木生長及樹幹形質，分析17年生造林木的樹高生長表現，以香楠平均15.7 m及烏心石14.0 m高生長最佳，而牛樟高生長亦可達12 m，川上氏石櫟樹高生長達9.3 m，樹種平均成活率均達70%以上，顯示台灣的原生闊葉樹未來可提供林業單位做為人工林造林樹種的選擇。

本試驗之17年生造林木調查分叉高及枝下高等資料，顯示香楠較其他闊葉樹造林木具有強烈的天然修枝特性；但各樹種均有達50%以上之分叉率，造林木枝下高及分叉習性影響木材利用甚鉅；香楠之分叉高度平均值為271.3 cm，包括烏心石及牛樟等造林木之分叉高度亦極低矮，顯示樹形分叉嚴重，闊葉樹人工林造林及早期幼齡林的修枝，甚至疏伐是極為重要的育林作業。

另本研究結果得知，由台灣黃蘗小徑材的甲醇抽出物具有顯著的白蟻致死之生物活性，台灣黃蘗幹材甲醇抽出物對白蟻致死機制可能分別是經由忌食及直接接觸造成死亡。顯示台灣黃蘗的人工造林木小徑幹材於抗白蟻試劑之開發上具有很大的潛力。

以8種闊葉樹種之枝梢材或小徑材為原料，進行各項森林特產物的開發研究，由試驗結果得知收炭率隨炭化溫度之增高而有明顯降低之趨勢，然而於同一炭化溫度下，收炭率隨氣乾比重增加而增大之趨勢不明顯。木炭之表面電阻隨炭化溫度之增高而明顯降低，而受氣乾比重之影響不明顯。

We investigated tree growths and stem forms of plantation trees. Among the 17-yr-old tree species examined, the best height growths of *Machilus zuihoensis* and *Michelia compressa* averaged 15.7 and 14.0 m, respectively. *Cinnamomum kanehirai* and *Pasania kawakamii* also reached average heights of 12 and 9.3 m. The average survival rate of the trees reaching 70% or better, indicating that these indigenous broadleaf trees can be priority afforestation species to be planted by the forestry organizations. The 17-yr-old trees were also examined for their forking heights and heights of the lowest living branches. The results indicated that *M. zuihoensis* possessed a stronger natural pruning tendency. But all species exhibited more than 50% forking rates. This characteristic significantly affects timber utilization of the species. The average forking height of *M. zuihoensis* was only 271.3 cm, and those of *M. compressa* and *C. kanehirai* were also very low. The results suggested that forking of saplings was serious among all species. Thus in afforestation using the broadleaf species pruning is needed at an earlier period during the sapling stage. Even thinning should be considered as a vital forest tending practice.

From the results, we found that the methanol extractive of small diameter *Phellodendron amurense* exhibited significant termicidal activity. The effective mechanisms might entail both aversion of ingestion and contact toxicity. The results indicated that the small diameter logs of the species from plantation may have substantial developmental potential as a termite control agent.

In a forest byproducts development using the branches or small diameter logs of the 8 plantation species, charcoal yields decreased with increasing carbonizing temperatures. At the same carbonizing temperature, charcoal yields increased with increasing air-dried wood specific gravities, but the trend was indistinct. Surface electrical resistance of the charcoals notably decreased with increasing carbonizing temperature; whereas it exhibited no distinctive correlation with the air-dried specific gravity of the logs.

闊葉人工林疏伐小徑木或枝梢材木炭製作。

Experiment of charcoal production of the branches or small diameter logs of broad-leaved plantation species.

超臨界二氧化碳法與二種水蒸汽蒸餾法對檜木萃取效率之研究

Efficiency of extracting *Chamaecyaris formosensis* wood by supercritical CO_2 and two hydrodistillation methods

尹華文

本研究係以超臨界二氧化碳(Supercritical carbon dioxide)、傳統水蒸汽蒸餾及新型雙重冷卻蒸餾三種方法萃取檜木(*Chamaecyparis formosensis Matsum*)，再比較其色澤、氣味以及萃取率，並使用反應曲面法(Response surface methodology；RSM)探討超臨界萃取的適當條件。試驗結果顯示：以超臨界二氧化碳的萃取物，最接近檜木粒片的天然香氣；而使用新型雙重冷卻裝置者，由於蒸餾過程經過雙重冷卻，將餾出的精油保持在低溫狀態，因此，檜木香氣的成份得以保留；而使用傳統水蒸汽抽提之精油氣味，較不似天然香氣。以超臨界二氧化碳萃取之萃取率則依操控條件之不同而異，最高可達15.65%，較水蒸汽蒸餾者，增加了3倍；將水蒸汽蒸餾後之檜木粒片，再以超臨界二氧化碳法，仍可再萃取出約9.0%，可知以水蒸汽蒸餾只萃取出全量的1/3。經反應曲面法解析使用超臨界二氧化碳由壓力(10-20MPa)、溫度(40-60℃)及時間(1.5-2.5h)組成17項條件之萃取結果，顯示壓力最具效應，其次為作業時間，操作溫度的影響則最小。

This study employed supercritical carbon dioxide extraction, conventional, and a novel double-cooling hydrodistillation to extract processing wastes of Taiwan red cypress (*Chamaecyparis formosensis* Matsum). Color, fragrance and extractive yields made by the 3 extraction methods were compared. Response surface method (RSM) was adopted to investigate the optimal conditions for the supercritical SC-CO_2 extraction. Among the extracts produced by the 3 methods, the purest fragrance was obtained by the SC-CO_2. Comparing the essential oils extracted by the 2 steam distillation methods, the double-cooling setup provided a better fragrance. The natural fragrances of Taiwan red cypress were preserved, as essential oils were kept at a lower temperature by the double-cooling unit during distillation. Yield of SC-CO_2 extraction reached as high as 15.65%, which was 3 times greater than those of the hydrodistillation methods. Various operating parameters produced different yields by the SC-CO_2 method. It could extract an additional 9% essential oil from the steam extracted Taiwan red cypress particles. Thus, steam only extracted 1/3 of overall lipophilics from the material. Analysis by RSM for the SC-CO_2 extractions revealed that pressure affected the extraction yields most significantly, followed by the extraction time and temperature. Optimal operational parameters were established by a factorial design with 17 experiments: pressure (10~20 MPa), extraction temperatures (40~60℃) and durations (1.5~2.5h).

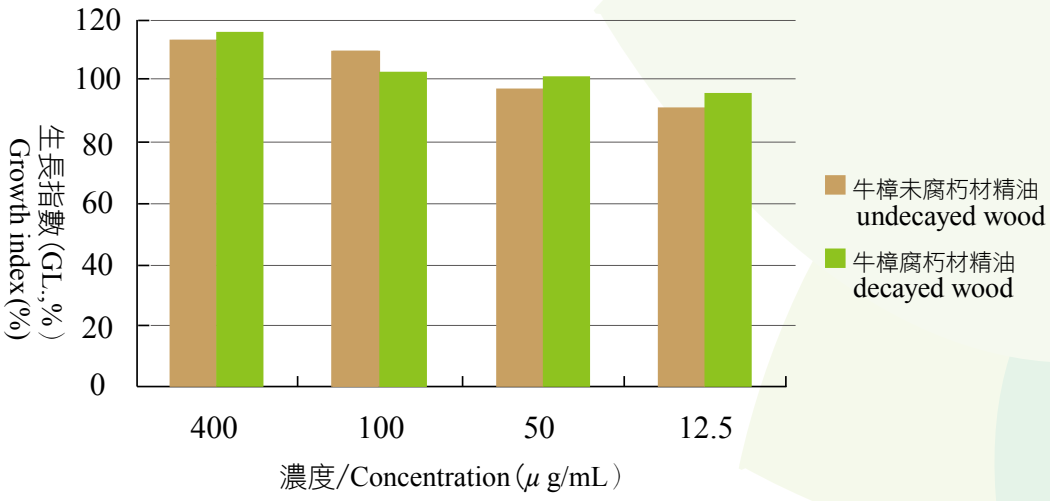
促進牛樟芝菌絲體生長之牛樟木材化學成分研究

Promotion of *Antrodia cinnamomea mycelial* growth by chemical components from wood of *Cinnamomum kanehirai*

謝瑞忠

為了解牛樟（*Cinnamomum kanehirae* Hayata）木材化學成分對牛樟芝（*Antrodia cinnamomea*）生長情形之影響，本試驗分別以牛樟腐朽與未腐朽材2種試材進行木材精油與抽出成分之抽取。其中牛樟腐朽材與未腐朽材精油經GC-MS成分分析顯示，牛樟腐朽材以(-)-Terpinen-4-ol（72.57%）為主要成分，而牛樟未腐朽材則以(-)-Terpinen-4-ol（38.21%）、Safrole（26.95%）與ρ-Cymene（13.42%）三者含量最高。顯示ρ-Cymene與Safrole兩種成分在腐朽之牛樟木材中明顯降低。而乙醇抽出成分含量以腐朽材（29.88%）略高於未腐朽材（27.34%），同時腐朽材（4.37%）以低極性之正己烷可溶部含量高於未腐朽材（2.25%），而未腐朽材則以高極性之成分含量較高。此外，無論腐朽材或未腐朽材之精油在濃度100 μg/mL以上對樟芝菌絲之生長均有促進效果。

This study tried to extract and identify the chemical components in the decay and sound wood of *Cinnamomum kanehirae* Hayata. Dominant component in essential oil of the decay wood was (-)-terpinen-4-ol (72.57%), whereas the main components of the sound wood were (-)-terpinen-4-ol (38.21%), safrole (26.95%), and ρ-cymene (13.42%). Contents of the n-hexane and alcohol extracts from decay wood were higher than those from the sound wood. Both essential oils of decay and sound wood promoted mycelial growth of *Antrodia cinnamomea*.



牛樟腐朽材與未腐朽材精油對牛樟芝生長之影響。

The effects of essential oils extracted from decayed and undecayed wood of *Cinnamomum kanehirae* on the growth of *Antrodia cinnamomea*.

適合樟芝培養用牛樟優良品系之選育與栽培

Breeding and cultivation of *Cinnamomum kanehirae* clones for growing *Androdia cinnamomea*

張淑華

生長在天然林的牛樟芝為台灣極有價值與昂貴的藥草，本計畫將伐採6至20年生的牛樟優良品系造林木，試驗其段木誘導牛樟芝形成的潛力。這些段木也將分析其結構與精油成分，以瞭解與牛樟芝形成的關係，作為選育品系的指標。這些經選育的優良品系將以扦插與組培繁殖，在台灣的東西部建立栽培區，預期發展出在6年生幼林木的段木上培育出牛樟芝的技術。本年度伐採15株6年生組培來源與扦插來源林木，伐採後6個月之根株都萌出1 m以上枝條，顯示牛樟的萌芽更新可行。牛樟芝菌絲接種在這些段木均長出菌絲，有些已經轉紅。從牛樟造林區選育25個優良營養系，採集6萬支以上插穗，分別在太麻里、六龜與台北扦插，以培育出扦插苗，供明年度栽植造林用。

Antrodia cinnamomea fruiting bodies grown on natural wood of *Cinnamomum kanehirae* are very valuable and expensive herbs in Taiwan. In this project, logs of superior *C. kanehirae* clones having been planted for 6 to 20 years were harvested and tested their potential to induce fruiting bodies of *Antrodia cinnamomea*. The logs were analyzed in terms of their structure and essential oil constituents to determine the relationships to the formation of *Antrodia cinnamomea* fruiting bodies, so that a selection index might be established. Plantations planted with these superior clones derived both from cuttings and tissue cultures will be setup at western and eastern areas of Taiwan. We expected to develop a technique so that fruiting bodies of *Antrodia cinnamomea* could sprout on younger logs harvested from 6-year-old plantations. This year, we harvested 15 6-year-old trees derived from tissue cultures and rooted cuttings. Shoots > 1 m high sproutinged from all stomps 6 mos after been the harvest, indicating that coppice regrowths could apply to *C. kanehirae*. The *A. cinnamomea* inoculated on these logs has formed mycelia and some even turned red. More than 60,000 cuttings were collected from 25 clones selected in the plantations and rooted at Tamali, Liukuei, and Taipei. These rooted cuttings will be planted next year.

茶油(苦茶油)及茶粕之超臨界二氧化碳萃取

Supercritical Carbon Dioxide Extraction of Camellia Oil and Tea Dregs

尹華文

本研究首先利用超臨界二氧化碳萃取小果油茶(*Camellia tenuifolia* (Hay.) Cohen-Stuart)籽之油脂；其次則另行萃取已使用冷壓及熱壓二種傳統方法榨油後之油茶粕，並比較二者之得油率。萃取作業係以壓力、流速及時間三項參數進行，並使用反應曲面法(Response surface methodology；RSM)，解析各項變因對得油率之影響，以建立最適之操控條件，試驗結果顯示：以壓力(25-28 MPa)、流速(4-6 L/min)及時間(100-140 min)三項參數組成17項條件萃取，其得油率約為22.45-25.98%；冷壓法及熱壓法二種油茶粕，再以超臨界二氧化碳萃取，仍可萃出茶油，冷榨油茶粕之得油率較高(11.95%)，而熱榨油茶粕則較低(8.12%)。經反應曲面法之評估，三項操控參數中，以二氧化碳流速對萃取苦茶油最具效應，其次為萃取時間，而壓力的影響則較小。藉由油茶籽及油茶粕之萃取，顯示超臨界萃取技術，較傳統榨油具有省時、質優、效率高等優點。

Supercritical carbon dioxide was employed to extract camellia oil from seeds and tea dregs of *Camellia brevistyla* (Hay.). Conventional extractions, including cold and hot press, were also conducted. Oil yields were also compared. Extraction parameters, including pressure, flow rate and duration, were investigated. Response surface methodology (RSM) was employed to analyze effect of oil yield by each parameters, and to establish optimized condition. Oil yields from 22.45-25.98% were obtained by 17 extraction conditions, including pressure (25-28 MPa), flow rates (4-6 L/min) and duration (100-140 min). Tea oils could still be extracted from dregs from cold and hot press by supercritical carbon dioxide. Oil yields were 11.95% from cold press dregs and 8.12 % hot press dregs. Among three parameters analyzed by RSM, carbon dioxide flow rate impacts the most on bitter tea oils extraction efficiency, followed by duration and pressure. Extraction of tea seeds and dregs demonstrated that supercritical carbon dioxide extraction were superior to conventional press with advantage of saving time, better quality and efficiency.

林產物香精抽取與生物活性研究

Extraction and bioactivity of essential oils from forest products

謝瑞忠

本研究主要探尋紅檜(*Chamaecyparis formosensis*)、臺灣扁柏(*Chamaecyparis obtusa* var. *formosana*)木材及白玉蘭(*Michelia alba*）花精油及化學成分抗菌活性，精油含量係使用水蒸氣蒸餾法測定，化學成分鑑定是使用氣相層析質譜儀(GC-MS)分析鑑定。結果顯示，紅檜木材精油以*cis*-Myrtanol(10.47%)、Myrtenal(6.83%)及τ-Cadinol(4.23%)為主要成分；臺灣扁柏木材精油依含量高低為δ-Cadinol(24.99%)、α-Terpineol(16.16%)、α-Pinene(5.82%)及Borneol(5.71%)為主要成分；白玉蘭花精油以Linalool(47.17%)為主要成分，次要成分為Phenylethylpropionate(19.45%)與α-Methylbutyric acid(13.95%)。此外，紅檜與臺灣扁柏精油在200 μg/mL濃度對*Gloeophyllum trabeum*、*Lenzitesbetulina*及*Collectotrichum gloeosporioides*等真菌均有良好的抑制效果，而玉蘭花精油則無明顯抑菌效果。顯示紅檜與臺灣扁柏精油具有良好抑菌效果及開發為天然殺菌劑之潛力。

This study investigated the chemical compounds and bioactivities in the heartwood of *Chamaecyparis formosensis* and *Chamaecyparis obtusa* var. *formosana*, and flowers of *Michelia alba*. Essential oils were obtained by steam distillation. Essential oil components were analyzed by a gas chromatography-mass spectrometry. The main components in the essential oil of *C. formosensis* were *cis*-myrtanol (10.47%), myrtenal (6.83%), and τ-cadinol (4.23%). The main components in the essential oil of *C. obtusa* var. *formosana* were δ-cadinol (24.99%), α-terpineol (16.16%), α-pinene (5.82%) and borneol (5.71%). Linalool (47.17%) was the major component in the essential oil of *M. alba* flower, the other main components including phenylethyl propionate (19.45%) and α-methylbutyric acid (13.95%) were also present. The essential oils of *C. formosensis* and *C. obtusa* var. *formosana* were shown to have antifungal activity against 3 wood-decay fungi, such as *Gloeophyllum trabeum*, *Lenzites betulina*, and *Collectotrichum gloeosporioides*; however, antifungal activity of the essential oil from *M. alba* flower was very weak.

表1 紅檜與臺灣扁柏心材精油對5種真菌的有效抑制效率IC_{50}

Table 1. IC_{50} values of essential oils extracted from *C. formosensis*, and *C. obtusa* var. *formosana* against 5 fungi species.

Fungi	Dosage (μg/mL)	
	Chamaecyparis formosensis	*Chamaecyparis obtusa* var. *formosana*
Gloeophyllum trabeum	101.61	75.56
Lenzites betulina	168.01	114.51
Collectotrichum gloeosporioides	169.92	47.9
Trichoderma sp.	69.81	52.83
Penicillium sp.	456.03	362.78

棲蘭山柳杉人工林行列疏伐與檜木更新之研究

Cypress stand regeneration and row thinning in the Cryptomeria plantation at Chilan Mt. area

邱志明

本研究在棲蘭山柳杉人工林進行行列疏伐後，配合栽植檜木苗、檜木種子撒播與中耕整地除草處理，嘗試瞭解試區在疏伐後不同程度之干擾，苗木之更新情形與各處理作業之間的關係，以尋求最佳作業方式。試驗在2007年1月完成疏伐作業，同年4月完成操作處理，總試區面積約3ha，調查時間為2年，項目包括檜木栽植苗之生長與存活率、種子發芽率及成苗密度、以及天然更新數量等。初步結果認為，棲蘭山柳杉人工林行列疏伐作業，佐以檜木栽植處理，2年存活率約66~68%，可成功改變林相為檜木人工林。紅檜及扁柏栽植苗的生長表現以紅檜較佳，尤其是基徑的生長，存活率在二者之間則無顯著差異。若執行撒播作業，可成功提高檜木苗的比例，成為檜木與闊葉樹混合更新之形態，紅檜、台灣扁柏及闊葉樹苗平均密度分別為0.84、0.46及0.56(n/m^2)，惟分布不均勻，在經營上是個缺點。整地除草作業初步觀察對更新苗的密度無顯著效應，對後續生長及競爭是否造成影響仍需持續觀察。目前僅發現台灣扁柏小苗，可在部分蕨類植物覆蓋下存活，檜木、闊葉樹種與草生地被彼此之競爭關係尚未釐清。疏伐區之天然更新，以闊葉樹為主，平均密度高達8,200株/ha，檜木及柳杉的種子則來源不足。營林者可依據經營之目的，建議以小面積行列疏伐柳杉純林後，配合天然更新及人工栽植或撒播種子，控制樹種比例，以達到期望之林分組成及結構。

This study examined the development of both naturally regenerated and planted seedlings and sown seeds of 2 *Chamaecyparis* spp. In order to select the best operation strategy, sowing and seedling planting were carried out in a *Cryptomeria japonica* stand after row thinning with intensive soil preparation and weeding. The entire thinned sites were about 3 ha in size; and row thinning was completed in January 2007, and treatment operations were completed in April of that year. The investigating experimental period lasted 2 years after row thinning. During this period, we measured the growth and survive rate of the planted cypress seedlings, the germination percentage, and survival rate of the seeds, as well as all the regenerated seedling density within within each thinning row.

Preliminary results showed that cypress seedling have no difficulty growing after row thinning of the *Cryptomeria* plantation. The survival ratio was around 66~68% over the two years period after thinning. This operation successfully changed the stand structure from a *Cryptomeria* forest to a cypress plantation forest. We found planted seedlings of *Chamaecyparis formosensis* had better growth performance than did the *C. obtusa*, especially in ground diameter growths. There was no significantly difference of the survival rates between the 2 *Chamaecyparis* spp. We also found that by sowing cypress seeds in the thinned *Cryptomeria* plantation, we could increase the percentage of cypress seedling establishment and transfer the stand into a mixed stand of regenerated cypress and broadleaf trees. Densities of the *C. formosensis*, *C. obtusa* and broadleaf trees of this new stand were 0.84, 0.46 and 0.56 n/m^2, respectively. Because the unevenly distributed seedlings, it could present a problem in management. Weeding did not affect the germinated seedling density during the experimental period, but further observations are necessary to ensure that the impact of weeds on seedling growth and competition. We have only observed that some of *C. obtusa* and *C. formosensis* seedlings could survive under the shades of ferns. Detailed competition situations among the cypresses, broadleaf trees and herbs are still not clear. After the row thinning, recruitment through natural regeneration was dominated by broadlleaf species with a density of 8,200 (n/ha). Seed sources of cypresses and *C. japonica* were largely insufficient. Based on the purpose of the management plan, forest managers may adopt different treatments in a *C. japonica* plantation, and we suggest using the row thinning silviculture in small areas and cooperating the natural regeneration and disturbances by planting seedlings or scattering seeds of the cypress to approach their desired stand structures and compositions.

柳杉人工林疏伐與天然林復育之微環境及生物多樣性動態之研究

Study on the microenvironments and biodiversity dynamics in thinned *Cryptomeria japonica* plantations and restorative regenerated natural forests

黃正良

台灣有廣達42萬公頃之人工林，為重要之森林生態系之一，過去人工林之經營偏重於經濟效益。然而為符合現今人工林永續生態系經營之理念，對現存之人工林實有必要實施合理之疏伐作業。然而該如何疏伐，不同疏伐處理對生物之多樣性與對森林功能之影響為何，對原生植群之更新及復育之影響又為何，相關之基礎資料相當缺乏。本計畫為達成蒐集本土實測之基礎科學資料，於南投林管處巒大事業區74、75與76林班設有不同疏伐處理試驗區處，長期觀測、蒐集當地之氣象資料與不同疏伐處理試驗區之微環境變化資料；並定期於試驗區內進行生長量及生物量調查，相關資料可作為釐定人工林永續經營發展並符合現代生態系經營法則之參考。

In Taiwan, artificial forest accounting for nearly 420,000 ha in area is an important forest ecosystem. In order to confirm the ecosystem management concept, an appropriate thinning practice should be applied to the plantation management system. But, the relevant data regarding implementation of thinning, the impacts on biodiversity and forest functions, and regeneration and restoration of endemic vegetation are still scanty. In order to build up the local scientific data on those issues, thinning plots with alternative thinning strategies were set up in the Compartments 74, 75, and 76 of the Luanda Working Unit of the Nantou Forest District. In the plots, issues related to meteorology, microclimate, timber growth, ground vegetation, and biomass were monitored and measured periodically. The relevant data collected could be used as references for the sustainable plantation management.

不同齡級及不同密度柳杉及檜木立木非破壞性材質評估與利用

Study on the non-destructive wood property evaluation of standing *Cryptomeria japonica* and *Chamaecyparis obtusa* var. *formosana* standing trees at stands of different age classes and densities

林振榮

本年度評估棲蘭山台灣扁柏天然下種更新林木不同林齡的生長及材質。年輪密度主要受到早材密度、最小密度、晚材率三個參數的影響。棲蘭山台灣扁柏的成熟材及未成熟材之境界，約在25～30年生。年輪密度及壓縮強度與林木胸徑及樹高之間，雖然有顯著性的負相關性存在，但是相關係數偏低，表示在棲蘭山天然更新的台灣扁柏林木生長限度內對林木材質沒有很大的影響。杉林溪30株不同徑級紅檜造林木材質評估，樹木之間及樹輪(樹齡)之間有顯著性差異，隨著樹木胸徑的增加樹輪寬度會變大，但是樹輪密度會變低。非破壞性試驗與破壞性檢測參數間有顯著性的相關性存在，劣勢木及中勢木之材質(木材密度及強度較高)較優勢木有較佳的表現，而優勢木的材質有較差(木材密度及強度較低)的傾向。

The purpose of this study was to understand the tree growth traits, longitudinal compressive strength, and ring characteristics of Taiwan red cypress at different ages at the Chilan area. The tree growth traits are tree crown characteristics, including diameter at breast height, tree height, crown length, crown width etc. Longitudinal compressive strengths of the increment cores were measured with a fractometer technique. Nine ring characteristics were investigated by an X-ray scanning and ring analysis system. Relationship between the tree growth and wood qualify was detected and understood by the data and a statistics method. The information could provide references to forest and ecological management practices. In addition, the wood properties of Taiwan red cypress from the Shanlinshi area were investigated as well. The results showed that the fast grown trees had poorer wood qualities, and that the slower grown trees had better wood properties (higher wood density and strength).

疏伐對柳杉人工林生態過程的影響

Effects of thinning a *Cryptomeria japonica* plantation on its ecological processes

林國銓

選取巒大事業區約35年生的柳杉林，該林分已於2007年完成疏伐。97年度起對此林分枯落物、枝葉層、葉和小枝分解進行2年的監測，本年度進入第2年。本年度1至9月份枯落物均量對照區為2.52 Mg ha^{-1}, 中度疏伐為1.61 Mg ha^{-1}，強度疏伐為1.45 Mg ha^{-1}。枯落物月份間變異極大，9月份為最大量。本年度枝葉層累積量兩季總量平均，對照區為9.15 Mg ha^{-1}較低，中度疏伐17.45 Mg ha^{-1}較高，強度疏伐12.42 Mg ha^{-1}介於其間，但統計上處理間無差異。柳杉葉和小枝本年度為12和18個月的分解，經18個月的分解剩餘重量為47.4-50.2%。各處理間無差異，顯示疏伐對柳杉葉和小枝的分解影響輕微。2008年枯落物養分分析結果顯示各養分平均濃度(均數±標準誤差)為C: 539±4 mg g^{-1}，N: 17.1±0.4 mg g^{-1}, P: 1.07±0.03 mg g^{-1}, K: 1.92±0.14 mg g^{-1}, Ca: 15.6±0.8 mg g^{-1}，Mg: 2.41±0.17 mg g^{-1}。柳杉葉與小枝分解期間養分的變化，N與Ca呈明顯上升趨勢。P則在分解91天時下降，然後上升，再保持穩定。K則在91天前保持穩定，此後即下降。Mg濃度變化又不同，初期呈上升狀態，至181天達最高後，快速下降。

A 35-yr old *Cryptomeria japonica* plantation thinned in 2007, and located in the Luanda Circle, Nantou County, was selected to monitor its litterfall, litter layer, and litter decomposition for 2 years in order to study the influences of thinning on the litterfall, litter layer, and litter decomposition at the stand. This is the second-year report. Having collected 9 monthly litterfall in 2009, the preliminary results were that the greatest total mean annual litterfall occurred at the control stands (2.54 Mg ha^{-1} yr^{-1}), the second at 25%-thinned stands (1.61 Mg ha^{-1} yr^{-1}), and the smallest at 50%-thinned stands (1.45 Mg ha^{-1} yr^{-1}). Litterfall amounts differed widely among the seasons. The largest amount occurred in September. Total amounts of the litter layer during the first 2 season of collections were 9.15, 17.45, and 12.42 Mg ha^{-1} in the control, 25%-thinned, and 50%-thinned stands, respectively. For those amounts, there was no significant difference among the treatments. The litter bags were collected after 12 and 18 months in the field. Masses of the remaining needles and twigs ranged from 47.4 to 50.2% after 18-month of decomposition. Since there was no significantly difference among the treatments, thinning appeared to have little influences on the needles and twigs decomposition. Chemical analyses indicated that means nutrient concentrations of the litterfall (mean±standard deviation) were as follows: C: 539±4 mg g^{-1}, N: 17.1±0.4 mg g^{-1}, P: 1.07±0.03 mg g^{-1}, K: 1.92±0.14 mg g^{-1}, Ca: 15.6±0.8 mg g^{-1} and Mg: 2.41±0.17 mg g^{-1}. Dynamics of the nutrient concentrations during decomposition varied widely; the nitrogen and calcium concentrations rose significantly; phosphorus decreased during the first 91 days, then increased, and kept stable; potassium kept stable in the first 91 days and then decreased; and magnesium was spurious which increased to a peak in the first 181 days, and then decreased sharply.

台灣杉單木生長競爭動態模式之研究

Competition effects on the individual tree growth in a *Taiwania* plantation

汪大雄

本研究於林業試驗所六龜研究中心之台灣杉造林地使用單木觀點之方法，進行台灣杉林分內林木生長競爭效應之分析。使用3 種不同競爭指數搜尋半徑和4種競爭指數公式，計算台灣杉林分內各林木之競爭指數，來衡量各林木在生長過程中遭遇競爭壓力之程度。並使用台灣杉林林木之生長資料配置林木單株生長式並評估在單株生長式中納入競爭指數之效果，以瞭解競爭指標對林木生長之貢獻。研究結果本研究所使用之競爭指標是與林木生長量呈現與理論上一致之相關，並發現在台灣杉單木生長配置中納入競爭指數會減少模式配置之MSE，而增加模式之配置效果，其中較大的搜尋半徑會使MSE降低之程度越多。

This study was conducted to investigate the impact of tree competition on the tree growth from an individual tree point of view for a *Taiwania* plantation in the Liukuei Experiment Forest. Four types of competition index (Bella, Staebler, Hegyi, and crown volume ratio) were used to calculate competition indices for assessing the competition status of each tree. Three different search radii were used to find out the competitor for each subject tree. Using the incremental data obtained from the permanent plot, a regression was developed to find out the empirical relationship among incremental initial attributes and growth competitions. Results showed that incorporation of the competition indices would reduce the MSE on the regression fitting. The wider radius used in the search of competitors, the more reduction in MSE would be obtained.

六龜區域森林永續經營準則與指標之建立及評估

Establishment and evaluation of criteria and indicators for the sustainable forest management of the Liukuei region

湯適謙

由於評估準則與指標架構的發展，可提供經營政策及科學發展之依據，為實踐森林永續經營之具體行動，本研究嘗試以六龜試驗林區域為對象，建立其森林經營單元(Forest management unit, FMU)層級之準則與指標。

而為解決問卷分析之語意上模糊而難以量化之情形，本研究以「模糊多準則決策分析」(FMCDM)法進行分析。

在研究程序上，先藉由德爾斐法(Delphi technique)專家學者之問卷調查，擬定生態系經營之準則與指標，再以模糊階層分析法(Fuzzy Analytic Hierarchical Process, FAHP)探討各準則與指標之重要性及優先順序，以提供經營決策之參考。

在德爾斐法問卷分析時，各準則與指標之篩選原則是依據「四分位差法」來進行「重要性」與「共識性」之統計分析；其結果是列出各學者專家具有「共識」，且可適用於六龜區域森林永續經營之準則與指標，然其準則與指標之相對權重及優先順序則有賴於多準則決策法之模糊階層分析法。根據各專家學者回覆之意見進行各項目之重要性與共識性統計分析表，所列之命題中，初擬之各項目均為〝重要〞以上，並至少都有〝中度〞之共識；在「原則」之項目包含「生物多樣性」、「生態系結構及功能」、「社會人文」及「經濟面向」等4項，在「準則」之項目包含「遺傳多樣性」、「物種多樣性」等共11項，並在其下各發展相關指標，並據以製成階層分析法(AHP)問卷。

再透過模糊階層分析法(FAHP)之演算，將模糊權重解模及標準化後，可得各評估指標之整合權重。各評估指標優先順序中，前面三者分別為「物種豐富度或歧異度」(0.041)、「自然力擾動之影響」(0.040)及「林木資源」(0.035)；後面三者則分別為「與其他單位管理權之劃分與區屬」(0.011)、「森林特殊產品」(0.013)及「林業勞動分析」(0.014)。

就以六龜區域而言，就所得結果分析，維持生態之完整及發揮森林公益功能占有較大之比重，其他有關社會人文及經濟面向亦占相當比重，但就整體而言，是相較為低，但是仍應依其重要性投入對等之資源；且在有關社會人文及經濟面向項下相關指標如「林木資源」(0.035)、「野生動物資源」(0.033)及「社會教育」(0.029)等仍有較高之權重，所以尚需投入較多資源加以經營。

Development of a framework for criteria and indicators (C&Is) can provide the basis in management and science. And it is also the underpinning to the sustainable forest management (SFM) practices. The study was proposed to establish a C&I of ecosystem management for the Liukuei Experimental Forest at the forest management unit (FMU) level. .

In order to solve the problems of semantic ambiguity and difficulty in quantification in questionnaires, the method of "fuzzy multicriteria decision making, (Fuzzy MCDM)" was applied to their analysis.

The study procedures were as follows: First, the Delphi technique was implemented. By repeated consultation to experts, the items for the SFM of Liukuei Experimental Forest could be confirmed. And then, the fuzzy analytic hierarchical process (FAHP) was applied to evaluate the importance and priority of the C&Is. The results could then be referred to by the decision makers.

During analysis of the Delphi technique questionnaire investigation, the "quartile method" was used to evaluate the "importance degree" and "common consensus degree" for sieving of the C&Is. But the relative weights and priorities were judged by the fuzzy AHP. By statistical analysis of the expert responses, all the initial items got at least the "importance" degrees and "middling" common consensus. For the "principle" aspects, there were 4 items including "biodiversity", "structure and function of ecosystem", "social humanities" and "economics issues". On the other hand, for the "criteria" aspect, there were 11 items including "diversity of inheritance", "diversity of species", and so forth. And the related indicators were developed. The results obtained by the Delphi technique were the bases for designing the questionnaire.

By calculation of the FAHP method, integrated weights of the indicators could be obtained from "graded mean integration representation method" and "normalized method". The first 3 priorities were "richness and diversity of species" (0.041), "influence of natural interference" (0.040) and "timber resources" (0.035); on the other hand, the last 3 were "divisions and belongings with other units" (0.011), "special products of forest" (0.013) and "forest labor analysis" (0.014).

For the Liukuei area, the following results could be summarized: Maintaining integrity of the ecosystem, and developing the public welfare functions from the forest got the highest weighing; another area such as the social and economic aspects got a fairly important rating, but with an overall lower ranking. Even though, corresponding management resources should be directed toward them in accordance with their importance. Furthermore, concerning the socioeconomic and cultural aspects, certain indicators such as "timber resources" (0.035), "wildlife resources" (0.033), and "social education (0.029) still scored a fairly high weighting. Therefore enough management resources should be directed toward these items.

「生態系結構及功能」為森林永續經營之一原則。
"Ecosystem structure and function" is one of the principle for sustainable forest management.

台灣杉人工林內已更新闊葉樹之經營策略

A management strategy to regenerate broadleaf forest in a *Taiwania* plantation

劉一新

本研究於林業試驗所太麻里研究中心之台灣杉造林地進行，除針對台灣杉造林木之生長現況及林下天然更新闊葉樹種進行調查外，並監測造林地穿落雨及土壤沖蝕的狀況，發現台灣杉上木之生長及林冠的鬱閉情形對下層闊葉樹之天然更新產生影響，亦發現林地土壤之沖蝕和累積與天然更新闊葉樹所形成的複層結構有關，顯示人工林撫育作業，可誘發林內闊葉樹之天然更新，並增加林分之複層結構，而有利於生物多樣性及水土資源的保育，此點在規劃後續經營策略方面應有其參考價值。

This study was conducted in Taiwan fir plantations established in 1980s at the Taimali Research Center, TFRI. The study focused on the relationships between plantations conditions and soil/water conservation, growth parameters of Taiwan fir, and natural regeneration trends of the undergrowth hardwood species. Meanwhile, the dynamics of penetrating precipitation and soil erosion/accumulation at different sites were monitored simultaneously, Results of the study showed that the growth and canopy conditions of the plantations would affect natural regeneration of the undergrowth hardwoods, and the relationships between soil erosion/accumulation dynamics and the multi-layered structure of natural regenerated hardwood actually existed. These results implied that silvicultural practices including thinning and pruning could stimulate natural regeneration of the undergrowth hardwoods to create a multi-layered structure of the plantations and further enhancing the biodiversity and soil/water conservation.

六龜人工林颱風干擾之復育研究

Study on the forest restoration after typhoon disturbances in a plantation at the Liukuei Experimental Fores

孫銘源

台灣人工林經營，常以永續生產高經濟價值的木材為經營重要目標，且林木生長時間漫長，在台灣地區颱風常為影響人工林經營之重要因子之一。因此，本研究擬以六龜試驗林中遭受颱風嚴重干擾的台灣杉(*Taiwania cryptomerioides*)及香杉(*Cunninghamia konishii*)人工林為研究對象。選擇台灣櫸(*Zelkova serrata*)、烏心石(*Michelia compressa*)、紅楠(*Machilus thunbergii*)三種具經濟價值的原生闊葉樹之幼苗，分別種植在三種不同光度的微生育地(microhabitat)，以比較其生長的差異，藉此可提供人工林孔隙地或造林失敗地進行二次造林時選擇樹種之參考。在(1)高光度區(相對光度平均為61.3%)、(2)中光度區(相對光度平均為33.25%)、(3)低光度區(相對光度平均為24.1%)，並對此三種不同的微生育地，進行林下光度監測，探討不同樹種之幼苗在三種光度下的成活率及生長量。在二年生後，初期苗木成活率，以台灣櫸最高，平均達96.3%，在高光度區之烏心石及紅楠成活率分別為62.5%、71.2%，顯示較耐陰之樹種，初期生長在有上木保護下，會有較佳成活率表現。苗木高生長及地徑生長均以烏心石較佳，平均為22.9cm及5.57mm。台灣櫸在低光度環境中，其高生長及地徑生長趨緩，並拉大與高光度下之差距。烏心石在低光度環境中仍有一定之高生長，顯示出耐陰性樹種的特性。紅楠則介於中間。將苗高及地徑生長量以單因子變異數(ANOVA)進行分析，結果在不同樹種間，樹高生長與地徑生長均呈極顯著差異。顯示不同光度下，對不同需光度的樹種，初期生長量即有明顯差異，藉此可提供人工林颱風孔隙地二次造林之樹種選擇參考。

The management purpose of plantation is to produce woods with high economical values. Selecting suitable planting species and operational strategy are necessary. The subjects of this study were *Taiwania cryptomerioides* and *Cunninghamia konishii* plantations seriously destroyed by a typhoon and located in the Liukuei Research Center, Taiwan Forestry Research Institute. We set up 7 transect lines; each 30~50 m long. All woody plants in the areas 1 meter astride the transect lines, and with DBH ≥ 1cm that presented in the quadrates were identified and their DBH measured. Lighting conditions under forest canopy above each transect line were estimated by 100 hemispherical images to measure the average light transitivity of each microhabitats. We then planted *Zelkova serrata*, *Michelia compressa* and *Machilus thunbergii* seedlings, high economical value and relatively primitive tree species, in 3 different microhabitats. The objective of this study was to investigate the survival rate and growth status of seedlings of the 3 different species under the different relative luminosities. The results are expected to be applied to the operational techniques for restoring the plantations.

植物種苗團隊—林木及綠化種苗產程標準模組之開發

Development of a standard cultivation process for the production of tree and greening seedlings

黃菊美、曾聰堯、何政坤

育苗過程中介質直接影響苗木生長表現，以目前台灣地區培育扦插苗常用之栽培介質及施肥方式進行研究。以市售及調配 7 種栽培介質培育紅豆杉及粗榧扦插苗，栽種數月後測定生育狀況。分析介質理化性質及測定苗木外觀型態，初步結果顯示，最佳的pH值介於 5.5 - 6.5 間。介質電導度與營養鹽含量成正相關，電導度越高營養鹽含量越多，栽培介質 C(碳)、N(氮)含量及 C/N ratio(碳氮比)則提供了另一種訊息供參考，分析結果以 H、V、P1 及 P3 較佳，而 J、C1 及 C3 碳氮比過高，栽培介質中有機物處於快速分解狀態，微生物快速分解吸收有機物，吸收無機態氮與苗木根部競爭氮素，在此情況下苗木易缺氮素，苗木生長受限，易罹病蟲害而枯死。可交換性鹽基(Mg, Ca, Na, K)各栽培介質含量足夠，並無缺乏。紅豆杉扦插苗在栽培數月後苗木的存活率差距極大，P3型介質近乎100% 存活，各種苗木生長參數 (根及莖生長量、苗木生長量、苗木乾重及苗木品質) 多數以V 、H及P3型較佳；粗榧扦插苗在不同栽培介質栽種之存活率沒有顯著差異，各種介質存活率都在9成左右，苗木品質也相近。目前為研究初步成果(第一年)，所以著重栽培介質的選定與肥培管理，爾後將針對產程加以串聯組成量產標準模組，進行撰擬生產履歷並進行長期試驗研究，盡速開發出林木及綠化種苗產程標準模組。

Growth of tree seedling is directly affected by the planting media or substrate during cultivation. The objective of this study was to develop a standard cultivation procedure of forest and greening seedlings. We used seedling materials collected from different media and fertilizers for cultivating cuttings and cloned seedlings. The seedlings were cultivated in different media and fertilizers placed in dibbling tubes in a greenhouse. Then traits of the seedlings were measured after growing for several months. We also measured the media for their physical and chemical properties and correlated these with the growth appearances of the seedlings after several months. The best substrate pH values were from 5.5 to 6.5. The states of substrate decompositions could be monitored by examining their C/N ratio. The results indicated that the substrates coded H, V, P1, and P3 were the better performers. Exchangeable cations of all the substrates could satisfy seedling needs. There were significant differences in the survival rates of *Taxus sumatrana*, and all parameters of plant growth were better for its seedlings growing in substrates H, V and P3. However, there was no significant difference in the survival rate and quantity indices of *Cephalotaxus wilsoniana* among different media. Through accumulation of these growth data, we expect to develop a standard procedure for cultivating forest trees and greening seedlings. In addition, new cultivation methods will be developed. Finally, we hope to find a new way to establish the method that befit low cost, energy conservation and ecosystem preservation.

栽培前(Before cultivation)　栽培後(After cultivation)

不同培養土栽培紅豆杉苗數月後結果。

Results of *Taxus sumatrana* seedling cultivated at different substrates V and J after several months.

社區林業促進公眾參與及原住民傳統知識和領域之研究

Traditional ecological knowledge and natural resource management--A case study of Paiwan people in the Jialan Village, Jingfeng Township, Taitung County

吳俊賢

目前台灣森林經營典範轉為森林生態系經營，其中強調社區參與和合作過程的概念，和應用傳統生態知識於自然保育的觀念不謀而合。國內2005年原住民族基本法通過後，原住民族管理及使用土地、自然資源的權利自此具有法源基礎，雖有法律賦予原住民族管理使用自然資源的權利，但原住民是否具有足夠的環境知識管理自然資源？原住民族共管經營土地的合法性部分來自長年持續使用祖先留下的傳統，台灣過去原住民傳統生態知識是用口語、傳說、祭典等儀式傳承下來，少有文字記載。原住民族具有那些智慧可以管理自然資源，即為本研究重點。

本計畫採問卷方式針對台東縣金峰鄉嘉蘭村排灣族原住民進行普查，探究原住民對傳統生態知識的認知與實踐、森林資源的利用以及對環境的態度。研究發現理論面的傳統生態知識受年齡影響有逐漸流失的現象，此外，此種理論面的知識並非均質的，性別、年齡、教育程度、所得及階級等社經因素均對理論面傳統生態知識的認知能力產生顯著影響。本研究利用原住民使用動植物的情形，代表實踐面的傳統生態知識，研究發現雖然研究地點位於山地原住民鄉，仳鄰森林資源，但約3成的受訪者並無使用動植物的行為，使用頻率以每月1-3次居多，反映出原住民不再完全依賴森林資源的生活型態。這些有使用動植物資源的人，使用的動植物不受性別、年齡、教育程度、所得及階級等因素影響。環境態度方面，研究發現受訪者認同由在地人來協助管理環境，才能落實自然保育工作的觀念，但其對傳統領域內的資源持有排他態度，認為大部分在林內的違法案件是外地人做的，並認為平地人沒有權利使用傳統領域內的自然資源。

Recently, a new paradigm that introduce concepts like local community participation and collaborative processes have led scientists in Taiwan to accept new approaches such as adaptive and ecosystem management. These concepts also contributed to using traditional ecological knowledge (TEK) in resource conservation. Since passing of the Aboriginal Basic Law in 2005, aborigines have rights to use natural resources and manage lands. To the general public, aboriginal people's legitimacy for co-managing the land partly lies in the traditions that still exist from so far back in history. In the pest TEK are transmitted by oral history, fables and ceremonies, lack of documents. The purpose of the study was thus to find out how the native people recognize TEK. An in-person survey was applied to the Paiwan people who live at the Jialan village, Jingfeng Township, Taitung County. The results showed that gender and other socioeconomic factors have significant effects on the perception of theatrical TEK. The analysis also pointed out that TEK was lost in young people. In addition, about 30% of the respondents neither use plants nor animals. It revealed that respondents no longer depended on natural resource for existence. Finally, this study also found that Jialan people agreed that local people participation could be beneficial in implementing natural conservation, but they excluded non-aborigines from the traditional territory and considered that non-local people committed most violations in forest.

台東縣金峰鄉嘉蘭村傳統生態知識調查情形，為克服母語翻譯的問題，由當地人協助進行調查。

Survey situation in the Jialan village, Jingfeng Township, Taitung County. To solve the translation difficulty of mother tongue, an aboriginal help us to make in-person survey.

台灣社區林業政策整體評估之研究

Policy outcomes of community forestry in Taiwan

王培蓉

台灣森林經營方向與原住民族密不可分，如何藉由社區林業計畫的推動，有系統的蒐集當地生態知識、建立部落為主體的環境意識、培養林業機關與原住民的夥伴關係、打造原鄉生態產業，是促成永續森林經營及生物多樣性保育的必要環節。因此，了解原住民社區對社區林業的參與度及參與類型，對於未來發展及政策調整至為重要。

本研究執行第一年由2002~2008年林務局社區林業資訊網之申辦社區林業案件資料庫，登錄1,242筆案件，含490個社區。過去有一些研究指出，原住民社區參與比例偏少，大多研究類型偏向教育訓練—即以研習或講座方式宣揚自然保育理念為主。分析結果發現：原住民參與社區林業的比例高於一般社區16倍以上。此係因原住民社區與整體社區於政策設計時未予分類，以致由統計結果無法說明原住民族參與率仍待加強的事實。故本研究建議應強調原住民為社區林業主要的政策標的團體，而做出不同申請對象的計畫區隔設計。

現行社區林業計畫對原住民社區與整體社區於政策設計時未予分類，導致政策主要標的團體的參與率及資源分配容易遭到稀釋與扭曲。參酌國外經驗，美、加等國社區林業計畫之設計內容，均與原住民計畫有所區隔；而發展中國家之社區林業則以森林周邊社區為主，不包括都會與新興市鎮。若能將社區林業三階段設定明確的政策對象，才能有效與森林經營管理結合。此外，社區林業三階段的設計，隱含著合作對象的空間尺度及社會力應該愈來愈大，才有足夠的規劃及合作空間。現行以社區為申請單元的方式，以「點」為參與單元，缺乏區域尺度的規劃與連結。未來在推動第二階段及[假想的]第三階段，可能會浮現單一社區的能力不足，而可能遭致失敗的困境。本研究建議重覆申請次數高的社區，應於後期計畫納入周邊社區的輔導與共同運作，以開展成「面」的結合，才能呼應跨社區尺度的資源經營問題及投入適當的團體規模。

Development of the forest management always intertwines with aboriginal people in Taiwan. Movements adopting community forestry programs to achieve objectives that involve collecting local ecosystem knowledge; building environment awareness; setting up a partnership of government and aborigines, and developing eco-industries. All the objectives are very important for sustainable management of forests and biodiversity conservation. Consequently, it is important for researchers to have knowledge of the participation degree and participation type of the community forestry in order to develop suitable policy and to modify it in the future.

This study extracted 1,242 community forestry application cases from 490 communities in the database of Taiwan Forestry Bureau from 2002 to 2008 for the first year of the study. We reviewed the published literatures pointing out that few aboriginal communities participated in the projects, and most prevalent participating types are educational trainings. The results showed that the number of aboriginal communities attended community forestry projects was more than 16 times that of the general communities. The figure was hard to explain. After an in-depth study, we noted that the population size and demography of the 2 groups were markedly different, and should have been treated separately. The study suggested that community forestry projects should be appropriately designed to segment the groups and to emphasize aboriginal communities as the major target groups, so as to achieve the goals of the community forestry projects.

Currently, there is no distinction made between the different targeted populations of aboriginal tribes and general communities. Thus, the real participatory rates and resource allocations could be weakened and misinterpreted. We referred to the experiences of developed countries showing that their community forestry policy often focus on urban areas rather than aboriginal communities. Conversely, in developing countries, forest-based communities, not urban and suburban areas are targeted. There are 3 stages of community forestry projects in Taiwan, it implies that entry of more stages require more spatial size and social capacity. Therefore, this study suggests that the practiced community forestry participators should expand their projects to integrate a lager dimension for appropriate group size and resources uses.

社區林業計畫烏來工作站現場訪談。
Field study at Wulia Working Station.

應用育林技術活絡原住民社區經濟及促進生產轉型之研究

Study on the application of silivcultural technologies to active aboriginal community economy and promote its productivity transformation

張乃航

針對台北縣烏來福山村原住民社區進行保留地利用型態調查及分類，透過進行原住民社區經濟活動之調查，彙集社區主要經濟活動型態資訊及人力結構，藉由對保留地造林作業的施行，並經由森林特殊產物的開發利用，尋求合作意願高之原住民，配合進行保留地多樹種闊葉樹混合造林示範，藉由闊葉樹造林撫育作業所生成之各種樹木衍生物，如樹皮、樹葉及小徑材等的加工利用，可以增加原住民村落經濟的活絡。而小西氏石櫟繁殖系統及選種方面，根據試驗初步結果顯示，可經由嫁接繁殖，嫁接成活率約35%左右，其果實種仁含量以種子較高，種子直徑與種子高的比值(高/直徑)大於80%雞蛋型的種子有較多的種仁。狗骨仔能在林下旺盛生長，材質佳、生長期短，可作為短期生產，增加部落現金周轉的來源。

This study meant to investigate and categorize the forms of land use and economic activities of the Fushan aboriginal village at Wulai, Taipei County. We encouraged the residents there to cooperate with us and participate in an experimental reforestation of mixed-hardwood forest to develop the values of non-timber products from the plantation. The practice of reforestation might also provide some financial incomes to the aboriginal economic activity.

According to our silvicultural experiment, *Pasania konishii* trees could be established using a grafting method, with a successful grafting ratio of 35%. The trees could be prompted to bear fruit quickly, with ample seed productions. The egg-shaped acorns of the tree having a mean seed height to diameter ratio > 0.80 often contain bigger kernels which could be incorporated into selection criteria. Another species, *Tricalysia dubia* tree could grow under forest canopies, it have good wood quality and is fast growing, which can be translated into a means of making good income for the aboriginal society.

臺灣原生樹種潛力開發之研究

Study on the potential developments of certain native tree species of Taiwan

黃怡菁

本年度已完成(1) 流蘇再生幼苗基段多側芽誘導試驗。(2)垂枝石松體外培養培植體之初步消毒方法比較。(3) 毛柿授粉昆虫及花粉管發育之觀察、生長積溫調查及模式推估，並建立試驗田。(4) 完成山肉桂、土肉桂、食茱萸、臭辣樹等種子之發芽與儲藏性質之研究並判斷其儲藏性質。(5) 以水蒸餾法及Headspace-GC二方法萃取山胡椒之各部位精油，分析其組成化合物及收率，並評估各部位精油之抗菌活性及紡織品抗菌能力測試。結果以果精油之效果為最佳，且其抗菌來源證實為citral化合物。(6) 臺灣產阿里山五味子種子有形態生理的休眠，其果實之丙酮萃取物，經分析共分得21個純化合物。

The followings were completed in this year: (1) the *in vitro* lateral bud induction test of basal section of *Chionanthus retusus*; (2) primary comparisons of sterilization methods for the *in vitro* culture of *Lycopodium phlegmaria*; (3) establishing the pollinating insects, growth characteristics of the pollen tube, and the growth accumulated temperature of *Diospyros discolor*; (4) research on seed storages and germinated mechanisms of the following 4 species: *Zanthoxylum ailanthoides*, *Tetradium glabrifolium*, *Cinnamomum insularimontanum*, and *Cinnamomum osmophloeum*; (5) extraction of tree components and evaluation of their biological activities for *Litsea cubeba*, the results revealed that the fruit has the best response; (6) the extracted components of the fruit of *Schisandra arisanensis* produced 21 pure chemicals, and its seeds exhibited morphological dormancy.

台灣森林地區水文與氣象因子變遷之研究

Studies on the changes of hydrologic and climatic factors for forested lands in Taiwan

陸象豫

溫室效應所引發的全球溫暖化現象日益明顯，已有研究顯示台灣低海拔地區近年來無論降雨或溫度在時間及空間分佈的形態均有所改變，極端暴雨事件與冷熱異常現象發生情形大增。而佔台灣面積三分之二以上的山坡地地區，咸信亦發生同樣的情形，惟缺乏具體的研究以驗證。本計擬選定記錄較長的試驗集水區與氣象站，分析台灣森林地區降雨量、降雨強度、降雨日數、平均溫度、最高溫度與最低溫度等因子，繪製等雨量線及溫度分佈曲線，以探討降雨量及氣溫變化趨勢、變動幅度與週期等特性。完成蓮華池氣象站1961年至2008年及畢祿溪氣象站1971至2008年氣象紀錄變遷分析，獲悉蓮華池地區無論日平均溫度、最高溫度在2000年以後都有上升的趨勢，最低溫度則有下降的現象；畢祿溪地區亦有相同之情形。此種現象顯示近年來該二地區白天溫度上升，夜晚溫度則降低。導致溫度變化的最大因素，初步判定為氣溫極端事件發生的頻率在最近10年來相對地增加。此二地區之降雨量在2006年之後的數年間均明顯地增加，但總體而言無明顯地變化趨勢；惟降雨天數無論乾濕季自1995年後均有減少的趨勢，尤以濕季的降雨天數最為明顯，顯示該等地區降雨有日漸集中的現象。

蓮華池地區降雨日趨集中，在乾季時溪流常枯竭，以前甚少發生此種現象。

The raining days in the Lienhuachih area was more and more decreased and was resulted that some streams were dry up during dry season. This phenomenon was very unusual in the past (about decades ago).

Many studies have indicated that regional heterogeneity in the amounts of precipitation and magnitude of temperature fluctuation were gradually increasing and extreme events were happening more frequently both in temperature and rainfall through years in the low-elevation areas of Taiwan due to the influences of global warming. Forested lands, which occupies more than two-third of the total areas of Taiwan, are believed to undergo the same situations but there was no direct evidence to prove this. The proposes of this project are to analyze the rainfall amounts (annual, wet and dry seasons), intensities, days of rainfall and the average, maximum and minimum air temperatures from meteorological stations having relative long historical records, and with supplemental records from the Central Weather Bureau, for investigating the trends of changes and their precipitation and temperature magnitudes in the mountainous areas of Taiwan. In addition, the characteristics of extreme events of temperature and rainfall and their related discharges will also be investigated to provide references to watershed and ecology management and research. The long-term trend analysis of temperature and rainfall has also been made for records from 1961 to 2008 of the Lienhuachih station and 1971 to 2008 of the Piluchi station. Results showed that the daily average temperature and maximum temperature for both stations increased significantly after 2000. However, the average daily minimum temperature decreased after 2000. The phenomenon indicated that the daytime temperatures tended to increase, nighttime temperatures decrease and extreme temperatures happened more frequently recently. Rainfall for both stations increased significantly during the period from 2006 to 2008 but no apparent tendency could be found. In addition, the days of rainfall from the records of both stations significantly decreased after 1995, especially for the wet seasons from May to October. This situation revealed that the time distribution of rainfall became more and more concentrated for those areas.

棲地管理與生物多樣性指標生物之研究

Studies on the habitats management and biodiversity indicators

范義彬

本研究包含扇平蝶類與植群關係的研究及水棲昆蟲相和蓮華池水域指標生物之研究，以獲得該地詳細生態資料。(1)蝶類與植群關係的研究方面，經由蝶類相及族群調查，以扇平生態科學教育園區為調查範圍，沿固定的調查樣線每月進行1次，進行鑑定及記錄，其中以粉蝶科數量最多，蛺蝶科物種數最高，最優勢的種類為沖繩小灰蝶。此外並調查園區內蝶類幼蟲食草、成蟲蜜源植物以作為植物繁殖的依據。(2)水棲昆蟲相及水域指標生物之研究方面，則於蓮華池地區設置四個樣站，包含靜水域之樣站一至三，及流水域之樣站四。利用D型水生物網及蘇伯氏採集於水域中進行採樣，並進行相關之環境因子之測量。然後在實驗室中以標準篩過濾樣本，取大於0.5mm之無脊椎動物進行分樣、鑑定及計數，以進行資料分析，並計算生物指標。其中流水域之物種數及FBI值皆優於靜水域；而靜水域樣站中，樣站一之生態池豐度明顯高另外二個人工化較嚴重之樣站，但FBI值偏高，表示多為耐污性高之生物；另由於該池淤積情形日益嚴重，可觀察到溶氧量下降及濁度上升之情形。本研究並栽植蝶類幼蟲寄主植物及成蟲蜜源植物，共計5科8種2,455株；另進行水域環境改善工程，比較棲地改變後水棲昆蟲相的變化，以了解控制棲地的多樣性與維持物種的多樣性之關聯，期能運用人工介入，使得生態系朝向更多樣性的方向演替。

Two parts of research work included: (1) Relationship between the flora and butterfly fauna; and (2) Aquatic insect fauna and their biological indices. Butterfly fauna at Shanping, Liukuei Research Center, was investigated by a monthly transect count. Among all butterfly species, Nymphalidae was the most diverse family; whereas, Pieridae was the most dominant family, and *Zizeeria maha okinawana* was the most dominant species. Host plants and nectar plants of the butterflies were also recorded and a total of 2,455 plants, belonging to 8 species in 5 families were grown. In the aquatic insect study, 4 sampling sites were established at the Lienhuachih research center. Aquatic insects were mainly collected by using D frame-nets and Surber's samplers, and some environment factors were measured. Invertebrates > 0.5 mm were identified and accounted for in the data analysis and biological indices calculations. According to the investigation data, Site 1 has a higher family richness than the other standing water sites, but it also has a higher turbidity and lower DO because of silting. The environments of Site 1 and Site 2 were rebuilt after the investigation. We try to find the best way to maintain biodiversity of a habitat through artificial management practices.

陰香對本土肉桂類樹種的威脅與因應研究

Study on the threat and coping strategy of exotic *Cinnamomum burmannii* vs. endemic *C. osmophloeum*

陳正豐

引自中國大陸的陰香，其造林木的天然下種苗數量最高可達10,192株/m^2，即便是曾經遭受人為干擾過的地區，最低亦有1,562株/m^2，且年平均苗高達8.7~12.7cm，顯見陰香不容忽視的天然下種能力；以陰香為父本、土肉桂為母本之授粉，有29.6%的成功率，而以土肉桂為父本、陰香為母本之授粉，則未見授粉成功之情況；陰香新芽綻放期約1個月，花期大約1-1.5個月，結實期則約有52-57天，果熟期約經43-57天，各地區之陰香物候現象並不一致，以花蓮地區較其他試區為慢；白頭翁取食陰香，其後隨排遺放出的種子發芽最快，全部種子發芽所需期間最短，且發芽率極高，評估陰香透過此種被動物傳播的狀況，將可能更為加速而利於其族群擴展。研究顯示，陰香對本土的肉桂類樹種之威脅與挑戰確實是不容忽視的。

Cinnamomum burmannii originated in China, in its natural habitat, seeding and seedling occurrence in the forest can reach 10,192~1,562 seedlings m-2, and an average annual height growth up to 8.7~12.7 cm. Obviously, threats of its natural seeding capacity shall not be ignored. Pollination success rate of *C. burmannii* male and *C. osmophloeum* female could reach 29.6%; whereas vice versa, there was no case of success. Blooming period of *C. burmannii* shoots required a month, the flowering period lasted approximately 1~1.5 months, and the fruiting phase was roughly 52~57 d; fruit maturity took about 43~57 d. At various regions, the *C. burmannii* phenological phenomena were different. In the Hualien area, they were slower in comparison to the other regions tested. Chinese bulbuls fed on *C. burmannii* fruits, with the excrement encased seeds having the fastest germination rate. All its seeds germination time was short, and the germination rate was extremely high. Evaluation of the *C. burmannii* spreading via birds indicated that this mode may accelerate the expansion of its populations. The study showed that the threats and challenges of the *C. burmannii* to the local Cinnamon species should not be neglected.

生態資訊學技術應用在森林經營之研究

A study to the application of ecoinformatics technique for forest management

鄭美如

本計畫主要目的為運用生態資訊學所建構的新方法論，作為林業經營所需的資料蒐集平台，並依目前國際長期生態網共同使用的生態後設資料語言(EML)建立資料倉儲、使用、分享、分析、整合等功能的資訊管理系統。同時調查六龜地區從事遊憩活動的潛在遊客特性、行為，結合監測系統所蒐集之資料，進行比對，提供經營單位建議及參考依據，改善園區軟硬體，提供更多服務。並藉由生態資訊管理技術及森林經營之國際交流，提升台灣在此一研究領域之技術及國際地位。本年度已完成園區整體有線與無線網路建構與改善、資料倉儲擴充及野外資料收集測點之設備更新。在國際技術交流方面，於本年6月舉辦生態資訊管理技術國際研討會，共有11位國外專家學者與會，並派員參與第13屆世界林業大會獲取最新林業技術等。此外，經實際遊客遊憩行為之傳統調查與利用無線感測網監測結果發現，兩者可得相近結果。

The purpose of this project is to apply the ecoinformatics techniques to forest management. The major method is to establish an EML-based data management system for the automatic collection of field sensor data, such as acoustic records, images, video records etc. Besides, the system can provide data storage, search, download, sharing, and integrating to researchers in the public domain. Furthermore, by knowing the characteristic and behavior of tourists through questionnaire survey, the survey results can provide the forest administration as reference materials. Benefits of this project include making the Shanping work station a model of ecological management site, and starting international collaborations. Moreover, the study results can provide authenticated information for making environmental protection, monitoring, and policy decisions to improve the facilities in Shanping.

In this year, a wireless sensor network system has been installed, including a field data collection equipment. In the part of international collaboration, we held an international information management workshop in June, 2009. In total, there was 11 foreign experts and scholars attended. TFRI also took part in the 13th World Forestry Congress and got the newest forestry development knowledge. In addition, the research results on the behavior of the tourists at Shanping were found to be similar either by a traditional survey or by electronic monitoring.

應用高解析度遙測技術協助森林資源調查之研究

Using high resolution remote sensing techniques to aid the national forest inventory

謝漢欽

本研究達成以台東縣太麻里地區2005年4月30日，同一日期、感測時間相近的IKONOS及FORMOSAT-2衛星影像輻射常態化處理後之NDVI綠度分類影像，以相同的最小面積單元(minimum mapping unit)及像元聚合法，選擇具獨立地性的地景結構指標進行格局結構量化分析。對於兩者不同空間解析度引起地景結構指標分析結果之異同進行比較。結果顯示尺度效應足以造成兩者的組類及地景層級結構指標之明顯差異。使用福衛二號時可充分利用其時間解析度的優勢進行森林覆蓋類型監測，但應注意伴隨空間解析度低於IKONOS而造成以相同光譜資訊(NDVI)分類結果的差異，足以影響地景指標評估之不同結果。反觀IKONOS空間解析度高，但時間解析度不如福衛二號，影像獲取成本高是其弱點，但在相同光譜資訊下，能得到較細緻的土地覆蓋分類結果，有利於大比例尺的監測。必須特別注意的是：未來應用不同空間解析度影像進行地景指標評估時，應注意其尺度效應的影響。

以台中縣台中港北防風林2007年4月12日及2008年3月3日感測之FORMOSAT-2衛星影像，先進行兩期影像包含減除地形效應輻射值常態化處理及以選擇輻射控制點(PIFs)之多時期影像迴歸輻射值校正處理。然後以NDVI與多譜影像4個波段之非監督分類影像，萃取出屬於非木麻黃覆蓋、並有闊葉樹或草類生長的孔隙，再以孔隙的最小面積單元臨界值及孔隙的形狀地景指標臨界值當作木麻黃褐根病孔隙篩選的萃取法則；最後依此法則萃取出兩期影像的褐根病發生孔隙，進行孔隙數與面積比較。結果2007年的孔隙數與孔隙面積皆大於2008年。除了有關多時期影像前處理及孔隙自動化分類與萃取法則的精度，主要影響因素為伴隨影像拍攝品質(受限於當時大氣狀況)及感測掃描角度影響孔隙監測結果。研究結果再與兩期人工數化的木麻黃褐根病孔隙圖進行比較，結果2007年孔隙數與孔隙面積仍皆大於2008年，其與自動化篩選結果一致。

This project obtained high resolution satellite images mainly from Formosat-2, accompanied by some IKONOS images, as the research materials to aid implementation of the 4th National Forest Inventory (FNFI). In this study: (1) we used the same date, April 30, 2005, and nearly the same time, to acquire the IKONOS and Formosat-2 satellite images of the Taimali District to produce the NDVI images. The same minimum mapping unit and pixel aggregation rule were determined in performing the same classification scheme for the NDVI greenness-clustering maps. These 2 maps were applied to evaluate the scale effects of the independent analysis of landscape metrics. Based on the 2 different spatial resolutions and other factors, the results showed that effects of the scale were sufficient to cause clusters and landscape level of the landscape metrics analysis to differ significantly. (2) At a study site of North windbreak forest, Taichung Harbor, 2 Formosat-2 satellite images acquired on April 12, 2007, and March 3, 2008 sensing were obtained. Then normalization treatment was carried out to reduce the topographic radiation effect, and to select the control points (PIFs) for the 2 images so that the radiation values of the many-times images could be calibrated by regression. These were followed by the NDVI and the 4-band multi-spectral images of the unsupervised classification images for extracting the non-*Casuarina* coverage, and broadleaf trees or grass growths in the gaps. Then the smallest gap threshold unit, and the critical values of landscape indicators of gap shapes were developed as the extraction filter rules for the brown root rot disease of *Casuarina* stands. Finally the 2 images extracted for brown root disease gaps were compared for the gap numbers and gap sizes. The results indicated that the gap numbers and sizes in the 2007 image were greater than that of the 2008.

國有林地土壤管理群組之建立與應用之研究

The Application and Establishment of Soil Management Groups for National Forest in Taiwan

杜清澤、黃菊美

本年度將去年度執行成果之6個暫定土壤管理群組(S-AT1, S-AT2, S-AT3, M-AT1, MAT2, M-AT3)依3種不同土壤坡度：SL1(≦15°)、SL2(16°~35°)、SL3(≧36°)，應用地理資訊軟體套疊分為16個不同坡度及土壤厚度及A層厚度的土壤管理組。在新竹、東勢、南投3個林區已採樣55個樣點，其現場判定之土壤管理群組與圖面所標相同者有24個，相符程度僅達41%，此情形應是台灣地形零碎而複雜，在採樣時受限於微環境限制所致。

The soil series is incorporated at the lowest and most detailed level of the soil classification system. But the string of terms that comprise the taxonomic classification of a soil are not readily apparent and diminish the value of utilizing the classification system. A simplified approach is needed using field determination of observable and textural characteristics of the soil to establish soil classification. Observable and textural soil properties are readily perceived and immediately useful when making local interpretation for land use. A classification method based on this approach will facilitate the exchange of soils information. The objectives of this study was attempted to group the soil series established by high mountain forest soil surveys into different forest soil management divisions (FSMDs) with Observable and textural soil properties in the fields.

This year we classified the tentative six soil management group (S-AT1, S-AT2, S-AT3, M-AT1, M-AT2, M-AT3) which classified last year in accordance with three level of soil slope which is SL1 (≦ 15°), SL2 (16° ~ 35°), SL3 (≧ 36°) by geographic information software. We got 16 different sets soil management group of slope and soil thickness and the thickness of A layer.

We had sampled 55 samples in Hsinchu, Dungshih and Nantou forest district. The soil management groups of these 55 samples has 24 samples conform to the soil map, precisely the extent to only 41%, this case should be induced by complex and fragment landform of Taiwan, subject to sampling limitations in the micro-topography.

台灣地區造林計畫之碳吸存能力與碳排放權交易可行模式之研究

Research on the carbon sequestration capability and feasible models of carbon credit trading from reforestation initiatives in Taiwan

吳俊賢

本計畫除全面普查歷年來全民造林及平地造林之基本資料，也將分析國外森林碳交易實例及自願性碳市場的現況及運作模式，並以問卷調查方式分析國內民眾對植林減碳的認知、態度及行為意向。結果顯示：

1. 平地造林樹種間之胸徑生長及成活率差別很大，樹形常多分叉。
2. 受訪者對全球暖化、水源污染、空氣污染、及氣候異常等四項問題的關心程度最高，也認為全球暖化問題相當嚴重；而其他環境與生態問題中之對過多的人口、外來物種入侵等二項問題的關心程度及認知的嚴重程度較低。對全球暖化議題認為是大家都需要關注的事，其中以「減少溫室氣體排放量是地球上每個人都要做的事」、「人類行為是造成全球暖化及氣候異常的主要來源」及「溫室效應造成的全球暖化及氣候異常現象愈來愈嚴重」等三項議題之認同程度最高；而「減少溫室氣體排放量是別人的事，不關我的事」、「減少溫室氣體排放量是別的國家要做的事」、「全球暖化的嚴重與否對我沒有影響」等三項反向議題之認同程度較低。知道政府推動「節能減碳」行動的受訪者占88.78%，有11.22%尚不知道。而就「碳中和」(carbon neutral)或低碳生活的說法，知道與不知道的比例相近，聽過者占50.68%，沒聽過者占49.32%。植樹造林為節能減碳的策略之一，也為個人或企業達成碳中和的方式之一；考慮或已從事植樹造林來達成減碳之目的者占80.61%；透過此認養林木(樹)的方式來參與「植樹造林減碳」工作，願意參與林木(樹)認養者占74.31%；而願參與林木(樹)認養，每棵林木(樹)願贊助的認養費用約為475元。
3. 全球暖化是全世界人類的夢魘，溫室氣體減量是世界各國非常重視的議題，我國現在也正在推動節能減碳，以期減少二氧化碳之排放及增加大氣中之二氧化碳吸存，農委會因應此趨勢而成立「節能減碳研究團隊」，由本所黃所長擔任本團隊之召集人。植林減碳是碳減量策略中低成本高效益的方式，也是一種綠色產業與行動，對環境有益且對工業之經濟發展衝擊最小。台灣地區綠色造林除加強造林之碳吸存功能的研究外，也可考慮投資海外造林，參與碳市場之模式，以突破台灣可造林土地面積狹小之困境。

The purpose of this research was to analyze carbon sequestration capability of the reforestation initiatives, such as the Farmland Reforestation Initiative, National Reforestation Initiative, and Level Ground Reforestation Initiative in Taiwan over the past years. The project focused on the performance of major tree species in plantations, and investigated timber stocking and carbon content, in order to evaluate benefit of carbon sequestration in future green reforestation initiatives, to assess the national forest carbon, and to select tree species of reforestation. Also, the potential models of carbon trading will be studied. The project will survey all the basic data from National Reforestation Initiative and On-the-plain Reforestation Initiative, and analyze real cases of foreign carbon trading, and the status quo and operational model of voluntary carbon market.

木本生質能源植物選育及種子生產技術的研究

The study on selection and seed production technique of woody bioenergy plants

游漢明

我們依前人研究結果初步選定台灣地區具種子油脂生產潛力的大戟科植物千年桐、三年桐、石栗及烏桕 為目標樹種，進行單株種源收集，母樹物候學觀察建立能源樹種母樹基本資料，98年共記錄千年桐28株、三年桐8株、石栗34株、烏桕 50株、山桕 11株及水黃皮2株，總計133單株，並採集了120株單株種子進行育苗作業，培育苗木進行栽植試驗，共培育得種子苗三年桐795株、千年桐1,960株、石栗3,799株及烏桕 4,341株，合計10,895株苗木。

能源樹種母樹物候全台每月調查一次，初步結果顯示三年桐及千年桐自4月開始陸續開花，北部地區花期較集中在4–5月份，而中南部可延續到6–7月份。花後果實發育期約5個月，而三年桐到8月底果實已進入成熟期；石栗開花及著果期相當長，可持續到10月，果實主要成熟期為7–8月；烏桕為秋、冬季落葉樹種，中部花期最早2月即開始，北部最晚5月，5–6月進入著果期，果實發育到9月，10月份果實開始成熟，11月果實開裂露出帶蠟之白色種子。

能源植物的造林試驗地目前在林試所太麻里研究中心設立2.0公頃種源保存區，栽植1個月後烏桕平均存活率達96%，三年桐86%、千年桐83%及石栗69%。

Bioenergy trees for the study were selected according to the references of former studies on seed oil species and potentially by-products. The selected Euphorbiaceae trees included *Aleurites fordii*, *A. montana*, *A. moluccana* and *Sapium sebiferum*. We labeled the mother trees and established a database for plant phenology investigation in which seeds were collected for raising seedlings and for the afforestation studies. A total of 133 mother trees were labeled and seeds of 120 individual trees were collected. The seedlings from *A. fordii*, *A. montana*, *A. moluccana*, and *Sapium sebiferum* were raised into 795, 1,960, 3,799, and 4,341 trees, respectively for a total of 10,895 trees. Plant phenological investigations were conducted monthly. Blossom dates of *A. fordii* and *A. montana* started in April in northern Taiwan, and bloomed from April to May. Blooming lasted from June to July in central and southern Taiwan for the 2 species. In August, the fruit of *A. fordii* matured. Blooming and fruiting stages of *A. moluccana* lasted for 5 months until it ripened in October. Its fruits mainly matured from July to August. For *S. sebiferum*, blooming occurred early in February in central Taiwan, and it flowed later in northern Taiwan in May. Fruiting stage of *S. sebiferum* was from May to June; in October, the fruits matured; and the capsule opened in November. A two ha plot was afforested in the Tamali Centre of TFRI for the energy plants progeny study. The planted *S. sebiferum* seedlings have a survival rate of 96%, 86% for *A. fordii*, 83% for *A. montana*, and only 69% for *A. moluccana*.

各種種子之形態。
Shapes of various seeds.

牛樟菇人工培植體系之建立

Establishing an artificial fruiting body cultivation system of *Antrodia cinnamonea*

張東柱

在天然林中，牛樟老齡樹的樹幹常生長牛樟菇。牛樟菇成為山老鼠盜採的熱門森林副產物，因民間傳說，牛樟菇對人體某些疾病具有特殊的療效。為了獲得穩定牛樟菇的來源，不僅牛樟菇是盜採的對象，牛樟樹也成為盜伐的標的物，如能在法規許可下，以政府或委外方式，將現有盜伐的牛樟木做適當經營管理，使其長出牛樟菇，提供市場需要，不但可以降低價格，同時可以減緩盜採與盜伐的壓力。

關於牛樟菇的段木培植，目前都沒有穩定的量產技術與體系。在實驗室有零星不穩定的出菇情形，此現象可能是對牛樟菇的整體培植條件仍不清楚。本計畫將從菌種、木材處理及接種方法等方面做有系統的研究，以期建立可行的培植體系。

自全台牛樟的天然生育地採集及分離牛樟菇菌種，並利用在人工洋菜培養基出菇的方法（Chang and Wang, 2004）篩選具有較可能出菇的菌種，供接種牛樟木材的菌種。

自竹東地區及南庄地區的林地，採集牛樟菇的材料，在實驗室進行分離純培養，以滅菌的解剖刀切除表面與外界接觸的菇體，切取大小約2×2×2mm的內部菇體放置在PDA（potato-dextrose-agar）或MEA（malt-dextrose-agar）平面培養基上，俟菌絲體生長後，以滅菌的解剖刀切取菌絲尖端，並移植到新的PDA或MEA培養基，此純化的菌種供菌種篩選之用。自竹東與南庄地區分別獲得7株菌株，將這14株菌株以Chang and Wang（2004）的方法，測定他們在營養洋菜培養基的出菇情形，其中有3株菌株（代號為TFRIB05，B08，B13）可以在2-3個月內於營養洋菜培養基形成子實體，其中選取兩株供接種於牛樟木材用。

Fruiting bodies of *Antrodia cinnamomea* were collected from the Chutung and Nanchuan areas. Fourteen pure cultures of *A. cinnamomea* were isolated from the collected fruiting bodies. The 14 isolates were tested with nutrient agar medium for their fruiting body forming abilities. Three out of the 14 isolates were able to produce fruiting bodies on the medium. These 3 isolates were used for inoculation on woods of *Cinnamomum kanehirai* in a cultivation system..

菌株可以在2-3個月內於營養洋菜培養基形成子實體。

Three out of of the 14 pure cultures isolated from wild *Antrodia cinnamomea* fruiting bodies could produce fruiting bodies on nutrient agar medium within 2-3 months.

木質廢棄物資源化策略研究

Strategic study on the conversion of waste wood into useful resources

黃國雄

銀合歡為恒春半島最普遍之外來入侵植物，受其影響之面積已達數千公頃，為了恢復原有之自然生態環境，該等入侵植物必須移除，然由於樹幹之徑級非常小而不易加工，若砍伐後棄置於林地任其腐朽並產生二氧化碳而回至大氣中，對二氧化碳減量而言，可能產生負面作用。

本研究以墾丁地區所伐除外來入侵種之銀合歡為原料，利用自行建造之土窯燒製木炭藉以達到資源化與碳保留之目的。將伐除之銀合歡裁斷成長度1 m後，測定其徑級分布、容積比重與進窯時含水率，木炭燒製時測定窯內炭化溫度與煙囪溫度等共10處，出窯時秤取木炭重量並計算收炭率，並由土窯內取不同炭化溫度之銀合歡木炭進行性質測試，試驗項目為表面電阻係數、pH、含碳量與真密度，同時亦計算土窯燒製木炭之碳保存率。

由試驗結果得知銀合歡試材以直徑5-7cm者最多，其占有率為66%，容積比重平均為0.61，進窯時含水率平均為43.21%，木炭燒製過程中窯內上層溫度之上升較下層者快，完成炭化作業封窯時之煙囪溫度為430℃，窯內上層溫度達750℃以上而下層溫度則約為580℃，出窯時之收炭率為29.97%。又由銀合歡木炭性質測試結果得知銀合歡木炭之表面電阻隨炭化溫度升高而明顯降低，pH值受炭化溫度之影響不明顯，碳含量隨炭化溫度升高而有增加之趨勢，真密度隨炭化溫度升高而明顯增大，利用土窯燒製銀合歡木炭之碳保存率為46.10%。

Leucaena leucocephala is one of the most widespread alien invasive plants on the Hengchun Peninsula and several thousand hectares of land were affected. In order to restore the natural ecological environment, these invasive plants must be eliminated. It is difficult, however, to process the wood of *Leucaena leucocephala* because of the small trunk diameters and poor tree forms. Carbon dioxide emission from decaying of the trees will returns to the atmosphere if the trees were cut down and discarded on the sites. Thus, simply removing the trees without subsequent processing will bring about a negative environmental effect.

In this study, the wood of *Leucaena leucocephala* harvested from a coastal forest restoration project carried out by the Kenting National Park Headquarters were used for resource reuse and carbon conservation through charcoal making. Carbonization and chimney temperatures of an earthen kiln during the charcoal making were separately measured by K-type thermocouples After producing the charcoal, the yield was calculated by weighing charcoal. In order to investigate the effect of different carbonization temperatures in the earthen kiln on the properties of wood charcoal, the true density and electric resistivity of the resulting charcoal were tested for the specimens sampled from different positions in kiln heights. Finally, the percentage of carbon preservation was estimated by the carbon contents of wood and charcoal.

From results of the temperature rise process at each measuring point in the earthen kiln, an isothermal curve of different temperatures was obtained. The carbonization temperature at the upper part rose earlier and more rapidly than that at the lower part. The highest temperature in the kiln at the end of carbonization reached > 750℃. The yield of wood charcoal was 29.97%. Electric resistivity of the wood charcoal decreased significantly with an increasing carbonization temperature. The pH of the wood charcoal was in the range of 9.39~9.80 and was not apparently affected by the carbonization temperature. Carbon content and true density of the wood charcoal increased with an increasing carbonization temperature. Percentage of the carbon conservation was 46.10% for charcoal making from *Leucaena leucocephala* using an earthen kiln.

速生高纖維樹種碳吸存及製漿節能效益之研究

Studies on benefit of fast-growing and high-fibered tree species on carbon sequestration and energy-saving in the pulping process

許原瑞

本計畫目標在於評估速生高纖維素樹種之碳吸存及製漿節能效益，藉以選定可供林漿紙產業造林應用之節能減碳林木品系。本年度選擇2個轉殖4CL基因及2個非轉殖赤桉營養系，八月取樣後，進行樣木之地上部生物量、碳含量、木材組成分如木質素與纖維素含量及木質素單體等以及製漿性質檢測，進而分析比較其碳吸存及製漿節能效益之差異。本計畫初步證實，轉殖反義式Euc4CL1木質素生合成基因的兩個赤桉營養系，確實可提高製漿得漿率，增加漿廠的紙漿收益，並降低製漿過程藥品之使用量，相對的節省蒸解、漂白過程所需的電熱能而達成節能減碳之目標。初步篩選出節能減碳之桉樹品系，建立評估之模式，據此將評估方法修飾完整，擴大進行節能減碳林木標的品系之篩選與應用。

The project proposed to evaluate benefits of the fast-growing and high-cellulose tree species on the carbon sequestration and energy saving in the pulping process. It is anticipated that energy-saving and carbon-reducing tree varieties will be selected to facilitate afforestation and supply raw materials to the pulp and paper industries. In this year, 2 transgenic *Eucalyptus camaldulensis* plants with antisense 4CL transgenes and 2 non-transgenic varieties were evaluated. Sample trees were harvested in August. The aboveground biomass, carbon content, major wood components, such as lignin and cellulose content, lignin components,. and pulping properties were determined. Differences in benefits of carbon sequestration and energy saving in the pulping process among the tree varieties were analyzed and compared. The results indicated that transgenic plants were better than the non-transgenic ones in energy-saving and carbon-reducing. Transgenic plants with the antisense 4CL transgenes have confirmed higher pulp yields and reduced the consumption of chemicals in the pulping process. And energy consumptions of the digestion and bleaching were reduced as well. The process would thus achieve the goal of reducing carbon. Based on the results, the evaluation protocol will be refined and be extensively used to screen target tree varieties.

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產學合作計畫推動及成果

延長框組壁式木構造房屋使用耐久性技術之研發

Development of technology in extending the service life of wood frame buildings

塗三賢

框組壁式木構造房屋是近代工業化後的產品，特色為以小斷面、小尺寸的木構材框架，組成承重結構牆系統的住宅建築，是北美住宅的主流，引進台灣後，近年來已成為國內木構造房屋的主要型式。然而台灣位處亞熱帶，高溫多濕的氣候，迥異於屬溫帶氣候的北美地區，因此木構造房屋的結構牆若不能依現地的氣候條件加以改良設計，造成壁體內水分的聚積，就容易有腐朽、發霉、遭白蟻危害、漏水等問題產生，因而減少了房屋的使用年限。

本計畫針對不同的木構造房屋結構牆設計，探究影響壁內水分含量變動的因子，以研發出低成本、高效能的結構牆設計與建造技術，達成延長框組壁式木建築使用耐久性的目的。

計畫主要執行成果如下：

1. 完成建造具單斜屋頂之試驗用框組壁式木構造房屋一棟，在其中2面長方向外牆部分分別以3片 1.2 × 2.4 m (4 × 8 ft)不同構造之結構牆組成。在設計上，採用3種不同型式之構造，分別為(A)傳統式框組壁牆、(B)高效能式框組壁牆與(C)高效能附加活性碳防潮布框組壁牆等3種不同構型設計，以比較水分阻隔設計的效果。試驗結果顯示在觀測期內，試驗木屋室內溫度變動的變異係數為9.67%，室外溫度變動的變異係數為13.28%，因此可知試驗木屋室內溫度變化較室外溫度的變化緩和；試驗木屋室內溫度變動的各時刻的平均溫度約在19~26℃之間，而室外平均溫度的變動則約在18~27℃之間。
2. 三種不同構造型式之框組壁牆組，對室外水氣的阻隔能力均與對照牆組差異顯著；其中對照牆組壁內的相對濕度平均約為89.6%，Type A牆組壁內的相對濕度平均為69.1%；Type B牆組壁內的相對濕度平均約為65.7%；而Type C牆組壁內的相對濕度平均則約為63.0%。監測結果顯示，三種不同構造型式之框組壁牆組的水氣阻隔能力為Type C > Type B > Type A。就建造成本分析，每減少1%的壁內相對濕度所需增加的建造成本，Type C、Type B及 Type A分別為36.7元、24.0 元及6.1元，由初步的監測結果顯示，Type A型測試牆組的成本效益比最高。

試驗木屋測試牆組成本效益比

	相對濕度平均值(%)	相對濕度減少量(%)	建造成本(元)	成本效益比(元/%)
對照牆組	89.6	-	5,616	-
Type A	69.1	22.9	5,756	6.1
Type B	65.7	26.7	6,256	24.0
Type C	63.0	29.7	6,706	36.7

Wood frame buildings are energy efficient, was set up to low cost, attractive, and comfortable. They also have superior seismic performance. If designed and built to meet specific climatic conditions, they are indefinitely durable. The key is to determine the optimal exterior wall design for performance vis-à-vis moisture and durability in the Taiwan climate. Excessive moisture entrapped within the wall cavities can lead to unhealthy moulds, decay inducing fungi, and termite infestations. A test hut was set up to address this issue. The hut enables moisture monitoring of alternative exterior wall designs to facilitate selection of the optimal design, and to ensure that designs that do not adequately perform are not built. Sensors measuring relative humidity, temperature, and moisture content of wood components are placed within the cavities of the walls under test. The source of such moisture is water vapour from very large atmospheric moisture loads in the Taiwan climate, that may enter the cavity through diffusion or air flow (leakage) and become entrapped and possibly condense within the cavity.

The current results of the project are as follows:

1. A 4.2×2.8×3 m test hut has already been built at the Fushan Station, TFRI. The lateral exterior walls are installed with by 3 different wall structure designs. Thay are (A) traditional wall, (B) high performance wall and (C) high performance wall with polystyrene insulation(HPP). Interior temperatures of the test hut fluctuated at 9.67%, and the outside environmental temperatures varied at. 13.28%. These results show that the test hut has a smaller temperature variation than the outside environment. In the testing period, the average interior temperature of the test hut is around 19~26℃.

2. Three different wall structure designs show different abilities of vapor barriers. The results show that the average relative humidity (RH) of the control wall is 89.6%, the average RH of the traditional wall is 69.1%, the average RH of the high performance wall is 65.7%, and the average RH of high performance with polystyrene insulation wall is 63.0%. The abilities of vapor barrier are Type-C > Type-B > Type-A. In comparison of construction cost, the costs of reducing 1% RH by each type of wall are Type-A 6.1 NT$, Type-B 24.0 NT$ and Type-C 36.7 NT$. The Type-A wall has the highest C/P value.

Comparison of C/P values in different walls

	Average RH(%)	RH reducing (%)	Built cost (NT$)	C/P value (NT$/%)
controled	89.6	-	5,616	-
Type A	69.1	22.9	5,756	6.1
Type B	65.7	26.7	6,256	24.0
Type C	63.0	29.7	6,706	36.7

台灣原生羅漢松科重要樹種種子保存與發芽技術

Seed storage and germination technology of the important native Podocarpaceae species in Taiwan

楊正釧

羅漢松科(Podocarpaceae)全球約有20屬，超過120種。台灣只有竹柏屬(*Nageia*)及羅漢松屬(*Podocarpus*)等2屬6種。這6種除叢花百日青(*Podocarpus fasciculus* de Laubenfels)生長在中高海拔外，其餘均為低海拔之中小喬木，以其優美適中的樹型，及對低地都市環境的良好適應性，長年被園藝業界廣泛應用為盆栽、圍籬、行道樹、庭園樹等，尤以蘭嶼羅漢松(*Podocarpus costalis* presl)及竹柏(*Nageia nagi* (Thunb.) O. Ktze.)此二種最為常見，也由於栽培數量龐大，使得蘭嶼羅漢松已從文化資產保存法的法定稀有植物名列中遭到除名。尤其時下密植小品盆栽的風行，其多是以樹木種子為材料，因為這股風潮已蔓延到中國大陸及歐美各地區，使得這些種子的需求用量更加驚人，又以蘭嶼羅漢松及竹柏此二種種子用量最鉅，所以每到果實成熟期，這些植物在各地的成熟母株均有專人鎖定採摘，然而所獲得的種子常因人為處置不當而大量死亡，抑或無法使種子播種後獲得較為一致的發芽，如竹柏種子可能是因成熟度不一致或部分具休眠性而無法在播種後整齊發芽。

然而，這幾種已被商業利用多年的樹種種子之儲藏及促進發芽方法在國內外卻仍未被完整的研究發表過，使得在運送過程中無意間折損大量優良品質種子，也無法藉由適當的儲藏作業來達到調節供需，進而使生產穩定以掌握市場，又常因發芽技術無法掌握而影響到爾後的商品價值。本研究針對台灣原生羅漢松科之重要樹種，進行種子保存與發芽技術的研究，包括蘭嶼羅漢松、竹柏及桃實百日青(*Podocarpus nakaii* Hayata)等3種羅漢松科樹種，目的為明瞭此3種羅漢松科樹種種子的發芽條件與機制，以作為育苗之基本參考資料，另判別此3樹種種子的儲藏行為與特性，以找出維持這些種子天然壽命的最佳儲藏條件，此結果可提供種子運輸與儲藏的良好方法。

目前的研究成果已找到解除竹柏種子休眠之方法，使種子經過本處理後能在播種後第2~4週內集中整齊發芽，能有效降低後續的園藝作業成本。另過去在1~2個月的商業運送過程中總是折損約40~50%優良品質種子之不良效應完全被解決，經開發的作業方法在2個月的運送過程中幾乎不喪失種子活力。因羅漢松科樹種種子非為長壽命的正儲型種子，目前已找到在3年內能維持竹柏大部分種子活力，及在1年內能維持蘭嶼羅漢松、桃實百日青大部分種子活力的儲藏方法。並於98年完成「竹柏種子的解除休眠、儲運方法與最佳儲藏條件」一項技轉。

The Podocarpaceae family is composed of more than 120 species in 20 genera all over the world. In Taiwan, there are only 6 species in 2 *Nageia* and *Podocarpus* genera. Among these 6 species, only *Podocarpus fasciculus* grows in middle-high altitude areas. The others are small trees distributed in low elevation regions. The plain species have become favorite potted plants, fences, shade trees, and garden trees in nursery and garden industry due to their delicate and moderate shapes as well as good adaptation to lowland and urban environments. Two of those species, *Podocarpus costalis*, and *Nageia nagi*, are the most popular. *P. costalis* is so widely used as a cultivated plant that it has been removed from the list of legal protection of cultural property of rare species in Taiwan. Nowadays, bonsai trees of these species are densely planted, which are very popular with many people in China, Europe and America. Tree seeds, especially *P. costalis* and *N. nagi* which are in great demands, are always seen as critical planting materials, so mature female individuals of these trees at various sites are usually guarded by someone especially assigned to collect the seeds when the fruits mature. However, the collected seeds are often inappropriately handled, which often causes massive failure of germination after sowing. As an example, seeds of *N. nagi* often fail to germinate normally after sowing due to inconsistent degree of maturity or seed dormancy.

Nevertheless, there is still no complete study on the storage and germination improvement of tree seeds of the species mentioned above which have been commercially used for many years. Therefore, seeds with good quality largely deteriorate throughout the transportation process by accident, and lack of proper storage is also disadvantageous to adjustment between supply and demand, production stabilization, and market intelligence. Furthermore, the shortage of germination techniques subsequently has effect on commodity value. This study attempts to investigate storage and germination technology of seeds of the important native Podocarpaceae species in Taiwan, including *P. costalis*, *N. nagi*, and *Podocarpus nakaii*. The purpose is to understand germination conditions and seed physiology of these 3 species and offer useful information about nursery operation. In addition, the seed storage behaviors and germination characteristics of the 3 species are used to find out the optimal storage conditions to sustain their seed longevities and contribute to providing the efficient method of seed transportation and storage.

The present study has shown how to break seed dormancy of *N. nagi*, which makes the seeds regularly germinate during 2~4 weeks after sowing and efficiently reduce the subsequent cost of nursery and gardening. Moreover, there is an efficient solution to lower the bad effect of deterioration of 40~50% seeds with good quality throughout 1~2 months of the transportation process in the past. After the developed treatments, the seeds almost do not lose their viability throughout the 2-month transportation process. In fact, seeds of the Podocarpaceae are non-orthodox with short longevity, and the current studies have found out the way to maintain the viability of most of seeds of *N. nagi* for at least 3 years and those of *P. costalis* and *P. nakaii* for 1 year. In addition, technology transfer of "Breaking Seed Dormancy, Transportation Methods, and the Optimal Storage Conditions of Seeds of *Nageia nagi*" has been accomplished in 2009.

牛樟組培苗生產樟芝段木技術之研發

Cultivation of tissue culture derived *Cinnamomum kanehirae* plants to supply wood for the production of *Antrodia cinnamomea* fruiting bodies

陳永修

為快速提供牛樟段木來源以培養牛樟芝，本計畫將繁殖經6年生牛樟營養系園中選育出之速生營養系。繁殖的方法包括扦插與組織培養。組織培養苗已經證實比扦插苗生長快，且健壯。本技術以技轉給合作產商，並協助廠商建立2公頃栽培區。本計畫也提供段木與枝葉給具有特殊之牛樟芝菌種與接種段木生菇技術的合作廠商。

In order to rapidly supply the wood sources of *Cinnamomum kanehirae* for fruiting body formation of *Antrodia cinnamomea*, we propagated superior clones of *C. kanehirae* selected from a 6-year-old type plantation. The propagated plants were raised from cuttings and tissue culture. Tissue cultured plants have been proven to grow faster and stronger than those from cuttings. This technology has been transferred to a cooperating company. We helped this company to establish a 2 ha plantations. In order to enhance *A. cinnamomea* growth on the man-made logs of *C. kanehirae*, we provided logs to the cooperating company that has specific strains of *A. cinnamomea* and know-how to grow fungi on the wood.

優良與耐寒麻瘋樹品系量產技術之開發

Mass propagation of superior and cold resistant clones of *Jatropha curcas*

馬復京

麻瘋樹種源與單株間之果實產量與種子的含油量差異很大，且其主要分佈於熱帶與亞熱帶，只能在平均氣溫18-28.5℃的環境下生存，遇低溫會有休眠與落葉現象產生，嚴重影響生育。因此選育具高油產量與耐寒特性之麻瘋樹可增加產油量與栽培範圍，對產業幫助極大。本計畫完成五個優良單株之微體繁殖體系、建立0.5公頃後裔檢定園、並建立基因轉殖體系，培育出帶有NPTII與GUS報告基因及帶有CBF1抗寒基因之麻瘋樹。

Fruit yields and contents of seed oil among provenances and individuals in a 2-year-old *Jatropha curcas* plantation varied greatly. This species distributes around the tropical and subtropical areas, and likes to grow in annual temperatures between 18~28.5℃. Dormancy and leaf dropping occur at lower temperatures, which seriously affect fruiting. Selecting cold-resistant clones with high seed oil quality is thus invaluable to meet the requirements of companies wanting to plant it in temperate zone. This year, we have finished micropropagating 5 superior clones, establishing a 0.5-ha progeny test, and seting-up a gene transformation system. We obtained transgenic lines that were transformed with NPTII, and GUS genes, and the CBF1 gene (a cold-resistant gene).

市場導向膠彩畫專用紙之研製

Preparation of a glue-infused handmade papers

徐建國

依據所收集到的紙樣分析及書畫家意見選用6種紙漿(A、B、C、D、E、F)依不同配比抄製出19種紙張供書畫家試用。經試驗結果發現：

1. 大多數紙張之力學性質不若標竿產品佳，但仍有部分紙張其裂斷長、比破裂度較標竿產品佳。
2. 試製紙張之酸鹼值皆較標竿產品高，利於作品之保存。
3. 試製紙張經書畫家試用後發現多數紙張塗上顏料後其顯色較灰、顏色飽和度較差且耐磨性不若標竿產品佳。
4. 試製紙張上色時顏色與顏色之交界處不明顯，顏色有時會混在一起，顏色乾燥後掉色情形少。
5. 在抄製19種紙張中有5種紙張經書畫家試用後認為其在品相及觸感上較接近標竿產品，其顯色效果亦不錯。

Based on the collected commercial products and the opinions of the artists, 6 fiber stocks were formulated with different blending ratio to produce 19 varieties of final products and these were tried by artists.

The results indicated that:

1. Most products had strength properties inferior to the reference product, there were several products with breaking lengths and bursting factors better than the reference.
2. The pH of the test products was all higher than the reference one which should be beneficial to the preservability of the artwork.
3. The artist trial found that most test products showed a grayer tone when applied with pigments. The color saturation and abrasion resistance were also poorer than the reference product.
4. The test products had indistinct color-to-color boundaries, blending of colors sometimes occurred. Upon drying, there were rarely pigment losses from the products.
5. There were 5 among the 19 test products that the artists deemed to have rendering properties and touches approaching the reference. These also had good coloring performance.

開發山胡椒植物活性組成分為機能性化妝品

Developing the active ingredients in *Litsea cubeba* into functional cosmetic products

何振隆

本研究收集山胡椒果實經萃取其精油後，分析其組成分為以檸檬醛(citral)為其主要成分。且將其果實精油以管柱層析純化後發現citral在具有主成分之次分離部具有相當優異的抗發炎活性。因citral能夠明顯地抑制革蘭氏陰性菌之內毒素(LPS)和革蘭氏陽性菌之Pam3Cys所導致的TNF-α、IL-1β與IL-6 蛋白質的表現，且對ERK1/2及ROS等有顯著的抑制作用。於皮膚細胞毒性試驗中發現，citral 對皮膚細胞不具有毒殺效果。於抑菌活性方面，citral對於抑制痤瘡丙酸桿菌 (Propionibacterium acnes)、顆粒丙酸桿菌(P. granulosum)，以及皮屑芽孢菌(Pityrosporum ovale) 均具極佳之抑菌活性。因此，此結果對於我們明年要將山胡椒果實精油之活性成分citral開發製造面膜、化妝水、洗髮液與活膚乳液等機能性化妝品產品商品化增進信心。

Litsea cubeba fruit was collected and extracted for its essential oil. After purification using a GPC column, the main component, citral, contains a subfraction that showed an excellent anti-inflammation activity. Results of the experimentation indicated that citral could significantly inhibit endotoxins LPS from Gram negative bacteria and the Pam3Cys of Gram positive bacteria which in turn affected the expression of proteins such as TNF-α, IL-1β and IL-6. The fraction also showed a significant inhibitory effect against ERK1/2 and ROS. In dermatological cytotoxicity assays citral did not kill skin cells. As for anti-bacterial activities, citral showed excellent inhibitive efficacies against acne-causing *Propionibacterium acnes*, *P. granulosum*, and *Pityrosporum ovale* bacteria. Based on these positive results, we are confident about the plan to incorporate the active ingredient of *L. cubeba*, citral, in functional cosmetics such as facial masks, cologne, shampoo and skin lotion etc.

2009 Annual Report

肆

附錄

2009年 1月—12月

1 JAN

- 育林組鍾振德副研究員赴美國參加「扁柏醇生合成與代謝計畫」之訓練。
- 育林組王巧萍副研究員赴德國執行國科會計畫「溶解性有機氮在台灣山地森林生態系氮循環之角色」。
- 森林經營組辦理「試驗林經營小組」第一次業務考察、97年度期末檢討暨99年度預定案、細部計畫審查會。
- 技術服務組辦理之「97年度混成教學應用獎勵指導方案」榮獲行政院農業委員會頒發優等獎。

2 FEB

- 人事室辦理新春團拜暨人事政風法令宣導活動。
- 植物園組於扇平森林生態科學園召開第4次志工聯誼會及32小時專業訓練，並赴四湖海岸植物園、鰲鼓及六輕進行戶外參訪。
- 植物園組辦理志工大會暨志工成長課程訓練。
- 技術服務組管理之本所資訊安全管理系統通過ISO 27001國際認證。
- 植物園組鄭育斌副研究員前往屏東縣瑪家鄉採集槲樹研究材料，因搭乘之座車意外翻落山坡，不幸逝世於屏東縣龍泉榮民醫院，得年43歲。

3 MAR

- 植物園組、林業經濟組、蓮華池研究中心於蓮華池研究中心合辦「自然資源在社區林業生態旅遊運用研習會」。
- 森林利用組林裕仁副研究員赴美國奧勒岡州波特蘭市世界林業中心研習十個月。
- 森林經營組邀請美國哥倫比亞大學Edward Cook and William E. Wright至本所演講樹輪學。
- 植物園組與臺北市國語實驗國民小學合辦「國語實小自然生態小尖兵『臺北植物園生物多樣性主題活動研習』。
- 育林組何政坤組長獲頒「98年林業及自然保育有功人士」。
- 森林保護組於高雄縣新威國小辦理「老樹褐根病防治講習」。
- 人事室於福山研究中心舉辦員工路跑競賽活動。
- 森林保護組於高雄縣神威天台山天台聖宮辦理「98年度樹木保護研習計畫」。
- 國立臺灣大學森林環境暨資源學系郭幸榮教授及學生蒞參本所。

4 APR

- 太麻里研究中心「森林土壤暨水質化學實驗室」榮獲TAF頒發認證證書。
- 森林保護組董景生助理研究員赴美國堪薩斯州立大學進行蟲癭與光合作用短期研究。
- 植物園組、福山研究中心與國家教育研究院、教育部自然與生活科技領域輔導群、中央課程與教學輔導諮詢教師團隊於福山研究中心辦理國小及國中「自然與生活科技領域輔導員生物多樣性戶外教學增能研習」，共計兩場60人參加。
- 植物園組、福山研究中心與英國文化協會於福山研究中心舉辦「自然中心經營福山工

作坊」，共計28人參加。

- 森林經營組辦理「試驗林經營及造林地清查講習班」。
- 森林保護組接受林務局委託「林木褐根病疫情管理及知識管理系統建立之研究」，辦理全國性褐根病普查。
- 植物園組與國家教育研究院、教育部自然與生活科技領域輔導群、中央課程與教學輔導諮詢教師團隊、福山研究中心於福山研究中心辦理「國中自然與生活科技領域輔導員生物多樣性戶外教學增能研習」，共30位教育部自然與生活科技領域輔導群、縣市課程督學、輔導員以及種子教師參加。
- 林業經濟組於蓮華池研究中心舉辦「2009年蓮華池螢火蟲季開鑼吟詩念歌會」。

5 MAY

- 植物園組、福山研究中心與華江雁鴨守護聯盟、大理高中於福山研究中心舉辦「福山生物多樣性戶外研習工作坊-初階班」，共計30人參加。
- 物園組、蓮華池研究中心、南投縣教育局於蓮華池研究中心合辦「98年蓮華池自然教育研習（第一梯次）」，共計8位教師參加。
- 育林組舉辦「2009台日檜木林生態與更新研討會」。
- 森林保護組林朝欽研究員赴大陸昆明參加「2009年兩岸生物多樣性研討會」。
- 森林保護組於東海大學辦理「生態資訊管理系統研習會」。
- 森林保護組於宜蘭縣礁溪國中辦理「98年度樹木褐根病防疫宣導研習」。
- 植物園組與台東林管處、台東縣政府教育處、台東縣忠孝國民小學、台東縣賓茂國民小學於台東林管處知本森林遊樂區辦理「台東縣永續校園環境教育基地研習計畫」，共計30人參加。
- 森林經營組於台糖花蓮光復糖廠辦理「傾聽人民心聲-綠色造林撫育作業講習」。

6 JUN

- 人事室辦理「培育優質人力促進就業計畫」僱用人員報到及訓練。
- 林國銓副所長榮獲「第33屆全國十大傑出農業專家」殊榮。
- 集水區經營組辦理「2009森林集水區經營研討會」，共計95人參加。
- 植物園組、福山研究中心與宜蘭縣政府教育處於福山研究中心合辦「福山生物多樣性戶外研習工作坊」，共計7位國小校長及14位教師參加。
- 森林保護組、技術服務組、蓮華池研究中心於蓮華池研究中心舉辦「2009年森林動態樣區資料庫資訊管理研討會」，計有美國、波多黎各、日本、馬來西亞等國之學者參加。
- 植物園組、恆春研究中心、福山研究中心於恆春研究中心舉辦「恆春生物多樣性戶外志工培訓工作坊」，共計20人參加。
- 植物園組與台北縣政府教育局、國泰國小於台北植物園、森林保育大樓合辦「台北赤蛙保育與植物探索教育研習」，共計36位教師參加。
- 森林利用組參加「2009農業技術交易展」，參展項目為「土窯燒製竹炭之技術」。
- 育林組舉辦「種苗與造林技術之研究與挑戰研討會」。
- 六龜研究中心與蓮田畫會在扇平森林生態科學園舉辦「扇平之美」畫展。

- 蓮華池研究中心接待中國大陸溫州市工業科學研究院人員，並介紹森林動態樣區。
- 秘書室、木材纖維組、森林化學組為配合行政院農業委員會合署辦公大樓之興建，完成林產大樓及其周邊房舍共計8棟之搬遷事宜。
- 蓮華池研究中心之蓮華池光纖網路布設完成：包含辦公室、生態教育館、小木屋、永久樣區氣象站　蓮華池無線網路架設：藥用植物園、苗圃， 並選用政府安全網路（GSN）加強資訊之穩定與安全性。
- 中國大陸溫州市工業科學研究院拜訪蓮華池研究中心，參觀蓮華池森林動態樣區。

7 JUL

- 森林經營組、蓮華池研究中心與東海大學合辦田野技術課程。
- 植物園組、福山研究中心與國際珍古德教育及保育協會於福山研究中心舉辦「2009年根與芽種子教師福山生物多樣性戶外研習工作坊」，共計27位教師參加。
- 森林保護組「林木健康服務網」榮獲農委會「第1屆政府服務品質獎」服務規劃類優等獎。
- 森林經營組辦理本所「試驗林經營小組」第二次業務現場查核，期中檢討暨100年度預定案預審會。
- 森林保護組董景生助理研究員赴日本福岡大學演講與參訪，並議定亞洲地區蟲癭研究的區域合作與分工。
- 植物園組、福山研究中心與湖光童軍團於福山研究中心舉辦「98年度童軍團服務員自然探索研習營」，共計32人參加。
- 植物園組、六龜研究中心與國立科學工藝博物館、英國文化協會於恆春研究中心舉辦「小小達爾文自然探索營－扇平自然探索」，共計18人參加。
- 植物園組、蓮華池研究中心、福山研究中心與國立自然科學博物館、英國文化協會於六龜研究中心舉辦「小小達爾文自然探索營－蓮華池自然探索」，共計30人參加。
- 人事室辦理本所親子活動暨人文藝術之旅，參訪「黃金博物園區」。
- 森林保護組於台南縣萬佛寺辦理「樹木褐根病防疫宣導會」。
- 太麻里研究中心接待海峽兩岸林產科技訪問團參訪。
- 太麻里研究中心舉辦大王國小附設幼稚園師生自然教育活動、本所中埔研究中心志工參訪、海峽兩岸林產科技訪問團參訪、 與林務局台東林管處共同宣導防治小花蔓澤蘭與香澤蘭活動、參與台東農改場特用植物栽植與應用成果等活動9場次。

8 AUG

- 中埔研究中心辦理生物多樣性認識植物親子闖關活動。
- 恆春研究中心辦理「根著墾丁走」活動，為遊客解說園區植物之根部型態、功能與特色。
- 植物園組、福山研究中心與國際珍古德教育及保育協會於福山研究中心舉辦「2009年根與芽種子教師福山生物多樣性戶外研習工作坊」，共計32位教師參加。
- 六龜研究中心、太麻里研究中心及恆春研究中心遭逢莫拉克颱風肆虐，豪雨成災，試驗林地、林道及辦公廳舍均受創嚴重。
- 森林保護組董景生助理研究員前往巴西參加第四屆國際蟲癭研討會，發表氣候暖化對刺桐釉小蜂分布之影響論文。

- 植物園組、福山研究中心與大理高中於福山研究中心舉辦「2009生態環境教育-大理高中種子教師培訓」，共計24人參加。
- 森林保護組辦理「98年度林業試驗所傾聽人民的心聲-連江縣樹木保護及林產加工研習營及考察」活動。
- 植物園組與教育廣播電台於台北植物園舉辦「樂活一夏之綠色大地-闖關活動暨黃昏音樂會」，共計2000人參加。
- 植物園組、福山研究中心與花蓮縣西寶國小合辦「自然教育之自然探索研習工作坊」，共計30位教師參加。
- 森林保護組林朝欽研究員赴澳洲參加2009年國際長期生態研究網年會(The ILTER Co-ordinating Committee Meeting in Barisbane, Australia)。
- 黃裕星所長與技術服務組陳燕章組長赴美國Oregon State University, the University of Washington 及加拿大University of British Columbia，觀摩各校之智慧財產權管理與技術移轉業務。
- 育林組何政坤組長、陳怡蒨助理研究員，及中埔研究中心許原瑞主任為執行「紐西蘭大學-代辦經費木材樹脂分解菌之篩選及應用」計畫，赴美國及加拿大進行參訪。
- 森林保護組葛兆年副研究員指導台裔青年Peter Lin(林上堯)參與國科會「2009科技台灣探索-候鳥計畫」，其實習成果榮獲國科會候鳥計畫生命科學組第三名。
- 六龜研究中心八八風災後扇平森林生態科學園受損嚴重：土地公廟、 水力發電室、木炭寮，樟腦寮，賞鳥屋、仿中國式古涼亭、溪邊涼亭、生態池、情人橋、水泥棧道區、一號量水量水堰均被土石流沖走，已變成扇平溪河床。林道的受損狀況：扇平林道多處損毀，特別是在2.8至3.1 K大崩塌，水平距離約300公尺，長約500公尺和4.9 K至5.4 K嚴重崩塌，水平距離約300公尺，長約500公尺；多納林道多處崩塌損毀，多納工作站傾斜；鳳崗林道及南鳳林道亦是多處崩塌損毀。

9 SEP

- 木材纖維組為促進與加拿大林業試驗研究機構之合作，組團前往the University of British Columbia木材科學系、British Columbia Ministry of Forests and Range、FPInovation, Canada Wood及育成中心進行參訪。
- 恆春研究中心於太平山國家森林遊樂區辦理志工移地訓練，共計30人參加。
- 森林保護組林朝欽研究員、技術服務組鄭美如助理研究員赴美國參加「生態資訊管理員會議及長期生態研究科學家會議」（The LTER Information Manager's Meeting and LTER All Scientists Meeting）。
- 森林保護組於彰化縣鹿港鎮文武廟辦理「鹿港鎮文武廟園區樹木感染褐根病防治講習及現場防除施作示範活動」。
- 中埔研究中心舉辦「第四屆環境保護林經營管理研討會」。
- 植物園組、福山研究中心與華江社區發展協會、大理高中於福山研究中心舉辦「自然教育之自然探索研習-進階班」，共計20人參加。
- 森林利用組、育林組參加「2009台北國際發明暨技術交易展」，展示「土窯燒製竹炭之技術」及能源植物。
- 森林經營組辦理「試驗林造林業務暨空間資訊管理系統教育訓練」。
- 森林經營組完成本所、林務局與美國The Center for Tropical Forest Science of Smithsonian Tropical Research Institute洽簽合作備忘錄事宜。

10 OCT

- 森林保護組林朝欽研究員赴丹麥參加2009年「全球生物多樣性資訊機構第16次理事會GB16」。
- 林國銓副所長、育林組何政坤組長前往馬來西亞參加「亞太林業研究機構聯合會」。
- 森林保護組於新竹縣關西鄉石光國小辦理「珍貴樹木保護研習」。
- 植物園組管理之台北植物園通過ISO 9001: 2008認證。
- 森林保護組徐嘉君助理研究員赴印度Bangalore參加「第五屆森林樹冠層國際研討會」(5th International Canopy Conference 2009)，並口頭發表論文。
- 木材纖維組舉辦「2009海峽兩岸林產科技研討會」，邀請南京林業大學等大陸製漿造紙與木材化學相關研究與管理人士與會。
- 森林保護組於雲林縣飛沙國小辦理「珍貴樹木保護研習」。
- 植物園組、福山研究中心與宜蘭縣人文國小於福山研究中心舉辦「自然教育之自然探索研習工作坊」，共計30位教師參加。
- 技術服務組完成「林業試驗所簡介」中英文版DVD自製出版作業。

11 NOV

- 植物園組與花蓮縣光復鄉農會、花蓮縣馬太鞍社區發展協會於馬太鞍溼地舉辦「生態探索教育工作坊」，共計15人參加。
- 森林保護組於花蓮市鑄強國小舉辦「98年樹木褐根病防治及樹木修剪實務研習」。
- 森林保護組林木疫情鑑定與鑑定中心通過ISO 2008續評。
- 植物園組與六龜、福山、中埔、恆春、蓮華池等研究中心於中興大學惠蓀實驗林場舉辦「98林試所生態保育志工聯合培訓」，共計70人參加。
- 植物園組、福山研究中心與臺北市國語實驗國民小學於福山研究中心舉辦「98年度國語實小生態小尖兵第五團自然探索研習營」，共計30人參加。
- 植物園組與蓮華池研究中心於蓮華池研究中心舉辦「自然教育之自然探索研習工作坊-初階班」，共計30位教師參加。
- 森林經營組邀請日本國立千葉大學教授Dr. Honjo Tsuyoshi、法國INRIA研究所Dr. Philippe de Reffye、中國科學院自動化研究所胡包鋼博士及康孟珍博士等人，蒞臨本所進行「樹木生長數位模擬和可視化作業」專題討論及演講。
- 森林保護組林朝欽研究員赴泰國參加「全球生物多樣性資訊機構(GBIF)亞洲區會議及生物多樣性資訊研討會」。
- 植物園組與清華大學及辜嚴倬雲植物保種中心合辦「東南亞植物園會議」，共計14國、32位代表與會，會後並參訪本所福山植物園及台北植物園。
- 森林保護組於台南縣台南高工辦理「珍貴樹木保護研習」。
- 集水區經營組於扇平舉辦「2009年林道災害調查及復建工程」研習會，共計50人參加。
- 森林保護組於高雄縣彌陀鄉公所辦理「高雄縣98年度樹木保護研習會」。
- 植物園組與台東林管處於知本自然教育中心舉辦「自然教育之自然探索研習工作坊」，共計30人參加。

- 森林保護組於宜蘭縣頭城國小及礁溪國中分別舉辦「宜蘭縣樹木褐根病防疫宣導講習」。
- 秘書室辦理「公文製作及公文管理」講習，邀請農委會蔡專門委員金龍及本所郭麗娜專員擔任講師，共計141人參加。

12 DEC

- 森林保護組於宜蘭縣黎明國小辦理「宜蘭縣樹木褐根病防疫宣導講習」。
- 森林利用組於台南縣龍崎鄉舉辦「傾聽人民心聲--國產竹炭產業之現況與發展」座談會。
- 為配合行政院農業委員會合署辦公大樓興建計畫，秘書室完成「林產大樓含周邊工廠設備搬遷工程及新空間裝修工程」之驗收。
- 森林保護組林朝欽研究員赴日本參加「亞太生物多樣性觀測網(Asia-Pacific Biodiversity Observation Network, AP-BON)」及「東亞及東南亞跨政府生物多樣性資訊新方案(The East and Southeast Asia Biodiversity Information Initiative, ESABII)」兩項會議。
- 人事室辦理南投竹藝工坊組織學習參訪交流活動。
- 植物園組與臺北市國語實驗國民小學附設幼稚園於台北植物園舉辦「98年度國語實小附設幼稚園生態闖關親子活動」，共計400人參加。
- 森林保護組舉辦「2009年樹木移植暨樹木醫學研討會」。
- 植物園組、福山研究中心與羅東林區管理處、宜蘭縣政府合辦「98年度林試所自然教育承辦人員年終檢討暨參訪研習」。
- 植物園組與英國文化協會於英國文化協會舉辦「歡慶英國文化協會75周年-家扶中心學童Fun學日」，共計45人參加。
- 太麻里研究中心發生第二林區牛樟林木盜伐案件，當場逮捕現行犯並查獲贓木一段。
- 太麻里研究中心完成98年度人工造林地清查與監測，及天然林永久樣區第1次複查作業。

國內外學者專題演講

日期	講題	演講者	服務機關
02/09	Carbon credit trading	Dr. Sun Joseph Chang	美國路易斯安納州立大學
03/02	Dendrochronology and Natural Resource Management	Dr. Edward Cook	Lamont-Doherty Earth Observatory of Columbia University
03/02	Dendroclimatology: Reconstructing Climate from Tree Growth with an example from Taiwan	Dr. William E. Wright	Lamont-Doherty Earth Observatory of Columbia University
04/13	Role of fire in plant regeneration : an Australian viewpoint	Dr. Siti Hidayati	Kings Park and Botanic Garden, West Perth,Western Australia and School of Plant Biology, The University of Western Australia
04/15	The impacts of climate change on plant establishment	Dr. Jeffrey Walck	Department of Biology, Middle Tennessee State University, USA
07/24	Repeated Standardized and Consistent Measures For Assessing Lepidoptera Biodiversity Through Time For Assessing Climate Change	Dr. Jeffrey C. Miller	Department of Rangeland Ecology and Management, Oregon State University
10/15	台灣山林先驅的研究故事	楊南郡	
11/11	A Collaborative Model for Forest Resources between Minority and Majority Folks in Sweden	Dr. Sang-Chul Park	Korea Polytechnic University/ KAIST
11/16	From AMAP to Greenlab Plant Growth and Architecture Model: History of Research Work and Recent Advances	Dr. de Reffye Philippe	Institut national de recherche en informatique et en automatique (INRIA), France
11/16	Greenlab Functional-structural Plant Model for Trees and Its Implementation	Dr. 康孟珍	中國科學院自動化研究所
11/16	Numerical Modeling in the Studies of Plant Growth and Eco-environments	Dr. 胡包鋼	中國科學院自動化研究所
11/16	Plant Reconstruction and Visualization	Dr. 胡包鋼	中國科學院自動化研究所
11/16	Landscape Simulation with Planting Modeling	Dr. Honjo Tsuyoshi	ChibaUniversity, Japan
12/07	Carbon storage and fluxes in managed forest ecosystems and landscapes	Dr. 陳吉泉	University of Toledo, Ohio, USA

科技研究專題演講

日期	講題	演講者	服務機關／職稱
05/01	利用組織培養生產喜樹鹼	張淑華	林試所育林組 副研究員
05/01	森林撫育經營策略對二氧化碳吸存之效應	邱志明	林試所森林經營組 研究員兼組長
06/26	台灣主要人工林碳吸存時空變異之探討	林國銓	林試所副所長室 研究員兼副所長
06/26	樹木褐根病的發生與經營	張東柱	林試所森林保護組 研究員
08/28	台灣六個原住民部落之山田燒墾農耕方式及其傳統生態知識	王相華	林試所福山研究中心 副研究員兼主任
08/28	由社區組織能力探討社區參與森林資源管理之可行性-比較桃米與五城村之發展歷程	王培蓉	林試所林業經濟組 助理研究員
11/02	平地造林地綠覆度分佈空間分析－以花蓮光復鄉台糖農地造林地區為例	謝漢欽	林試所森林經營組 副研究員
11/02	清潔發展機制(CDM)之造林專案分析	林俊成	林試所太麻里研究中心 副研究員兼主任
12/31	土窯燒製竹炭與品質評估	黃國雄	林試所森林利用組 研究員兼組長
12/31	基因轉殖桉樹生物安全平台之建構	鍾振德	林試所育林組 副研究員

98年出版品一覽

圖書類｜林業叢刊

刊號	題名	作者	出版日
185	珊瑚礁與森林的相遇	伍淑惠等撰	1月
192	林木種子目錄 2008 — 2009	楊正釧	2月
193	福山地區螞蟻監測及鑑定指南	董景生、山馥爛、林宗岐文；余偲嫣、許嘉錦圖	10月
194	藝術家的眼睛：台北植物園之美詩畫集	李招治、吳維修撰稿	5月
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45	人工草地的常見無脊椎動物	范義彬、葉耕帆文	3月
46	蓮華池研究中心簡介	黃正良、陳明男、林仁瀚文	9月
47	嘉義樹木園百年風華：林業試驗所嘉義樹木園簡介	蔡景株等文	7月
48	樹木醫療站：林木健康服務網	莊鈴木、吳孟鈴、陸聲山文	10月
49	Taipei Botanical Garden	Yi-Bin Fan	11月

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	24卷2期	林朝欽	6月
	24卷3期	林朝欽	9月
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其他圖書類

題名	作者	出版日
第四屆環境保護林經營管理研討會論文集	王志斌等著；許原瑞主編。	9月
質樸與風華—紙的前世今生	徐健國文	12月

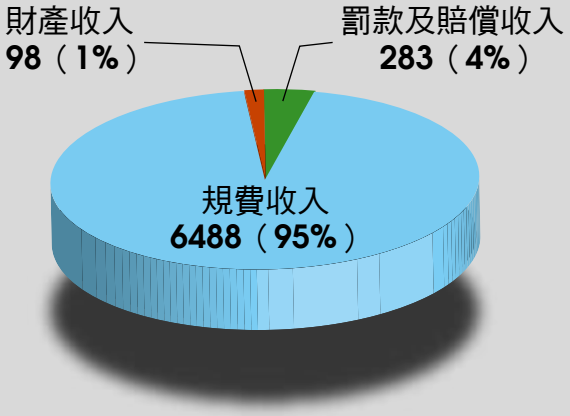
非書資料類｜影音光碟

名稱	製作	出版日
林業試驗所簡介(DVD)	陳燕章	10月

2009年會計預算

(一) 2009年預算編製

本所2009年歲入預算6,869千元，較2008年6,916千元減列47千元；歲出預算698,655千元，較2008年760,882千元減列62,227千元，有關歲入預算及歲出預算主要內容（如圖1、圖2）

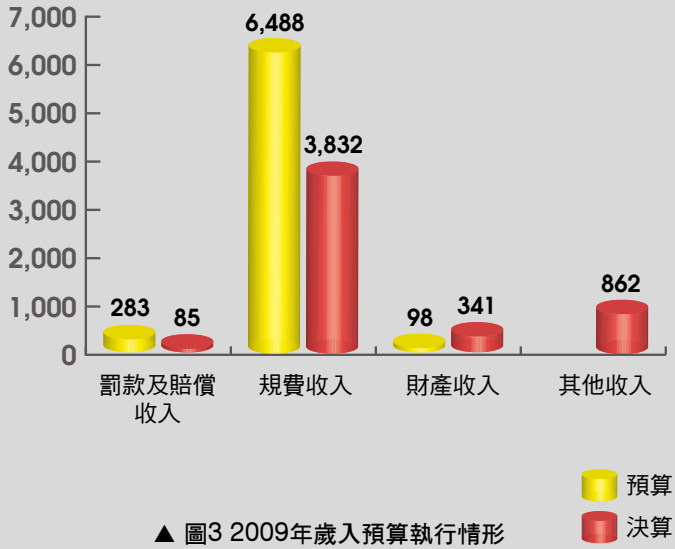


▲ 圖1 2009年歲入預算主要內容

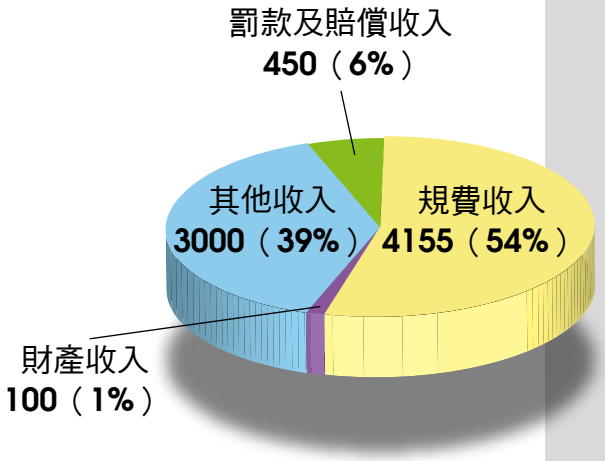
(二) 2009年決算編製

1.歲入：本所2009年歲入預算6,869千元，決算數為5,120千元，較預算數減收1,749千元，各項歲入執行情形（如圖3）

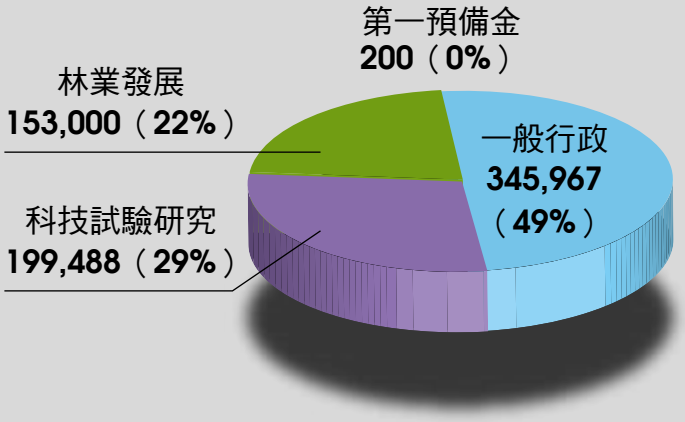
2.歲出：本所2009年歲出預算698,655千元，決算數為657,728千元，執行率為94.14%，各項歲出執行情形（如圖4）



▲ 圖3 2009年歲入預算執行情形



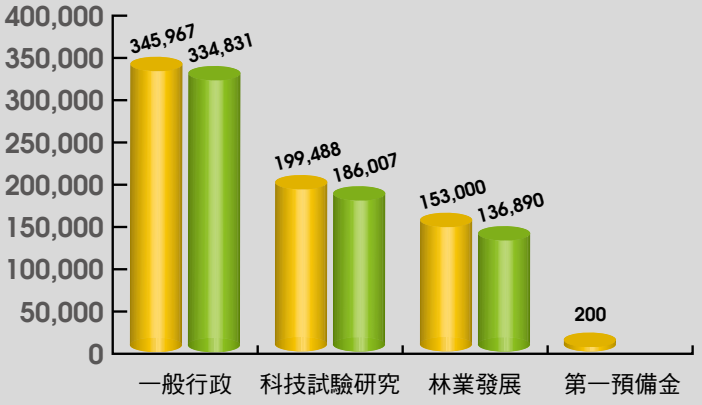
◀ 圖5 2010年歲入預算主要內容



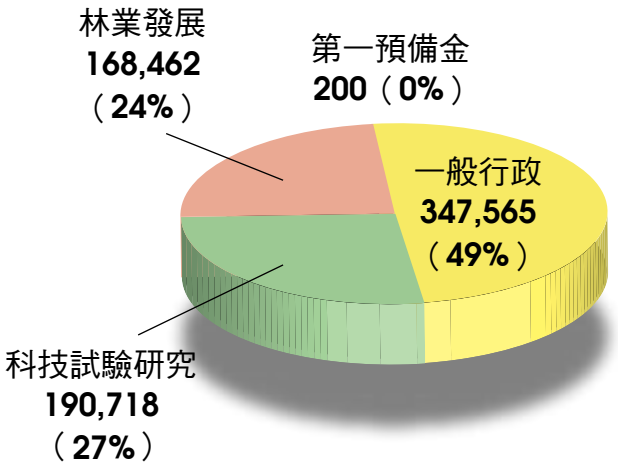
▲ 圖2 2009年歲出預算主要內容

(三) 2010年預算編製

本所2010年歲入預算7,705千元，較2009年6,869千元增列836千元；歲出預算706,945千元，較2009年698,655千元增列8,290千元，有關歲入預算及歲出預算主要內容（如圖5、圖6）



▲ 圖4 2009年歲出預算執行情形



▶ 圖6 2010年歲出預算主要內容

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