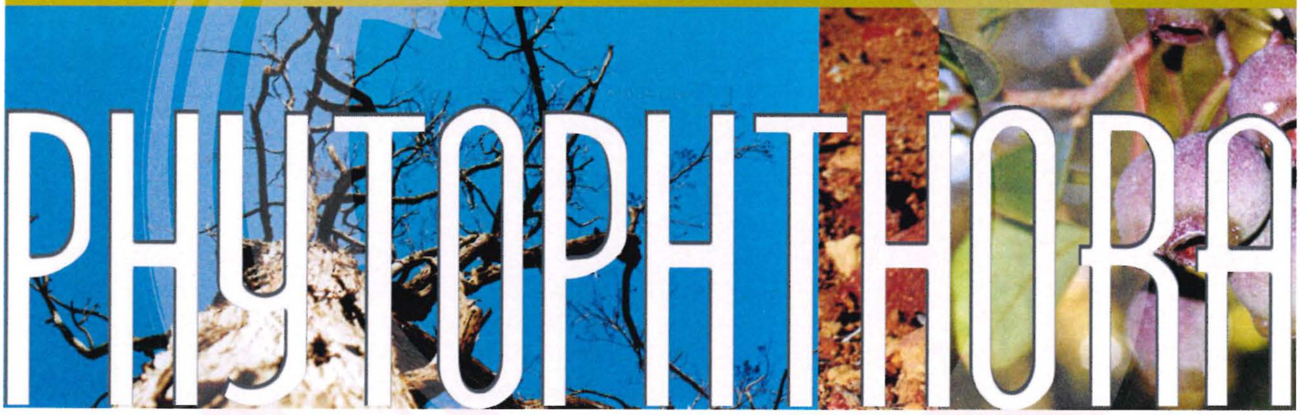
MEETING HANDBOOK



in Forests & Natural Ecosystems

2nd International IUFRO Meeting

Esplanade Hotel
Albany, Western Australia
30 September - 5 October 2001

IUFRO · MURDOCH UNIVERSITY · ALCOA · CALM · CSIRO · APPS

SECOND IUFRO MEETING ON

PHYTOPHTHORA IN FORESTS AND NATURAL ECOSYSTEMS

30 September –5 October 2001

WELCOME

The organizing committee of the Second International IUFRO Meeting on *Phytophthora* in Forests and Natural Ecosystems welcomes you to this meeting.

Western Australia is known worldwide for its huge botanical diversity and you will have the opportunity to observe some of this during the meeting. In turn you will see the devastating impact *Phytophthora cinnamomi* is having on a wide range of plant species from small shrubs to large trees in different plant communities. In Western Australia alone, *P. cinnamomi* impacts directly on some 2000 plant species.

We look forward to the opportunity of sharing research and management experiences of the genus *Phytophthora* and the diseases it causes. We hope that everyone will leave this meeting stimulated and with new ideas to meet the challenges of understanding and managing *Phytophthora* in the many different environments where we work. Have many stimulating discussions, lots of fun and most importantly we hope you make many new friends.

Giles Hardy, Inez Tommerup, Philip O'Brien, Jen McComb, Ian Colquhoun and Bryan Shearer.

Tel: (08) 9360 6272
Fax: (08) 9360 6303
Email: g-hardy@central.murdoch.edu.au
Giles Hardy Meeting Coordinator

Book of Abstracts compiled by Inez Tommerup and Treena Burgess

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Our Conference Logo – The Splendid Blue Fairy-wren

Malurus splendens splendens, Maluridae (Quoy and Gaimard 1830)

A brilliant flash of vibrant blue energy is sometimes seen in the forests and woodlands in the south-west of Western Australia. Late August to January is the breeding season of the Splendid Blue Fairy-wren, when the plumage of the dominant male in a community acquires its spectacular blues.

M. splendens is a co-operatively breeding species of endemic Australian passerines, but despite the common name, they are more closely related to Australian honeyeaters than the northern hemisphere wrens. Weighing 7-11 grams with a length of 11-13.5cms (1), they can live to 8 years (females) and to 12 years (males) (2). They have a complex, but strategic communal lifestyle. Initially monogamous, a couple establish, or inherit, a territory and raise offspring which they retain as helpers for territorial defence and to assist with feeding of subsequent nestlings. The original coupling is usually maintained and pair bonding may be affirmed by flower petal presentation, allopreening and song duets (1). Dispersal is mostly by females, leaving only one breeding female in a territory with the dominant male and immature male helpers. The female and the juvenile non-breeding males have a greyish-brown plumage with blue tail feathers. Older males, including the dominant male, will make forays into adjacent territories to mate; initial overtures often include a petal carrying display and an undulating flight pattern. Even when establishing their own territories they rarely venture far from the natal territory (2). Territories may be proclaimed with a loud, warbling trill, delivered from the top of a small bush, while communication between members of a group is in series of staccato 'trrrt...trrrt' calls (4).

The female gathers cobwebs, grass and other material to construct an ovoid nest about 125mm high, often finishing it with inner bark from the cycad, *Macrozamia riedlei.* With a small entrance on one side, the nest is usually positioned low in a small shrub, about 80 cms from the ground. More than one clutch may be produced in each season with 2-4 pinkish-white eggs, with red-brown speckles, in each (1). After an incubation period of 14-15 days, nestlings emerge, blind and red skinned, then begin to fledge within a week, becoming independent at about 4 weeks (2). The nests are parasitised by Horsfield's Bronze-Cuckoo, *Chrysococcyx babalis*, and failure of an early clutch will be followed by another attempt, but the nestlings of late clutches may suffer heat stress and be unable to survive the high temperatures of summer. Predators include reptiles, larger birds, and feral or domestic cats. One duty of the helpers is to distract predators from eggs and nestlings. This they attempt by crouching, with wings slightly spread, then scurrying along the ground, tail down, in imitation of a small mammal which, hopefully, the predator may be tempted to pursue (2). Habitat may be threatened by clearing of land (e.g. for agriculture), by bushfire - a summer hazard in Australia, or by the introduced pathogen *Phytophthora cinnamomi* to which a number of understorey shrubs, particularly Proteaceae, are susceptible. These shrubs are not only of benefit to the Fairy-wrens as nesting sites but also attract invertebrates, a favoured food of the birds, to the nectar of their flowers. *Macrozamia riedlei* used as nesting material, is also susceptible to *P.cinnamomi.*

Diet consists mainly of seeds and invertebrates (4). Ants (Formicoidea) and bugs (Hemiptera) are normally consumed by the adults; the nestlings are fed crickets, grasshoppers (Orthoptera) and spiders (Araneida) (1). The distribution of *M. splendens splendens* is limited to Western Australia and they are moderately common in the south-west of the State. Related races of *M. splendens* are found in other parts of Australia (3).

The logo was designed by Daniel Hüberli who has recently completed his PhD at Murdoch University working on Variation in Pathogenicity to *Eucalyptus marginata* (Jarrah) and Other Phenotypes of *Phytophthora cinnamomi* Isolates from One Clonal Lineage in the Southwest of Western Australia. Across the background of a stylised green *E. marginata* (jarrah) leaf and the orange glow of the sun, strides the Splendid Blue Fairy-wren. An excellent choice for the logo, when the timing of the conference coincides with its breeding season, this diminutive bird reminds us of the importance of maintaining the health of the forest and other ecosystems, protecting resources for all indigenous fauna.

1. Higgins, P.J., Peter, J. M. and Steele, W.K. (Eds.) (2001). Handbook of Australian, New Zealand and Antarctic Birds. Volume 5: Tyrant-flycatchers to Chat. Oxford University Press, Melbourne
2. Rowley, I., Brooker, M. and Russell, E. (1991). The Breeding Biology of the Splendid Fairy-wren *Malurus splendens*: the Significance of Multiple Broods. *EMU* 91: 197-221.
3. Simpson, K. and Day, N. (1993) 'Field Guide to the Birds of Australia.' Penguin Books: Ringwood, Australia.
4. Thomson, C. and Hunter, J. (1996). 'Common Birds of the South-West Forests.' Department of Conservation and Land Management (CALM) Western Australia.

BOTANICAL HISTORY, GEOLOGY, VEGETATION AND FLORA OF THE ALBANY AREA

Sarah Barrett

Department of Conservation and Land Management, Albany

Western Australia is renowned for its unique flora. A significant proportion of the State's 13,000 taxa is concentrated in the South-West where some 75% of species are endemic. Western Australia has also a large number of threatened flora, one third of Australia's total. Some localised endemics are naturally rare while others species are threatened by human influences including land clearing, salinity, weeds and disease. In the Albany area, the plant pathogen Phytophthora cinnamomi threatens the survival of some 20 out of 70 threatened taxa, of these 10 taxa are considered to be critically endangered. Aboriginal Noongar people have lived in the Albany area for thousands of years and utilised roots, seeds, fruits and berries of native plants. European settlement commenced at King George Sound in 1826 with the arrival of Major Edmund Lockyer aboard the brig "Amity". However, European botanical exploration had commenced earlier in 1792 with Archibald Menzies on board Captain Vancouver's "H.M.S Discovery" followed in 1801 by Robert Brown on Mathew Flinder's "Investigator". James Drummond conducted major collections from 1841 to 1851 from Albany to the Barren Ranges. Well known local collectors include Ken Newby and Eileen Croxford whose extensive collections are housed in the Albany Regional Herbarium. The names of many famous botanists and explorers are commemorated in the names of plants. The large number of endemic taxa in the South-West is attributed to a long history of climatic and geological stability. The landform has largely weathered in situ resulting in a mosaic of soils where the flora has evolved in isolation. Four tectonic units are recognised in the Albany area. The Archean Yilgarn Craton is composed of 2600- 3100 myo gneiss and granite. The Albany-Fraser Province, visible near Albany as the Porongurup Range, Mt Manypeaks and Mt Gardner, is composed of 1200-1400 myo Proterozoic gneiss and granite. The Stirling Range Formation and Mt Barren group are comprised of highly metamorphosed sandstones and shales. The Bremer Basin which overlies part of the Yilgarn Craton and the Albany-Fraser Province consists of 135 myo marine sediments composed of sand, silt, clay and sponge spicules. With a wide range in rainfall, topography, geology and soils, vegetation associations and species composition are very diverse. West of Albany and on the upper slopes of the Porongurup Range are pockets of tall Karri (Eucalyptus diversicolor) forest. Near Albany, Jarrah (E. marginata)-Sheoak (Allocasuarina fraseriana) low forests occur on sand over laterite. In the Stirling Range dense thickets occur on mountain summits, mallee-heaths on slopes, Jarrah-Marri (Corymbia calophylla) woodland in deep valleys and Wandoo (E. wandoo) woodlands on flats. East and south-east of the Stirling Range Banksia scrub-heath and mallee-heath occur extensively on sandy plains. Heavier soils and breakaways support Yate (E. occidentalis), Moort (E. platypus) or Mallet (E. gardneri) woodlands. The Barren Ranges in the Fitzgerald River National Park are dominated by dense thickets and mallee-heath. Saline water courses and lakes support samphire (Sarcocornia, Halosarcia spp.), sedgeland and paperbark (Melaleuca spp.) communities. Sedgeland, heath and paperbark woodlands occur in seasonally or permanently inundated areas of peaty sands on the coastal plain. Coastal vegetation consists of coastal heath on dunes and limestone, Peppermint (Agonis flexuosa) woodland on siliceous dunes and scrub-heath on granite.

TUESDAY 2nd OCTOBER

8:30-9:00 **Welcome and Introduction**

Regional Overviews
Chair Cécile Robin

9:00-10:00 PROGRESS IN UNDERSTANDING *PHYTOPHTHORA* DISEASES OF TREES IN EUROPE AND AFRICA
C. M. Brasier and T. Jung

10:00-10:30 **Morning Tea**

10:30-11:30 *PHYTOPHTHORA* IN FORESTS OF THE AMERICAS-2001
E. M. Hansen

10:30-12:30 *PHYTOPHTHORA* IN AUSTRALASIA AND THE WAY FORWARD IN DISEASE MANAGEMENT
G. E. StJ Hardy, I.C. Tommerup, I. Colquhoun and B. L. Shearer

12:30-1:30 **Lunch**

Session 1: **Pathogenicity**
Chair David Cahill

1:30-1:50 PROGRESS IN SELECTION AND PRODUCTION OF JARRAH (*EUCALYPTUS MARGINATA*) RESISTANT TO *PHYTOPHTHORA CINNAMOMI* FOR USE IN REHABILITATION PLANTINGS.
M.J.C. Stukely, J.A. McComb, I.J. Colquhoun and I.J. Bennett

1:50-2:10 DEVELOPMENT OF DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN MATURE *XANTHORRHOEA AUSTRALIS*
M.J. Aberton, B.A. Wilson, J. Hill and D.M. Cahill

2:10-2:30 IDENTIFICATION OF PATHOGENICITY GENES IN *PHYTOPHTHORA NICOTIANAE*
Dubravka Škalamera and Adrienne Hardham

2:30-2:50 VARIATION, DISTRIBUTION AND PATHOGENICITY OF THE HYBRID ALDER *PHYTOPHTHORAS*
C. M. Brasier

2:50-3:10 BREEDING FOR RESISTANCE TO *PHYTOPHTHORA LATERALIS* IN PORT-ORFORD-CEDAR: CURRENT STATUS AND CONSIDERATIONS FOR DEVELOPING DURABLE RESISTANCE
Richard A. Sniezko and Everett M. Hansen

3:10-3:40 **Afternoon Tea**

Session 2:	**Molecular and Developmental Studies**
Chair	David Cooke and Phillip O'Brien

3:40-4:00 THE RELIABILITY OF rDNA INTERNAL TRANSCRIBED SPACER SEQUENCE ANALYSIS IN *PHYTOPHTHORA* IDENTIFICATION AND TAXONOMY.
David E. L. Cooke, Naomi A. Williams and James M. Duncan

4:00-4:20 DETECTION OF *PHYTOPHTHORA CINNAMOMI* USING PCR.
P.A. O'Brien, and M.D. Farbey,

4:20-4:40 CONTINENT-WIDE CLONAL LINEAGES OF *PHYTOPHTHORA CINNAMOMI* SHOW FREQUENT MITOTIC RECOMBINATION
M. P. Dobrowolski, I. C. Tommerup, B. L. Shearer and P. A. O'Brien

4:40-5:00 THE EFFECT OF PHOSPHITE ON MEIOSIS AND SEXUAL REPRODUCTION
Meredith M. Fairbanks, Giles E.St.J. Hardy and Jen A. McComb

5:00-5:20 EFFECTS OF POTASSIUM PHOSPHONATE ON PHOSPHORUS METABOLISM IN *PHYTOPHTHORA*
J. Niere, G. DeAngelis, J. McDonell, F. Stringer, J. H. Grant, B. R. Grant

WEDNESDAY 3rd OCTOBER

Session 1:	**Impact of *Phytophthora* in Australia**
Chair	Keith McDougall and Bryan Shearer

8:30-8:50 THE DISTRIBUTION AND IMPACT OF *PHYTOPHTHORA CINNAMOMI* RANDS IN THE SOUTH COAST REGION OF WESTERN AUSTRALIA
Malcom Grant and Sarah Barrett

8:50-9:10 THE DIEBACK CYCLE IN VICTORIAN FORESTS: A 30 YEAR STUDY OF THE CHANGES CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN VICTORIAN OPEN FORESTS, MEASURED PERIODICALLY ON DEFINED QUADRATS
Gretna Weste, Jill Kennedy and Ken Brown

9:10-9:30 IMPACT OF *PHYTOPHTHORA CINNAMOMI* ON MAMMALS IN SOUTHERN AUSTRALIA
B. A. Wilson and W. S. Laidlaw

9:30-9:50 THE IMPACT OF *PHYTOPHTHORA CINNAMOMI* RANDS. ON THE FLORA AND VEGETATION OF NEW SOUTH WALES – A RE-APPRAISAL
K.L. McDougall and B.A. Summerell

9:50-10:10 HOW SUSCEPTIBLE IS THE FLORA OF SOUTH-WESTERN AUSTRALIA TO *PHYTOPHTHORA CINNAMONI*?
B. L. Shearer, C. E. Crane, M. Dillon and A. Cochrane

10:10-10:40 **Morning Tea**

Session 2: **Use of phosphite in management of *Phytophthora***
Chair Mark Dobrowolski

10:40-11:00 *IN PLANTA* PHOSPHITE CONCENTRATIONS AND PHYTOTOXICITY AFTER LOW-VOLUME PHOSPHITE APPLICATION TO NATIVE SPECIES
Sarah Barrett

11:00-11:20 PHOSPHITE CONTROLS *PHYTOPHTHORA CINNAMOMI* AT ANGLESEA AND WILSON'S PROMONTORY NATIONAL PARK, VICTORIA.
M. J. Aberton, B.A. Wilson, J. Hill and D. M. Cahill

11:20-11:40 MONITORING OF AERIAL PHOSPHITE APPLICATIONS FOR THE CONTROL OF *PHYTOPHTHORA CINNAMOMI* IN THE ALBANY DISTRICT
Sarah Barrett

11:40-12:00 AERIAL APPLICATION OF PHOSPHITE TO PROTECT ENDANGERED WESTERN AUSTRALIAN FLORA
R. S. Smith

12:00-5:30 **Field Trip and Boxed Lunch**

7:30-11.55 **Conference Dinner**

THURSDAY 4th OCTOBER

Session 1: **Impact of *Phytophthora* in Australia and New Zealand**
Chair Tim Rudman

9:00-9:20 *PHYTOPHTHORA CINNAMOMI* IN NEW ZEALAND NATIVE FORESTS
P. R. Johnston, R. E. Beever and I. J. Horner

9:20-9:40 FOLIAR DISEASE OF *EUCALYPTUS* CAUSED BY *PHYTOPHTHORA* SPP.
M.A. Dick, W.J. Faulds, K. Dobbie and R. Crabtree

9:40-10:00 THE DECLINE OF AUSTRALIAN MAMMALS: IMPLICATIONS FOR ECOSYSTEM FUNCTION IN *PHYTOPHTHORA* AFFECTED COMMUNITIES
Mark Garkaklis, Giles Hardy, Bernie Dell and Barbara Wilson

10:00-10:20 STRATEGIC REVIEW OF *PHYTOPHTHORA CINNAMOMI* IN PARKS AND RESERVES IN VICTORIA, AUSTRALIA
D. Cahill, B. Wilson, M Garkaklis, J. O'May, R. Milne, I. Sieler
— contracts to Parks Vic

10:20-10:50 **Morning tea**

10:50-1:00 **Poster Viewing**
Impact group of postes
Chair Andrea Vannini and Jenny Davidson
Management group of posters
Chair Richard Sniezko and Don Goheen

1:00-2:00	**Lunch**

Session 2:	**Management of *Phytophthora* in natural ecosystems**
Chair	Ellen Goheen

2:00-2:20	A METHOD OF STRATEGIC CONSERVATION PLANNING FOR SPECIES AND COMMUNITIES HIGHLY SUSCEPTIBLE TO *P. CINNAMOMI* IN TASMANIA. Tim Rudman, Richard Schahinge[1], Tim Wardlaw
2:20-2:40	*PHYTOPHTHORA* – A PLANT QUARANTINE RISK FOR NORTHERN TERRITORY FOREST AND SAVANNA ECOSYSTEMS S. E. Bellgard and M. Weinert
2:40-3:00	PHYTOPHTHORA DISEASE OF ALDERS IN BAVARIA: EXTENT OF DAMAGE, MODE OF SPREAD, AND MANAGEMENT STRATEGIES T. Jung, M. Blaschke, A. Schlenzig, W. Oßwald and H.-J. Gulder
3:00-3:30	**Afternoon tea**
3:30-3:50	MONITORING EFFECTIVENESS OF ROADSIDE SANITATION TREATMENTS TO DECREASE LIKELIHOOD OF SPREAD OF *PHYTOPTHORA LATERALIS* IN SOUTHWEST OREGON USA Donald J. Goheen and Katrina Marshall
3:50-4:10	ADDRESSING SUDDEN OAK DEATH FOR THE STATE OF CALIFORNIA S.J. Frankel
4:10-4:30	*PHYTOPHTHORA* WARS: THE CONTRIBUTION OF RESEARCH IN THE FOREST DEPARTMENT OF WESTERN AUSTRALIA AND THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT TO THE FIGHT AGAINST *PHYTOPHTHORA* SPECIES IN NATIVE VEGETATION OF SOUTH-WESTERN AUSTRALIA OVER THE LAST TWO DECADES B. L. Shearer
7:30-9.30	**Management Symposium**
Chair	Ian Colquhoun

FRIDAY 5th OCTOBER

Session 1:	**Impact of *Phytophthora* in Europe**
Chair	Clive Brasier

8:30-9:00	PHYTOPHTHORA IN THE EUROPEAN OAK FOREST – RESULTS OF A EUROPEAN UNION RESEARCH PROJECT C. Delatour, N. Anselmi, P. Barzanti, M-C. Bianco, H. Blaschke, C.M. Brasier, P. Capretti, M-L. Desprez-Loustau, E. Dreyer, E.M. Hansen, C. Heyne, T. Jung, N. Luisi, B. Marçais, R. Matyssek, M. Maurel, W. Oßwald, E. Paoletti, A. Ragazzi, C. Robin, A. Vannini and A-M. Vettraino
9:00-9:20	OCCURRENCE OF *PHYTOPHTHORA* SPECIES ON OAKS IN TURKEY Yilmaz Balci

9:20-9:40	EFFECT OF ENVIRONMENTAL CONSTRAINTS ON PHYTOPHTHORA-MEDIATED OAK DECLINE IN CENTRAL EUROPE T. Jung, H. Blaschke and W. Oßwald
9:40-10:00	RESULTS OF 10 YEARS OF INVESTIGATIONS ON INK DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* ON *QUERCUS RUBRA* AND *Q. ROBUR*: ETIOLOGY, BREEDING FOR RESISTANCE, AND HAZARD MAPPING Cécile Robin, Marie-Laure Desprez-Loustau, Benoit Marçais, Claude Delatour
10:00-10:30	**Morning Tea**

Session 2: **Chair**	**Biology of *Phytophthora*** Thomas Jung
10:30-10:50	MEASURING RESISTANCE IN JARRAH, *EUCALYPTUS MARGINATA*, TO *PHYTOPHTHORA CINNAMOMI*: WHAT CHANGE DISEASE EXPRESSION? D. Hüberli[1], I. C. Tommerup[2], I. Colquhoun[3] and G. E. St. J. Hardy[1]
10:50-11:10	VARIATION AMONG 29 SEEDLING FAMILIES OF *CHAMAECYPARIS LAWSONIANA* IN MORTALITY IN A SHORT-TERM TEST OF *PHYTOPHTHORA LATERALIS* RESISTANCE R. A. Sniezko, E. M. Hansen' and J.Hamlin
11:10-11:30	VARIATION EXHIBITED BY ISOLATES OF *PHYTOPHTHORA MEGASPERMA* CAUSING SEEDLING AND TREE DECLINE IN S-W AUSTRALIAN COASTAL NATIONAL PARKS S.E. Bellgard, C.E. Crane and B.L. Shearer
11:30-11:50	LONG TERM SURVIVAL OF *PHYTOPHTHORA CINNAMOMI* IN MATURE *BANKSIA GRANDIS* TREES IN REMNANT JARRAH FOREST S. Collins, B. Shearer, J. McComb, I. Colquhoun, G. Hardy
11:50-12:10	GENETIC VARIATION IN *PHYTOPHTHORA CINNAMOMI* ISOLATED FROM FRASER FIR IN WESTERN NORTH CAROLINA J. Frampton, J.F. Li, M. Benson and D. O'Malley
12:10-12:30	SEASONAL VITALITY OF *PHYTOPHTHORA CAMBIVORA* IN SOIL AND CHESTNUT TISSUES A.M. Vettraino, M. Giubilei, A. Anselmi and A. Vannini
12:30-12:50	ASPECTS OF THE INTERACTION BETWEEN *XANTHORRHOEA AUSTRALIS* AND *PHYTOPHTHORA CINNAMOMI* IN VICTORIA, AUSTRALIA R. Daniel, B. Wilson and D. Cahill
12:50-2:00	**Lunch**

Session 3: **Chair**	**Impact of *Phytophthora* in America** Frank Tainter
2:00-2:20	SUSCEPTIBILITY OF URBAN OAK TREES TO FOUR SPECIES OF *PHYTOPHTHORA* T. D. Spainhour, F. H. Tainter, A. K. Wood, S. N. Jeffers, and E. P. Van Arsdel

2:20-2:40 TRANSMISSION AND SURVIVAL OF SUDDEN OAK DEATH *PHYTOPHTHORA* SPECIES NOVUS
J. M. Davidson, D. M. Rizzo, M. Garbelotto, S. Tjosvold and G. W. Slaughter

2:40-3:00 A NEW *PHYTOPHTHORA* INFECTS SEVERAL PLANT SPECIES AND CAUSES EXTENSIVE MORTALITY OF THREE TREE SPECIES IN COASTAL WOODLANDS IN CALIFORNIA
M. Garbelotto, D. M. Rizzo, J. M. Davidson, G. W. Slaughter and S. T. Koike

3:00-3:20 *PHYTOPHTHORA PALMIVORA*, THE CAUSE OF RED FOOT OF BALSA TREES (*OCHROMA PYRAMIDALIS*) IN ECUADOR
F. H. Tainter, W. D. Kelly and E. P. Van Arsdel

3:20-3:50 **Poster Viewing**
Biology group of posters
Chair Wendy Sutton and Jen McComb

3:50-4:20 **Afternoon Tea**

4:20-5:00 RETHINKING PHYTOPHTHORA
E. M Hansen

5:00- **Business Meeting**

POSTERS

Impact of *Phytophthora*
Chair Andrea Vannini and Jenny Davidson

PHYTOPHTHORA SPECIES INFECTING TYPICAL PLANTS OF THE MEDITERRANEAN REGION
Cacciola S. O., Raudino F., Cooke D. E. L., Duncan J. M.and Magnano di San Lio G.

ALNUS CORDATA MORTALITY IN ITALY BY A NEW *PHYTOPHTHORA* SPECIES
G.P. Barzanti, P. Capretti, A. Santini, A. Vannini, N. Anselmi and A.M. Vettraino.

PHYTOPHTHORA IN OREGON FORESTS
Wendy Sutton and E. M. Hansen

THE ROLE OF PHYTOPHTHORAS IN TREE YELLOWING AND DEATH IN TEXAS
E. P. Van Arsdel

THE DISTRIBUTION AND IMPACT OF *PHYTOPHTHORA CINNAMOMI* IN ROYAL NATIONAL PARK, NEW SOUTH WALES.
Jillian Walsh , Keith McDougall , Rob Whelan and Brett Summerell

NEW ALARM OF *PHYTOPHTHORA* ROOT ROT OF WALNUT IN ITALY
A.M. Vettraino, S. Belisario, E. Monteleone and A. Vannini

INK DISEASE DISTRIBUTION ON SWEET CHESTNUT IN FRANCE AND ITALY AND *PHYTOPHTHORA* SPECIES ASSOCIATED

A.M. Vettraino, O. Morel, C. Robin and A. Vannini

VARIABILITY IN RESISTANCE TO *PHYTOPHTHORA CAMBIVORA* OF *CASTANEA SATIVA* WILD POPULATION AND SELECTED CULTIVARS IN ITALY AND SPAIN
A.M. Vettraino, A. Scalise, S. Cherubini and A. Vannini

RARE FLORA THREATENED BY *PHYTOPHTHORA CINNAMOMI* IN THE ALBANY AREA, WESTERN AUSTRALIA
Sarah Barrett

DISTRIBUTION OF *PHYTOPHTHORA* SPECIES IN FOREST SOILS OF UPSTATE SOUTH CAROLINA, USA
A.K. Wood, F.H. Tainter, S.N. Jeffers, and E.P. Van Arsdel

THE SUSCEPTIBILITY OF NANCE, *BYRSONIMA CRASSIFOLIA*, TO *PHYTOPHTHORA CINNAMOMI*
A.K. Wood, F.H. Tainter, S.N. Jeffers, and E.P. Van Arsdel

INTERACTION OF SUDDEN OAK DEATH PHYTOPHTHORA WITH ASSOCIATED ORGANISMS
Pavel Švihra

OCCURRENCE, DISTRIBUTION AND SEVERITY OF FOOT ROT FUNGUS (*PHYTOPHTHORA PARASITICA)* IN THE FOREST AND HIGHLAND AGRO-ECOLOGICAL ZONES IN EASTERN AND WESTERN UGANDA
S. Namukyawa [1], P. Ensywa [1] and S.Namada[2]

Use of molecular tools
Chair Richard Sniezko and Don Goheen

TOWARDS MULTIPLEX PCR DETECTION OF *PHYTOPHTHORA CINNAMOMI* AND *P. CALMBIVORA* FROM FRENCH CHESTNUT GROVE SOILS
O. Morel, C. Robin and S. R. H. Langrell

HISTOLOGICAL ANALYSIS OF THE EFFECT OF PHOSPHONATE ON THE INTERACTION BETWEEN *PHYTOPHTHORA CINNAMOMI* AND *XANTHORRHOEA AUSTRALIS*
R. Daniel, B. Wilson and D. Cahill

OCCURENCE OF THE ALDER (*ALNUS GLUTINOSA* L.) DECLINE IN SWEDEN AND AFFINITIES OF THE CAUSAL *PHYTOPHTHORA* PATHOGEN AS ASSESSED BY ISOZYME ANALYSIS
Christer H. B. Olsson

Use of phosphite to control
Chair Richard Sniezko and Don Goheen

THE DILUTION OF PHOSPHITE IN RAPIDLY GROWING PLANTS AND HOW SOIL AND PLANT PHOSPHATE LEVELS INTERACT WITH PHOSPHITE AND ITS ABILITY TO INDUCE HOST-RESISTANT RESPONSES WHEN CHALLENGED BY *PHYTOPHTHORA CINNAMOMI.*
C . Auckland , B .L . Shearer and G .E .St .J . Hardy

PHOSPHITE REDUCES THE RATE OF SPREAD OF *PHYTOPHTHORA CINNAMONI* IN *BANKSIA* WOODLAND, EVEN AFTER FIRE
B. L. Shearer, C. E. Crane and R. G. Fairman

WILL *PHYTOPHTHORA CINNAMOMI* BECOME RESISTANT TO PHOSPHITE WITH ITS INCREASING USE?
M. P. Dobrowolski, G. E. St. J. Hardy, I. C. Tommerup, B. L. Shearer, I. Colquhoun and P. A. O'Brien

FOLIAR APPLICATION OF PHOSPHITE DELAYS AND REDUCES THE RATE OF MORTALITY OF THREE *BANKSIA* SPECIES IN COMMUNITIES INFESTED WITH *PHYTOPHTHORA CINNAMONI* IN
B. L. Shearer, and R. G. Fairman

PHOSPHITE INHIBITS LESION DEVELOPMENT OF *PHYTOPHTHORA CINNAMOMI* FOR AT LEAST FOUR YEARS FOLLOWING TRUNK INJECTION OF *BANKSIA* SPECIES AND *EUCALYPTUS MARGINATA*
B. L. Shearer, and R. G. Fairman

PHOSPHITE-ITS PHYTOTOXICITY AND EFFECTIVENESS IN THE PROTECTION OF *EUCALYPTUS MARGINATA* FOREST FROM *PHYTOPHTHORA CINNAMOMI.*
R. Bennallick, I.J. Colquhoun, B.L. Shearer and G.E.St.J. Hardy

PHYTOPHTHORA CINNAMOMI AND PHOSPHITE IN VITRO VS IN PLANTA RESPONSES. C. Wilkinson, B. L. Shearer, J. Holmes, K. Tynan, B. Dell, J.A. McComb, J. Maroudas and G.E.St.J. Hardy.

PHYTOPHTHORA CINNAMOMI CONTROL USING PHOSPHITE. C. Wilkinson, J. Holmes, G.E.St.J. Hardy, K. Tynan, B. Dell, and J.A. McComb.

PHOSPHITE HAS NO EFFECT ON FORMATION OF ECTOMYCORRHIZA. K. Howard, B. Dell and G.E.St.J. Hardy.

Pathogenicity
Chair Wendy Sutton and Jen McComb

PATHOGENICITY OF *PHYTOPHTHORA* SPECIES ON *QUERCUS* SEEDLINGS
M. C. Bianco, D. Di Brisco, N. Luisi and P. Lerario

THE INFECTION OF PERIDERM BY ZOOSPORES OF *PHYTOPHTHORA CINNAMOMI.* A HISTOLOGICAL DETECTIVE STORY.
E. O'Gara, J.A. McComb and G.E.St.J. Hardy.

Management of *Phytophthora*
Chair Richard Sniezko and Don Goheen

THE USE OF MULCHES AS A METHOD OF CONTROLL NG PHYTOPHTHORA C NNAMOM N AVOCADOS
S. Fraser, R. Hill, R. Farrell, R. Janson, J. Croskery

BIOLOGICAL CONTROL OF *PHYTOPHTHORA CINNAMOMI*: THE POTENTIAL OF FIVE WESTERN AUSTRALIAN NATIVE *ACACIA* SPECIES TO PROTECT *BANKSIA GRANDIS.*
N. K. D'Souza, I. J. Colquhoun, B. L. Shearer and G. E. St. J. Hardy

BIOLOGICAL CONTROL OF *PHYTOPHTHORA CINNAMOMI*: THE POTENTIAL OF WESTERN AUSTRALIAN NATIVE LEGUME SPECIES TO REDUCE INOCULUM LEVELS IN SOIL.
N. K. D'Souza, I. J. Colquhoun, B. L. Shearer and G. E. St. J. Hardy

THE VEGETATION HEALTH SERVICE: A RESOURCE FOR RESEARCHERS AND MANAGERS OF *PHYTOPHTHORA* DISEASE.
N. K. D'Souza, J. L. Webster, F. C. S. Tay and M. J. C. Stukely

PHYTOPHTHORA IN SOUTH AUSTRALIA – A QUANTUM SHIFT IN AWARENESS
Renate Velzeboer and Kylie Moritz

THE HOLISTIC APPROACH TO *PHYTOPHTHORA* MANAGEMENT ON KANGAROO ISLAND, SA
Kylie Moritz

COPPER SULPHATE TO CONTROL *PHYTOPHTHORA CINNAMOMI.*
K. Howard, I.J. Colquhoun and G.E.St.J. Hardy.

DEVELOPMENT OF AN INTEGRATED DISEASE MANAGEMENT (IDM) PACKAGE FOR LATE BLIGHT ON POTATOES ACROSS DIFFERENT AGRO-ECOLOGICAL ZONES IN UGANDA
J. Nabirye, P. Ensywa and P.J. Hakiza

Biology of *Phytophthora*
Chair Wendy Sutton and Jen McComb

SUMMER RAINFALL AND THE DEVELOPMENT OF DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN DROUGHTED *EUCALYPTUS MARGINATA* PLANTS.
A. Lucas, J.A. McComb, I.J. Colquhoun and G.E.St.J. Hardy

PHYTOPHTHORA SPP. ASSOCIATED WITH *EUCALYPTUS SMITHII* DIEBACK IN SOUTH AFRICA
B.O.Z Maseko, T. Burgess, T.A Coutinho and M.J Wingfield

LONG-TERM SURVIVAL OF *PHYTOPHTHORA CINNAMOMI* IN ORGANIC MATTER UNDER DIFFERENT SOIL MOISTURE CONDITIONS
S. Collins, B. Shearer, J. McComb, I. Colquhoun, G. Hardy

THE INFLUENCE OF SOIL FROM A TOPOGRAPHIC GRADIENT IN THE FITZGERALD RIVER NATIONAL PARK ON MORTALITY OF *BANKSIA BAXTERI* FOLLOWING INFECTION BY *PHYTOPHTHORA CINNAMONI*
B. L. Shearer and C. E. Crane

TIME COURSE STUDIES OF THE EFFECT OF TEMPERATURE AND STIMULATION OF SOIL AT DIFFERENT DEPTHS ON SPORANGIUM PRODUCTION BY *PHYTOPHTHORA CINNAMONI*
B. L. Shearer

TUESDAY 2nd OCTOBER

Regional Overviews
Chair Cécile Robin

PROGRESS IN UNDERSTANDING *PHYTOPHTHORA* DISEASES OF TREES IN EUROPE AND AFRICA

C. M. Brasier[1] and T. Jung[2]

[1]Forest Research, Farnham, Surrey GU10 4LH, UK;
[2]Bavarian State Institute of Forestry, Am Hochanger 11, 85354 Freising, Germany

Significant progress and unexpected developments since the 1999 meeting will be reviewed. Topics covered will include the following. Understanding the role of Phytopthoras in European oak declines; continuing spread and evolution of the new hybrid alder Phytopthoras; status of Phytophthoras involved in chestnut mortality; the remarkable array of new *Phytopthora* taxa now being characterised in Europe; emerging evidence of the role of nurseries in the evolution and spread of *Phytopthora* diseases; and the connection between a new *Phytophthora* on rhododendrons in Europe and Sudden Oak Death *Phytophthora* in California.

PHYTOPHTHORA IN FORESTS OF THE AMERICAS-2001

E. M. Hansen

Department of Botany and Plant Pathology, Oregon State University, Corvallis Oregon 97331, USA

A dramatic new disease dominates this update of the status of Phytophthora diseases and research in the Western Hemisphere. At the time our last meeting in Grants Pass, a disease called Sudden Oak Death was causing increasing concern in California around San Francisco Bay, but no causal agent had been identified. Not long after the meeting, an apparently undescribed species of *Phytophthora* was isolated from lethal stem cankers on coastal oaks, and activity (and concern) escalated. Now a major international research effort addressing origins, biology, and control, including quarantines, is underway. This has triggered *Phytophthora* surveys in forests in several parts of North America, leading to new host reports, and new species. On other fronts, active forest *Phytophthora* research continues in Argentina, looking for the cause of Mal des Cipres, in Mexico with *P. cinnamomi* and possibly other species on oaks, and in Oregon, focused on Port-Orford-cedar and *P. lateralis*. A new "Rangewide Assessment" of the status of POC and *P. lateralis* has been prepared. Breeding for resistance continues, with the containerized seed orchard organized by breeding zone to produce locally adapted seed, and the first seedlings expected to be available for operational forest planting in 2002.

PHYTOPHTHORA IN AUSTRALASIA AND THE WAY FORWARD IN DISEASE MANAGEMENT

G. E. StJ Hardy[1], I.C. Tommerup[2], I. Colquhoun[3] and B. L. Shearer[4]

[1] School of Biological Sciences and Biotechnology, Murdoch University, Murdoch, Western Australia, 6150.
[2] Division of Forestry and Forestry Products, CSIRO, Wembley, Western Australia.
[3] Alcoa World Alumina, Environmental Department, Booragoon, 6953, Western Australia.
[4] Department of Conservation and Land Management, Science Division, Kensington, 6983, Western Australia..

Unlike the USA and Europe, Australasia has not in the last two years faced any unexpected developments in new *Phytophthora* diseases in forests and natural ecosystems. Consequently, we will focus on the way forward for disease management and examine the challenges that will need to be faced over the next few years to control the impact and rate of spread of this disease.

Session 1:	**Pathogenicity**
Chair	David Cahill

PROGRESS IN SELECTION AND PRODUCTION OF JARRAH (*EUCALYPTUS MARGINATA*) RESISTANT TO *PHYTOPHTHORA CINNAMOMI* FOR USE IN REHABILITATION PLANTINGS.

M.J.C. Stukely[1], J.A. McComb[2], I.J. Colquhoun[3] and I.J. Bennett[4]

1 Department of Conservation and Land Management, CALMScience Division, 17 Dick Perry Ave, Kensington, WA 6151
2 School of Biological and Environmental Sciences, Murdoch University, Murdoch, WA 6150
3 Alcoa World Alumina Australia, PO Box 252, Applecross, WA 6953
4 Department of Applied Science, Edith Cowan University, Mt Lawley, WA 6050

Resistance to *Phytophthora cinnamomi* in jarrah (*Eucalyptus marginata*) is under strong genetic control. It has high heritability and is probably polygenic, and is durable in field trials. Resistant jarrah seedlings derived from healthy mother trees growing on long-term dieback sites were selected from glasshouse inoculation trials and micropropagated by tissue culture. The resulting clonal lines were planted in field validation trials on dieback-affected sites and soil at the base of the plants was inoculated with *P.cinnamomi* to test survival and growth. In spite of some drought deaths, survival of most resistant lines has been high. Some 50 unrelated resistant lines have been selected. However, due to high costs of production and establishment problems in forest sites, it is not feasible to use the clonal jarrah directly in large-scale operational plantings. Clonal seed orchards are now being planted to supply seed of resistant jarrah for use in rehabilitation of bauxite pits, plantings in dieback-affected forest and on cleared agricultural land. Jarrah is being included in trials on groundwater recharge sites on agricultural land where increasing soil salinity is a long-term problem.

DEVELOPMENT OF DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN MATURE *XANTHORRHOEA AUSTRALIS*

M.J. Aberton[1], B.A. Wilson[1], J. Hill[2] and D.M. Cahill[1]

[1]School of Biological and Chemical Sciences, Deakin University, Geelong 3217
[2]Portland Aluminium, Private Bag 1, Portland, Vic. 3305, Australia.

Xanthorrhoea australis (Austral Grass-tree) is a species identified to be a good indicator of disease caused by *Phytophthora cinnamomi* in native forests and heathlands within Victoria. The plant is under serious threat from *P. cinnamomi* invasion and shows rapid death upon first infection from the disease. This research shows that the proportion of disease within the plant is relative to the disease symptoms or

decline stage (DS) shown by the plant in the form of chlorosis to leaves. Plants showing severe disease symptoms had 67% and 86% of roots infected, while those with less severe disease symptoms had 40% of roots infected. One dead plant and all healthy plants had 0% of their roots infected. Isolation of the pathogen from roots showed a large variation in distribution of the pathogen within the roots of each plant. Microscopy showed that the pathogen is situated through xylem and metaxylem within the roots. Massive lesions were located in plants with severe disease symptoms but isolation from these lesions proved difficult.

IDENTIFICATION OF PATHOGENICITY GENES IN *PHYTOPHTHORA NICOTIANAE*

Dubravka Škalamera and Adrienne Hardham

CRC for Tropical Plant Protection and Plant Cell Biology Group, Research School of Biological Sciences, Australian National University, Canberra ACT 2601

Zoospores are the main infective agent for most plant pathogenic oomycetes, including *Phytophthora.* The focus of our research is identification of zoospore-specific genes that may be crucial for pathogenicity of *Phytophthora.* In order to achieve this, a high quality cDNA library was made from mRNA isolated from zoospores of *Phytophthora nicotianae.* This species was chosen because it produces abundant zoospores and because of its wide host range which includes scientific model plants such as tobacco. The library was plated on duplicate grids that were subsequently used to differentially screen with cDNA probes originating from either mycelium or zoospore mRNA. Candidate zoospore specific genes, that were identified in this way were then passed through another round of screening and then partially sequenced from their 5'end. Comparison with other sequences in Genebank revealed homologies with known genes involved in a number of metabolic pathways as well as a number of unannotated sequences identified in the Phytophthora genome project. Of particular interest were clones that had multiple hits solely in the *P. sojae* zoospore-derived library. These clones will be characterised further.Future experiments will involve identifying the function of these genes through transformation experiments. Continuation of this research will identify important pathogenicity factors that could be used as targets in novel control measures for *Phytophthora* diseases.

VARIATION, DISTRIBUTION AND PATHOGENICITY OF THE HYBRID ALDER *PHYTOPHTHORAS*

C. M. Brasier

Forest Research, Farnham, Surrey GU10 4LH, UK

Results of further studies on comparative variation in the standard and variant heteroploid Phytopthora hybrids now spreading on alder in Europe, and on the putative parent species of the hybrids, will be presented. This will include data on differences in the stability of their asexual propagules; oospore viability; pathogenicity to alder bark; host specificity; molecular profiles and geographic distribution. The issue of the taxonomic status of the hybrids, and the issue of the potential threat to alders on other continents, will be discussed.

BREEDING FOR RESISTANCE TO *PHYTOPHTHORA LATERALIS* IN PORT-ORFORD-CEDAR : CURRENT STATUS AND CONSIDERATIONS FOR DEVELOPING DURABLE RESISTANCE

R. A. Sniezko[1], E. M. Hansen[2] and J.Hamlin[3]

[1]USDA Forest Service, Dorena Tree Improvement Center, 34963 Shoreview Road, Cottage Grove, Oregon 97424, U.S.A.;
[2]Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, Oregon 97331, U.S.A;
[3]USDA Forest Service, Umpqua National Forest, Roseburg, Oregon

Port-Orford-cedar (*Chamaecyparis lawsoniana*) is an important component of the forest ecosystems of southwestern Oregon and northwestern California. The presence of a non-native root disease caused by *Phytophthora lateralis*, is causing widespread mortality throughout the range of Port-Orford-cedar. In 1997, the Forest Service and BLM in collaboration with Oregon State University initiated a operational breeding program for resistance. Including a few selections made prior to 1997, a branch dip test has been use to evaluate over 9700 field selections through 2000. Over 1000 candidates ranked high in the branch lesion test are being evaluated further using rooted cuttings in a root dip test or in field tests. Although the branch dip test appears only weakly correlated with other tests many of the highest surviving parents also are highly ranked in all tests. The frequency of resistant candidates is low, and depends on the criteria used to define a candidate as resistant. Large differences in family survival occur, sometimes varying from 0% to 100%. The oldest field tests indicate good survival through 12 years for rooted cuttings and seedlings of top parents. Some results from crossing suggest a major gene for resistance, but some minor conflict exists among the different types of tests. The number and types of resistance mechanisms are unknown, and may be difficult to discern without diagnostic races of the pathogen. Current evidence suggests there is little genetic variability in this introduced pathogen. Breeding in Port-Orford-cedar can be done at a very early age which favors the development of increasing levels of resistance. Management activities that reduce the spread of the pathogen, the size of the pathogen population size, or the introduction or new strains will aid in developing effective resistance.

Session 2:	**Molecular and Developmental Studies**
Chair	David Cooke and Phillip O'Brien

THE RELIABILITY OF rDNA INTERNAL TRANSCRIBED SPACER SEQUENCE ANALYSIS IN *PHYTOPHTHORA* IDENTIFICATION AND TAXONOMY

David E. L. Cooke, Naomi A. Williams and James M. Duncan

Mycology, Bacteriology and Nematology, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK.

The approach to taxonomic and evolutionary issues in the genus *Phytophthora* is being revolutionised by the application of molecular analyses. The internal transcribed spacer (ITS) regions of the ribosomal RNA resolve at an appropriate taxonomic level and the PCR amplification protocols are robust. This, combined with an expanding database of ITS sequences has resulted in their widespread use in isolate characterisation. Such a molecular approach simultaneously yields objective characters for taxonomic discrimination and sufficient information for phylogenetic studies that identify the nearest known relatives for comparative analysis. Over a dozen new taxa have been discovered over the past few years and ITS sequence analysis has frequently provided the primary support for their status as distinct species. While colony characteristics and morphology are still important, increasingly the first step is ITS sequencing and a database comparison. While the approach is clearly a powerful one, caution should be exercised. There are many unanswered questions and challenges relating to levels of intraspecific ITS variation, database reliability, discrimination of recently evolved species with identical ITS sequences and

the impact of reticulation and hybridisation events on ITS regions. This paper reviews the current status of the SCRI and GenBank ITS sequence databases in the context of such issues.

DETECTION OF *PHYTOPHTHORA CINNAMOMI* USING PCR.

P.A. O'Brien, and M.D. Farbey,

School of Biological Sciences & Biotechnology, Murdoch University, Murdoch, WA 6150, Australia

In Western Australia jarrah dieback disease caused by the fungus *Phytophthora cinnamomi* is placing many species of native vegetation at risk of extinction. For disease management purposes it is important to be able to detect the fungus so that it's spread into unaffected areas can be avoided. We report on the development of methods for the detection of *Phytophthora cinnamomi* in soil and plant material using PCR to detect the fungal DNA. A species-specific probe was isolated and developed into a PCR reaction specific for *P. cinnamomi.* Efforts to extract PCR amplifiable DNA have been compounded by the co-extraction of PCR inhibitory substances from soil and plant tissue. A number of DNA extraction methods have been compared, and modifications of the extraction procedure and amplification procedures designed to overcome this problem have been investigated with success. The results of experiments to compare the efficiency and sensitivity of PCR detection with baiting will be presented. Future trends in detection of pathogens using DNA methods will be discussed.

CONTINENT-WIDE CLONAL LINEAGES OF *PHYTOPHTHORA CINNAMOMI* SHOW FREQUENT MITOTIC RECOMBINATION

M. P. Dobrowolski[1], I. C. Tommerup[2], B. L. Shearer[3] and P. A. O'Brien[1]

[1]School of Biological Sciences and Biotechnology, Murdoch University, Murdoch 6150, Western Australia;
[2]Forestry and Forest Products, CSIRO Perth, PO Box 5, Wembley 6913, Western Australia;
[3]Science and Information Division, Department of Conservation and Land Management, Como 6152, Western Australia.

Genetic studies of *Phytophthora cinnamomi* using isozymes have revealed low levels of diversity suggesting, though not proving, clonality in a large proportion of worldwide populations (1). In Australia, only three isozyme types (representing both mating types) are found with no evidence for sexual recombination (2). Using microsatellite markers, we have shown that these isozyme types are clonal lineages of *P. cinnamomi* and that these same lineages are found elsewhere in the world. Our study used 647 isolates from three intensively and hierarchically sampled *P. cinnamomi* disease fronts located in south-west Australia. In addition 133 isolates from an Australia-wide culture collection and 27 isolates from elsewhere in the world were analysed with four microsatellite markers. One disease front contained all three clonal lineages within close proximity in soil and plant tissue but no sexual recombinant isolates were found, even with very intensive sampling. However, within these clonal lineages we frequently found evidence for mitotic recombination (mitotic crossing over). This mechanism for producing genetic variation may explain phenotypic variation known to occur within the identified clonal lineages.

1. Oudemans, P. and Coffey, M.D. (1991) *Mycol. Res.* **95**: 19-30
2. Old, K.M., Moran, G.F. and Bell, J.C. (1984) *Can. J. Bot.* **62**: 2016-2022

THE EFFECT OF PHOSPHITE ON MEIOSIS AND SEXUAL REPRODUCTION

Meredith M. Fairbanks, Giles E.St.J. Hardy and Jen A. McComb

School of Biological Science and Biotechnology, Murdoch University, Perth, Australia

The fungicide phosphite is used to control *Phythorthora cinnamomi* Rands in Western Australia. Fungicides may have secondary non-target effects on plants either through an effect of the applied compound, or after its metabolism *in planta*. These effects range from poor germination and stunting of plants to genetic changes including chromosomal and gene mutation leading to inherited alterations. We have recorded a significant reduction in pollen fertility for native Australian and horticultural species after phosphite treatment. To determine whether the fungicide causes abnormalities of cell division, *Vicia faba* and *Petunia hybrida* were sprayed with phosphite to run-off, and mitosis in root tips observed. There was no effect on mitotic index but the proportion of mitotic cells with chromosome abnormalities was high for 7 days and was still evident up to 21 days after spraying. Phosphite also significantly increased the percent of cells with cytological abnormalities at all stages of the meiotic cycle of *Tradescantia virginiana* microspores for 7 days after spraying, and the effect lasted for 28 days.

EFFECTS OF POTASSIUM PHOSPHONATE ON PHOSPHORUS METABOLISM IN *PHYTOPHTHORA*

J. Niere[1], G. DeAngelis[1], J. McDonell[1], F. Stringer [1], J. H. Grant[1], B. R. Grant[2]

[1]Department of Applied Chemistry, RMIT, Melbourne 3000 Australia
[2]School of Biochemistry, University of Melbourne, Parkville 3052, Australia

Potassium phosphonate is an effective and selective inhibitor of many plant diseases caused by the fungal genus *Phytophthora*. The biochemistry of *Phytophthora* differs in many ways from that of the true fungi. In particular, unlike true fungi, *Phytophthora* contains little or no long-chain polyphosphate but an abundance of the short-chain, acid-extractable polymer (1). ^{31}P NMR spectroscopy was used to examine changes in phosphorylated metabolites within living mycelium of the plant pathogen, *Phytophthora palmivora* over twenty-four hours. Mycelium raised in conventional, defined growth medium afforded spectra consisting of relatively narrow peaks, some of which were superimposed on broader resonances attributed to pyrophosphate and short-chain polyphosphates. Treatment of *Phytophthora* mycelium with potassium phosphonate over a period of days is known to induce formation of isohypophosphate and increase levels of a phosphate ester and of pyro- and tripolyphosphate[1]. The *in vivo* NMR spectra displayed increases in the phosphate ester and isohypophosphate signals within 6 hours of phosphonate addition. However, corresponding increases in the pyro- and polyphosphate regions were absent and the intensity of one of the polyphosphate signals decreased.

1. Niere, J. O., De Angelis, G. & Grant, B. R. (1994). The effect of phosphonate on acid-soluble phosphorus components in the genus *Phytophthora. Microbiology* 140, 1661-1670.

WEDNESDAY 3rd OCTOBER

Session 1: **Impact of *Phytophthora* in Australia**
Chair Keith McDougall and Bryan Shearer

THE DISTRIBUTION AND IMPACT OF *PHYTOPHTHORA CINNAMOMI* RANDS IN THE SOUTH COAST REGION OF WESTERN AUSTRALIA

Malcom Grant and Sarah Barrett

Department of Conservation and Land Management, Albany

Climate, soils, topography and susceptible plant communities, in combination with the movement of infested soil by human activity, has resulted in *Phytophthora cinnamomi* becoming the most destructive plant pathogen in native plant communities in the south coast region of Western Australia. Centres of disease activity occur near Albany and in the Stirling Range and Cape le Grand National Parks. Incidence generally decreases in a north-easterly direction in association with drier climatic conditions. *P. cinnamomi* causes death of susceptible species, in particular members of the Proteaeceae, Epacridaceae, Papilionaceae and Myrtaceae, and results in changes in community structure and species composition. Two-thirds of the Stirling Range National Park, notable for its 1,530 plant taxa and high numbers of rare and endemic species, is infested. Sixteen of these species are threatened with extinction by *P. cinnamomi*, eight are critically endangered. The Montane Heath and Thicket Community of the eastern Stirling Range is also critically endangered. The Fitzgerald River National Park with 1748 plant taxa is largely disease-free although a sizeable infestation occurs in the core of the Park. Appropriate management of areas with high conservation values infested by *P. cinnamomi* as well as the protection of those areas currently disease-free, remains an ongoing challenge.

THE DIEBACK CYCLE IN VICTORIAN FORESTS: A 30 YEAR STUDY OF THE CHANGES CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN VICTORIAN OPEN FORESTS, MEASURED PERIODICALLY ON DEFINED QUADRATS

Gretna Weste, Jill Kennedy and Ken Brown

Botany School, University of Melbourne, Victoria, 3010

Changes in both vegetation and in pathogen population and distribution were monitored periodically on defined infested quadrats and on similar pathogen-free quadrats on 13 sites representing major types of forest and woodland between 1970 and 2000. The susceptible eucalypts in the overstorey of infested sites showed severe dieback, loss of crown and deaths. All trees died on some sites, others presented dead leaders with epicormic growth on lower branches. Dieback of the understorey, followed by death occurred in 50-75 % of the species in the heathy understorey, including the dominant *Xanthorrhoea australis*, thereby changing the community and the species composition. Species richness in infested quadrats declined, and percentage cover and percentage contribution to the community by susceptible species were almost eliminated. On steep slopes, the ground remained bare, but on other sites the susceptible flora was replaced by field resistant species of sedges and rushes, and by the partly resistant teatrees, *Leptospermum* spp., which formed a dense cover.

The pathogen was isolated from 100% of the root samples from infested quadrats from 1970 to 1984, but then gradually declined. In 2000, *P. cinnamomi* was rare on some sites and not isolated from four. Regeneration of 30 to 40 susceptible species, previously eliminated, was recorded from infested sites, and two thirds of these were growing on more than one quadrat. Copius regeneration of the previously dominant but highly susceptible *X. australis* occurred on four sites. Significant recovery and recruitment of the overstorey has not been observed. It is not yet clear whether the regeneration of the understorey is stable, or whether successive cycles of disease and recovery will occur.

IMPACT OF *PHYTOPHTHORA CINNAMOMI* ON MAMMALS IN SOUTHERN AUSTRALIA

B. A. Wilson[1] and W. S. Laidlaw[2]

[1] School of Ecology and Environment, Deakin University, Geelong, Australia 3217;
[2] Department of Botany, University of Melbourne, Parkville, Australia 3010.

The plant pathogen *Phytophthora cinnamomi* (cinnamon fungus) has a major effect on vegetation floristics and structure in sclerophyll vegetation in Australia. Effects include loss of plant species, decline in vegetation cover, increases in bare ground and the abundance of resistant plant species. These changes would be predicted to have effects on faunal communities inhabiting infected habitats. Analyses in heathlands and woodlands of south-eastern Australia have identified *P. cinnamomi* infection as being associated with low species richness, and low abundance of small mammals. Studies of *Antechinus stuartii* (Brown Antechinus) in woodlands found that there were lower capture rates in infected areas, and habitat utilisation was altered. The major contributing factor was alterations to vegetation structure, rather than food availability. In heathlands, species such as *Rattus lutreolus* (Swamp Rat), *Rattus fuscipes* (Bush Rat), *Antechinus agilis* (Agile Antechinus) and *Sminthopsis leucopus* (White-footed Dunnart) were found to be less abundant in diseased areas, or utilised them less frequently. An analysis of mammals that occur in Victoria found that for twenty-two species, five of which are rare or endangered, more than 20% of their range coincides with the reported distribution of *P. cinnamomi.*

THE IMPACT OF *PHYTOPHTHORA CINNAMOMI* RANDS. ON THE FLORA AND VEGETATION OF NEW SOUTH WALES – A RE-APPRAISAL

K.L. McDougall[1] and B.A. Summerell[2]

[1]NSW National Parks and Wildlife Service, PO Box 2115, Queanbeyan NSW Australia, 2620;
[2]Royal Botanic Gardens Sydney, Mrs Macquaries Road, Sydney, NSW 2000

Although *Phytophthora cinnamomi* is widely regarded as having a significant impact on native vegetation in many parts of southern Australia, the pathogen has been considered benign and possibly endemic in New South Wales. The evidence for the different behaviour in NSW has included that 1) *P. cinnamomi* is extremely widespread and easy to detect in soils, 2) generally susceptible genera such as *Banksia* are unaffected when it is present (suggesting a long host/pathogen interaction), 3) multiple plant deaths associated with *P. cinnamomi* are extremely rare and 4) *P. cinnamomi* has been recovered in remote areas (suggesting that it is endemic). Recent surveys of National Parks in eastern NSW have found that although *P. cinnamomi* is widespread it cannot be detected in some areas despite extensive soil sampling. Although most *Banksia* spp. seem to be relatively resistant to symptoms of infection, other taxa (especially some *Xanthorrhoea* spp.) are very susceptible. The loss of *Xanthorrhoea* cover may adversely affect threatened animals such as the Smoky Mouse and Southern Brown Bandicoot, which use the plants for cover and nesting. Glasshouse susceptibility trials have shown that a number of rare taxa are very susceptible to infection. The NSW floral emblem, *Telopea speciosissima,* is also susceptible. *P. cinnamomi* may be widespread in NSW, however it is doubtful that it is endemic and is certainly not always benign.

HOW SUSCEPTIBLE IS THE FLORA OF SOUTH-WESTERN AUSTRALIA TO *PHYTOPHTHORA CINNAMONI*?

B. L. Shearer, C. E. Crane, M. Dillon and A. Cochrane

CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

Despite the high impact of *Phytophthora cinnamomi* infection on the flora of south-western Australia, the susceptibility of the component plant species to infection is poorly understood. From an assessment of the impact of *P. cinnamomi* in the plant communities of the Stirling range National Park, Wills (3) concluded that the proportion of the plant species susceptible to the pathogen was 36-43%. Susceptibility databases from *Eucalyptus marginata* forest (1), *Banksia* woodland (2) and threatened and rare flora (Shearer, Crane and Cochrane *unpublished*) will be used to analyse and compare estimates of the susceptibility of south-western flora to *P. cinnamomi*.

1. Shearer B.L., Dillon M. (1995) Susceptibility of plant species in *Eucalyptus marginata* forest to infection by *Phytophthora cinnamomi*. *Australian Journal of Botany* **43**, 113-134.
2. Shearer B.L., Dillon M. (1996) Susceptibility of plant species in *Banksia* woodlands on the Swan Coastal Plain, Western Australia to infection by *Phytophthora cinnamomi*. *Australian Journal of Botany* **44**, 433-445.
4. Wills R.T. (1993) The ecological impact of *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia. *Australian Journal of Ecology* **18**, 145-159.

Session 2: **Use of phosphite in management of *Phytophthora***
Chair Mark Dobrowolski

IN PLANTA PHOSPHITE CONCENTRATIONS AND PHYTOTOXICITY AFTER LOW-VOLUME PHOSPHITE APPLICATION TO NATIVE SPECIES

Sarah Barrett

Department of Conservation and Land Management, Albany

The fungicide phosphite has been used in recent years to protect native plant species and communities threatened by *Phytophthora cinnamomi*. Native plant species may vary considerably in their uptake of phosphite and in their sensitivity to phosphite as expressed by phytotoxicity. *In planta* phosphite concentrations of nine species five weeks after low volume phosphite application at 36, 72 and 144 kg ha^{-1} showed a significant correlation with phytotoxicity symptoms. *In planta* phosphite concentrations varied significantly between species and application rates. Growth abnormalities and chlorosis after low-volume phosphite application at rates ranging from 24 to 144 kg ha^{-1} were observed from five months post-spray in 32 and 36 of the 207 species assessed, respectively.

Shoot growth, root and shoot dry weight and root length in *Corymbia calophylla* and *Banksia brownii* were not significantly reduced by low-volume phosphite application at rates of 24, 48 and 96 kg ha^{-1} in a glasshouse study. Percentage vesicular-arbuscular (VAM) and ectomycorrhizal colonisation and total VAM and ectomycorrhizal root lengths were not significantly different in treated and control plants of *C. calophylla* four months after phosphite application. Low volume phosphite application at 24 kg ha^{-1} appears to be an appropriate rate for native vegetation in terms of effects on root development. Selection of appropriate aerial phosphite application rates for native plant communities must ensure a balance between achieving adequate phosphite concentrations for disease control while minimising phytotoxicity symptoms in the range of species present.

PHOSPHITE CONTROLS *PHYTOPHTHORA CINNAMOMI* AT ANGLESEA AND WILSON'S PROMONTORY NATIONAL PARK, VICTORIA.

M. J. Aberton[1], B.A. Wilson[1], J. Hill[2] and D. M. Cahill[1]

[1]School of Biological and Chemical Sciences, Deakin University, Geelong, 3217, Victoria
[2]Portland Aluminium, Private Bag 1, Portland, Vic. 3305, Australia.

The use of phosphite at concentrations of 2 and 4g a.i./L proved to be successful in controlling the spread of *Phytophthora cinnamomi* within different vegetation communities at Anglesea (Alcoa lease area) and Tidal River (Wilson's Promontory National Park). At nine sites, phosphite was sprayed to runoff with a Solo® 422 motorised backpack sprayer with $2L/25m^2$ quadrat. Using aerial and ground photography, quadrats were monitored over a two-year period to determine changes in species abundance due to the pathogen. There was a significant difference ($p<0.05$) between the proportions of healthy *Xanthorrhoea australis* in phosphite sprayed quadrats (2 and 4g a.i./L with 0.5% surfactant) compared to those sprayed with a control (water and 0.5% surfactant, water only). Vegetation in quadrats where *P. cinnamomi* was present was protected by phosphite for 2 years (4g a.i./L) and 12 months (2g a.i./L). However, vegetation in quadrats where the pathogen was present died where phosphite was not sprayed. Phosphite provided protection for *X. australis*, *Isopogon ceratophyllus* and *Monotoca scoparia* (3 species highly susceptible to *P. cinnamomi*). From the results of this research we recommend the use of phosphite in susceptible vegetation communities with 4g a.i./L phosphite to assist with already existing management strategies for the protection of Victorian heathlands and forests from *P. cinnamomi*.

MONITORING OF AERIAL PHOSPHITE APPLICATIONS FOR THE CONTROL OF *PHYTOPHTHORA CINNAMOMI* IN THE ALBANY DISTRICT

Sarah Barrett

Department of Conservation and Land Management, Albany

Operational phosphite applications in autumn 1997 were monitored at the Bell Track in the Fitzgerald River National Park and on Bluff Knoll in the critically endangered Eastern Stirling Range Montane community. The Montane community, which is extensively infested by *Phytophtora cinnamomi*, is notable for 11 Threatened plant taxa, four of which are critically endangered. Aerial phosphite application at 24 kg a.i. ha^{-1} resulted in significantly higher percentage survival of *Phytophthora*-susceptible species in sprayed compared with non-sprayed quadrats on a dieback front at the Bell Track for up to two years post-spray. Similar observations were made at Bluff Knoll after phosphite application to uniformly infested vegetation. *Sphenotoma* sp. Stirling Range sampled from Bluff Knoll had considerably higher phosphite concentrations at two weeks and five months post-spray than *Lambertia inermis* sampled from the Bell Track. Phytotoxicity symptoms in terms of foliar necrosis and defoliation post-spray were generally mild although selected species showed greater sensitivity. Growth abnormalities were observed in a small percentage of species assessed at the Bell Track site. Concerns regarding potential phytotoxic effects of phosphite on plant health must be balanced by the threat posed to the survival of critically endangered species and plant communities by *Phytophthora cinnamomi*.

AERIAL APPLICATION OF PHOSPHITE TO PROTECT ENDANGERED WESTERN AUSTRALIAN FLORA

R. S. Smith

Department of Conservation and Land Management, North Boyanup Road, Western Australia.

Research into the trunk injection of phosphite, a buffered solution of phosphorous acid (H_3PO_3), to protect native plants against *Phytophthora cinnamomi* disease was first carried out in Western Australia in the late 1980's. Initial aerial application trails took place near Albany in autumn 1993 at one fifth of the present standard application rate because of concerns about possible phytotoxicity. The current standard rate for aerially applied phosphite is 24 kg/ha^{-1} of $400g/kg^{-1}$ formulation together with a surfactant or wetting agent at 0.3% (v/v). Symptoms of phytotoxicity at these rates are minor. Generally, the chemical is applied as two treatments in autumn, about one month apart. The first broadscale aerial application of phosphite took place in 1997, since then about 640 ha of native vegetation at more than 50 sites has been treated, mostly to protect endangered flora. Several sites near Albany received their third application this year. Spraying is normally done in autumn to take advantage of calm, clear weather in the Stirling Ranges where most aerial application takes place. Recent research has indicated, for some species at least, that autumn application may lead to greater foliar uptake of phosphite. Monitoring indicates that aerial phosphite treatments will need to take place at least every two years and in some cases, where only a few wild plants are left, annual applications may be needed. The area of most urgent research need is the interaction between phosphite, wildfire and regeneration of rare flora to determine optimum application rates and frequency.

THURSDAY 4th OCTOBER

Session 1:	**Impact of *Phytophthora* in Australia and New Zealand**
Chair	Tim Rudman

PHYTOPHTHORA CINNAMOMI IN NEW ZEALAND NATIVE FORESTS

P. R. Johnston[1], R. E. Beever[1] and I. J. Horner[2]

[1]Landcare Research, Private Bag 92170, Auckland, New Zealand;
[2]HortResearch, Hawkes Bay Research Centre, Private Bag 1401, Havelock North, New Zealand

Phytophthora cinnamomi is not native to New Zealand, but perhaps it was introduced by Polynesians, as *Phytophthora*-like symptoms were observed in the early 1800's. The fungus is widespread in native forest soils. It can cause noticeable, localised damage during periods of weather suited to inoculum build-up (warm, wet winters), followed by periods of stress on the plants (unusually dry summers). However, the moderate New Zealand climate means that in native forests damage is rarely visible in above-ground parts of plants. Some roots are killed, but in New Zealand plants generally require only a proportion of their roots for normal growth. Despite major disease episodes being rare, *P. cinnamomi* could have subtle, longer term, effects on New Zealand's vegetation. Variation in plant susceptibility alone will cause changes to plant community structure over time. Seedlings of some major forest trees are highly susceptible. Although kauri (*Agathis australis*) forests appear to be re-establishing vigorously in many parts of northern New Zealand, at some sites seedlings survive only when protected against *Phytophthtora* by fungicides. In southern New Zealand, *Nothofagus* seedlings are susceptible to *P.*

cinnamomi unless their roots are strongly mycorrhizal. This may prevent *Nothofagus* establishment in soils not already infected with ectomycorrhizal fungi.

FOLIAR DISEASE OF *EUCALYPTUS* CAUSED BY *PHYTOPHTHORA* SPP.

M.A. Dick, W.J. Faulds, K. Dobbie and R. Crabtree

Forest Health Group, NZ Forest Research Institute, Private Bag 3020, Rotorua, New Zealand

Locally severe crown dieback of *Eucalyptus botryoides, E. fastigata* and *E. saligna* has been recorded in the central North Island - Bay of Plenty area of New Zealand since 1986. At least two different species of *Phytophthora* have been associated with twig and small branch lesions, leaf spots and petiole infection . Pathogenicity has been demonstrated in inoculation trials. Affected trees ranged from 4-12 years of age. Individual trees within a plantation can vary markedly in susceptibility, ranging from being unaffected to almost entire crown defoliation. Sporulation of the *Phytophthora* spp. has not been observed in the field. Although the *Phytophthora* spp. have been found in the soil beneath symptomatic trees the height of the trees precludes spore splash from the soil as a mode of fungal dispersal. Attempts to find evidence of the fungi on insects travelling up the trunks of the trees have not been successful. The fungi are probably undescribed species of *Phytophthora.*

THE DECLINE OF AUSTRALIAN MAMMALS: IMPLICATIONS FOR ECOSYSTEM FUNCTION IN *PHYTOPHTHORA* AFFECTED COMMUNITIES

Mark Garkaklis[1], Giles Hardy[1], Bernie Dell[1] and Barbara Wilson[2]

[1]School of Biology and Biotechnology, Murdoch University, Western Australia 6150;
[2] School of Ecology and Environment, Deakin University, Geelong, Victoria 3217.

Phytophthora cinnamomi has major effects on floristics and structure in native sclerophyll vegetation in Australia and recent studies have shown that *P. cinnamomi* can also alter the diversity and abundance of small mammals within affected areas. Overseas research has found that vertebrate fauna can influence a number of key ecosystem processes. This paper reviews some of the evidence for similar effects in Australia and examines the implications of a decline in vertebrate fauna for ecosystem function in *Phytophthora* affected communities.

The effects of digging on ecosystem function is demonstrated by studies of the Woylie (*Bettongia penicillata*) in Australia. Woylies forage for the underground fruiting bodies of ectomycorrhizal fungi and create up to 110 diggings per night. At this rate individual Woylies can disturb in excess of 5.5 tonnes of soil annually. Experiments using simulated woylie diggings show that they reduce soil water repellency, affect the availability of nutrients and alter the particle size distribution of the soil. These studies also show that a decline in their population results in a loss of this digging activity and suggests any large scale disturbance that alters the guild of fauna within an ecosystem may alter functional processes as well.

In experiments currently being initiated, the changes in functional processes due to altered fauna guilds will be examined in *Phytophthora* affected communities in southern Australia. It will provide a detailed examination of soil disturbance (biopedturbation) by a suite of digging species as they forage for the fruiting bodies of underground fungi (mycophagy). These fungi (ectomycorrhizae) play a vital role in the supply of nutrients to plants. However, there is little information on the impact of *Phytophthora* on the production of fruiting bodies, or the effects on vertebrate foraging and soil disturbance. Nectar resources and vertebrate pollination will also be measured.

STRATEGIC REVIEW OF *PHYTOPHTHORA CINNAMOMI* IN PARKS AND RESERVES IN VICTORIA, AUSTRALIA

D. Cahill[1], B. Wilson[2], M Garkaklis[3], J. O'May[4], R. Milne[4], I. Sieler[5]

[1]School of Biological and Chemical Sciences, Deakin University, Geelong, Victoria 3217;
[2]School of Ecology and Environment, Deakin University, Geelong, Victoria 3217;
[3]Department of Zoology, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009;
[4]Centre for Environmental Management, University of Ballarat, PO Box 663, Ballarat, Victoria 3353;
[5]Parks Victoria, 535 Bourke St, Melbourne Vic 3000

Phytophthora cinnamomi continues to have a significant impact on flora and fauna in Victoria. Parks Victoria aims to quantify the effects of threatening processes and this project was initiated to review the impact of disease across the park estate. It addresses several of the objectives of the draft National Threat Abatement Plan for *P. cinnamomi* including promoting recovery of endangered or vulnerable species and ecological communities, preventing invasion into new areas, and improving knowledge of the disease process. Specific objectives were to determine the current and potential distribution of the pathogen and distributions of susceptible species and communities. Also examined were environmental and anthropogenic factors that may limit or spread *P. cinnamomi.* A literature review and geospatial analyses have determined the historical, current and predicted extent of *P. cinnamomi* across Victoria. The analyses identify and map potentially susceptible vegetation associations and individual species. Risk of infestation is predicted through analyses of environmental factors, vectors, and pathogen distribution. A GIS layer documents the distribution and potential impact of *P. cinnamomi* on native communities. Modelling the potential for disease spread and the level of risk by geographic locality enables management options and priorities to be identified throughout the park estate.

Session 2:	**Management of *Phytophthora* in natural ecosystems**
Chair	Ellen Goheen

A METHOD OF STRATEGIC CONSERVATION PLANNING FOR SPECIES AND COMMUNITIES HIGHLY SUSCEPTIBLE TO *P. CINNAMOMI* IN TASMANIA.

Tim Rudman[1], Richard Schahinger[1], Tim Wardlaw[2]

[1]Dept of Primary Industries, Water & Environment, PO Box 44, Hobart, Tas. 7001
[2]Forestry Tasmania, GPO Box 207, Hobart, Tas. 7001

The method employed to establish a representative suite of management areas for the conservation of plant communities that are severely degraded by *P. cinnamomi* in Tasmania is described. Target plant communities are identified by screening communities that occur within the environmental domain of *P. cinnamomi* and contain elements known to be highly susceptible to *P. cinnamomi* in the field. Mapped vegetation assemblages are used in planning where knowledge of the distribution of individual plant communities is insufficient for spatial analysis. Potential *P. cinnamomi* management areas are identified by spatial analysis of *P. cinnamomi* distribution, community/ vegetation assemblage distribution, natural boundaries for pathogen spread, land use and access. Field surveys are undertaken in these areas to update information on plant communities, disease status and management issues. For each community/ vegetation assemblage the overall disease status is determined and optimum disease-free management units are identified against a suite of risk and manageability criteria. Where disease free management areas are not available, the most feasible management area is chosen. Selection of management areas is reduced by favouring areas that capture a range of target communities. For each management area management recommendations and actions are to be prepared.

PHYTOPHTHORA – A PLANT QUARANTINE RISK FOR NORTHERN TERRITORY FOREST AND SAVANNA ECOSYSTEMS

S.E. Bellgard[1], and M. Weinert[2]

[1]Katherine Research Station, Northern Territory Department of Primary Industry and Fisheries, PO Box 1346, Katherine, NT. 0851
[2]Northern Australian Quarantine Strategy, Berrimah Agricultural Research Centre, NTDPI&F, Strath Road, Berrimah, NT. 0828

The horticultural industry has developed rapidly in northern Australia, with centers of expansion focused on Kununnurra, Darwin and Katherine. Rootstock, irrigation management, variety evaluations, seedling assessment and selections are principal areas of research and development. During 1990/91, a survey was conducted of Northern Territory nurseries to determine the incidence of root and collar rots. Four *Phytophthora* species, including *P. cinnamomi* were recovered. Additionally, 13 *Pythium* species were detected. This paper provides a historical review of the occurrence, impacts and distribution of *Phytophthora* species in the Northern Territory. With the prospect of horticulture expanding into remote areas of the NT, there exists the possibility for the future accidental introduction of *Phytophthora* inoculum in potted plants, and in clods of dirt adhering to agricultural and earthmoving equipment.

PHYTOPHTHORA DISEASE OF ALDERS IN BAVARIA: EXTENT OF DAMAGE, MODE OF SPREAD, AND MANAGEMENT STRATEGIES

T. Jung[1], M. Blaschke[1], A. Schlenzig[2], W. Oßwald[2] and H.-J. Gulder[1]

[1]Bavarian State Institute of Forestry (LWF), Section Forest Ecology and Protection, Am Hochanger 11, 85354 Freising, Germany; [2]Institute of Forest Botany, Section Phytopathology, Technische Universität München, Am Hochanger 13, 85354 Freising, Germany.

During a 2-year study it could be shown that a new lethal Phytophthora root and collar rot of common (*Alnus glutinosa*) and grey alder (*A. incana*), which was first identified in 1993 in the UK, is widespread along most riversystems in Bavaria. Symptoms include abnormally small and often yellowish leaves, a sparse canopy, tarry or rusty spots on the outer bark of the stem base with tongue shaped necroses of the inner bark. Once introduced to a river system, the alder *Phytophthora* spreads downstream infecting the collar or bare roots of riparian alders via lenticells and adventitious roots. The disease is also present in young plantations on former agricultural land without contact to any watercourses indicating disease transmission via infected nursery stocks. Baiting tests revealed the presence of the pathogen in rootstocks of alders from two out of three Bavarian nurseries tested. In a new project, measures shall be developed to prevent further disease spread, and facilitate the sanitation of diseased alder stands. As a first result, a code of good practice for the production of alders was negotiated with the Bavarian nursery owners. Furthermore, coppice trials with diseased alders growing under flooded and non-flooded conditions, and a screening for resistant alders in the field were started. Finally, a disease leaflet was produced, and sent to all local forestry, river and environmental authorities, aiming in a detailed survey of the disease distribution.

MONITORING EFFECTIVENESS OF ROADSIDE SANITATION TREATMENTS TO DECREASE LIKELIHOOD OF SPREAD OF *PHYTOPTHORA LATERALIS* IN SOUTHWEST OREGON USA

Donald J. Goheen and Katrina Marshall

USDA Forest Service, Southwest Oregon Forest Insect and Disease Service Center, 2606 Old Stage Road, Central Point, Oregon, USA

Phytophthora lateralis is an introduced pathogen that causes a severe root disease of Port-Orford-cedar (*Chamaecyparis lawsoniana*) in Southwest Oregon and Northwest California USA. A number of management techniques are employed to reduce the probability of spread of *P. lateralis* on federally managed forests. One of these, the roadside sanitation treatment, involves killing all Port-Orford-cedar in buffer strips approximately 8m wide on either side of selected roads. The objective of the treatment is to either reduce likelihood of vehicles picking up infested soil along roadsides where *P. lateralis* infection already occurs or to remove hosts in the zone of greatest vulnerability to infection in areas where the pathogen has not yet been established. Although roadside sanitation has been widely used, it is controversial with some sectors of the Public, and its effectiveness has not been thoroughly evaluated. We monitored 13 treatment areas for up to 8 years using Port-Orford-seedlings as baits. Each spring, seedlings were planted in the same locations along transects, collected after 8 weeks, and assayed for infection. We found that where Port-Orford-cedar root disease was present and severe along a road, sanitation significantly reduced amount of inoculum four years after treatment.

ADDRESSING SUDDEN OAK DEATH FOR THE STATE OF CALIFORNIA

S.J. Frankel

USDA Forest Service, Pacific Southwest Region, State and Private Forestry, 1323 Club Drive, Vallejo, Ca 94592 USA

Sudden Oak Death, caused by *Phytophthora ramorum,* has killed tens of thousands of oak (primarily *Quercus agrifolia*, and *Quercus kellogii*) and tanoak (*Lithocarpus densiflorus*) trees in central coastal California. The dead and dying trees are scattered throughout mixed ownerships in an area where approximately 8 million people live. This complicates management of the disease and necessitates the cooperation of hundreds of organizations, involving thousands of people. To coordinate the response to Sudden Oak Death, the California Oak Mortality Task Force was formed. The task force developed state and federal regulations for the pathogen, as well as programs for monitoring, management, research, education, funding, fire prevention and wood utilization.

PHYTOPHTHORA WARS: THE CONTRIBUTION OF RESEARCH IN THE FOREST DEPARTMENT OF WESTERN AUSTRALIA AND THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT TO THE FIGHT AGAINST *PHYTOPHTHORA* SPECIES IN NATIVE VEGETATION OF SOUTH-WESTERN AUSTRALIA OVER THE LAST TWO DECADES

B. L. Shearer

CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

Most of the significant advances in the understanding and management of *Phytophthora* species in native flora of south-western Australia has come from government funded research in the Forest Department of Western Australia and the Department of Conservation and Land Management. These include:

- Elucidation in the early 1980's of the population dynamics of *Phytophthora cinnamomi* in the soil, underpinned hygiene prescriptions.
- Development of sampling procedures allowed for accurate mapping of disease distribution from aerial photography and was the beginning of the current Vegetation Health Service.
- Manipulation of the *Eucalyptus marginata* forest understorey by fire to reduce disease development.

- Identification of the relationship between site characteristics and disease development.
- Identification of resistance in *Piinus radiata* and *E. marginata.*
- Elucidation of the host-pathogen interactions in *E. marginata* and the effects of water relations on the outcomes of the interaction.
- Quantification of the impact of *P. cinnamomi, P. citricola* and *P. megasperma* on native plant communities.
- Identification of the potential for phosphite to reduce infection and disease development in native communities and the development of application procedures to protect rare and endangered flora.

Future advances will depend on addressing the current minimum commitment of resources to *Phytophthora* research.

FRIDAY 5th OCTOBER

Session 1: **Impact of *Phytophthora* in Europe**
Chair Clive Brasier

PHYTOPHTHORA IN THE EUROPEAN OAK FOREST – RESULTS OF A EUROPEAN UNION RESEARCH PROJECT

C. Delatour[1], N. Anselmi[2], P. Barzanti[3], M-C. Bianco[4], H. Blaschke[5], C.M. Brasier[6], P. Capretti[3], M-L. Desprez-Loustau[7], E. Dreyer[8], E.M. Hansen[9], C. Heyne[5], T. Jung[5], N. Luisi[4], B. Marçais[1], R. Matyssek[5], M. Maurel[7], W. Oßwald[5], E. Paoletti[10], A. Ragazzi[3], C. Robin[7], A. Vannini[2] and A-M. Vettraino[2]

[1]Unité de Pathologie forestière, INRA, F-54280 Champenoux, France;
[2]Università della Tuscia, DIPROB, I-01100 Viterbo, Italy;
[3]Università di Firenze, I-50144 Firenze, Italy;
[4]Università degli Studi di Bari, Dipart. Patologia Vegetale, I-70125 Bari, Italy;
[5]Technischen Universität München, D-85354 Freising, Germany;
[6]Forestry Commission Research Agency, GU104LH, Alice Holt, UK;
[7]UMR Santé Végétale, INRA Bordeaux, F-33883 Villenave d'Ornon, France;
[8]UMR INRA-UHP Écologie-Écophysiologie Forestières, F-54280 Champenoux, France;
[9]Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR USA;
[10]CNR, I-50144 Firenze, Italy.

An approach to the studyof decline processes in oak was developed, integrating long term ecological dynamics and short term ecophysiological processes. Extensive forest surveys showed that many *Phytophthora* species, *P. quercina* (41% of 58 positive sites); *P. citricola* (38%); *P. cinnamomi* (17%); *P. gonapodyides* (16%); *P. cambivora* (16%); *P. europaea* (14%); *P. syringae* (14%); *P. megasperma* (10%); *P. cactorum* (7%); *P. psychrophylla* (2%); and *P. cryptogea* (2%) were detected in the soil of European oak forests . *Phytophthora* spp. were not detected at half the sites. These sites were usually located on the most acid soils where, nevertheless, decline could be severe. In soil infestation experiments on 2 year-old oak seedlings, root reduction by *P. cinnamomi* and *P. cambivora* was up to approximately 50-60% within 3-4 months; compared with *P. quercina* (up to 50%). Damage by other species was generally lower, but occasionally high. Dramatic impairment in water relations of seedlings only occured when roots were very severely reduced. In central Europe where decline is more prevalent, *P. quercina* could be involved in some atypical symptoms observed. In oak forest, Phytophthoras may act as an important selective pressure parameter. Specific conditions are required for a significant disease impact.

OCCURRENCE OF *PHYTOPHTHORA* SPECIES ON OAKS IN TURKEY

Yilmaz Balci

Institute of Forest Entomology, Forest Pathology and Forest Protection, Billrothstrasse 53/1/4, 1190 Wien-Austria

Sixty healthy and declined natural oak forests in Turkey have been screened for *Phytophthora* species. Eight *Phytophthora* species and one unidentified species were isolated from the rhizosphere soil using the bating method with young oak leaves. The morphology, physiology and RAPD banding patterns of the isolates were compared with other *Phytophthora* species previously isolated from Austrian oak stands. rDNA ITS sequences of some isolates were similar to *P. citricola*, however morphological characteristics were highly variable and differed from the holotype. Frequently isolated species *P. quercina* was common on slopes susceptible to drought. This species was isolated more frequently from the European part of Turkey, but occurred on some stands in the Asian part. *P. cinnamomi* was isolated only from one site in a open native oak dominated forest. In declining stands, necroses of fine roots was commonly detected. Significant differences in the isolation frequency of various *Phytophthora* species were observed between healthy and declining trees. No *Phytophthora* was isolated on sites with a mean soil pH ($CaCl_2$) ≤ 3.2. The possible role of *Phytophthora* species at oak decline will be discussed and the results are compared with the other studies in Europe.

EFFECT OF ENVIRONMENTAL CONSTRAINTS ON PHYTOPHTHORA-MEDIATED OAK DECLINE IN CENTRAL EUROPE

T. Jung[1], H. Blaschke[2] and W. Oßwald[2]

[1]Bavarian State Institute of Forestry (LWF), Section Forest Ecology and Protection, Am Hochanger 11, 85354 Freising, Germany;
[2]Institute of Forest Botany, Section Phytopathology, Technische Universität München, Am Hochanger 13, 85354 Freising, Germany.

Anthropogenic nitrogen input into forest soils and the increase of summer droughts are discussed as triggering factors of Phytophthora-mediated oak decline in Central Europe. Therefore, the effects of different nitrate concentrations in flooding water (0, 50 and 100 ppm) and different water regimes on root damage of young *Quercus robur* trees caused by *P. cinnamomi, P. quercina, P. cambivora, P. citricola* and *P. syringae* aff. were studied using soil infestation tests. In both experiments non-inoculated control plants showed almost no root damages, and *P. cinnamomi* and *P. quercina* were the most aggressive pathogens. In the drought stress experiment root condition of oak was significantly more influenced by *Phytophthora* infection than by drought stress alone. All *Phytophthora* species were able to survive and produce root damage under repeated drought stress, and the root damage caused by *P. cinnamomi* and *P. quercina* tended to be more severe when interacting with drought. In the nitrate experiment root growth of non-inoculated control plants was stimulated, and the difference in fine root length and number of root tips between non-inoculated control plants and oaks growing in infested soil was increasing with increasing nitrate concentrations. The potential importance of these results for the aetiology of the disease in the field is discussed.

RESULTS OF 10 YEARS OF INVESTIGATIONS ON INK DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* ON *QUERCUS RUBRA* AND *Q. ROBUR*: ETIOLOGY, BREEDING FOR RESISTANCE, AND HAZARD MAPPING.

Cécile Robin [1], Marie-Laure Desprez-Loustau [1], Benoit Marçais [2], Claude Delatour [2]

[1]UMR Santé Végétale, INRA Bordeaux, F-33883 Villenave d'Ornon, France,
[2] Unité de Pathologie forestière, INRA, F-54280 Champenoux, France

Phytophthora cinnamomi Rands is the causal agent of ink disease on *Quercus rubra* and *Q. robur*. Using controlled root inoculations, we showed that root infection in both species is low and the principal symptom of ink disease is cortical and bleeding cankers which develop on main roots, collar and then trunks. Our aim during the last ten years was to understand and predict the disease development oak trunks. Techniques of stem analysis and dendrochronolgy were adapted to study the spatial and temporal evolution of lesions in trunks of naturally infected trees. Intraspecific variablity of susceptibility was studied using a provenance and progeny tests of *Q. rubra* which was introduced in France at the beginning of the 19th century. Estimates of heritability of resistance were obtained. A model was developed in order to relate winter temperatures (sum of negative degree days) that are likely to be a limiting factor of disease development in trunks to the survival of the fungus at the cambium level. Disease hazard, related to the frequency of predicted survival over the last 30 years, was mapped for France. Present disease distribution in France only covers a part of high hazard zones.

Session 2:	**Biology of *Phytophthora***
Chair	Thomas Jung

MEASURING RESISTANCE IN JARRAH, *EUCALYPTUS MARGINATA*, TO *PHYTOPHTHORA CINNAMOMI*: WHAT FACTORS CHANGE DISEASE EXPRESSION?

D. Hüberli[1], I. C. Tommerup[2], I. Colquhoun[3] and G. E. St. J. Hardy[1]

[1]School of Biological Sciences and Biotechnology, Murdoch University, Murdoch 6150, Western Australia
[2]Forestry and Forest Products, CSIRO Perth, PO Box 5, Wembley 6913, Western Australia
[3]Alcoa World Alumina Australia, Environmental Department, PO Box 252, Applecross 6153, Western Australia.

The interaction between *Eucalyptus marginata* (jarrah), the dominant and important timber species in jarrah forests, and *Phytophthora cinnamomi*, is not a co-evolved one. Jarrah appears to have a wide range of variability in resistance to *P. cinnamomi* in the forest. Jarrah clonal lines resistant (RR) and susceptible (SS) to the pathogen have been produced [1].

Our glasshouse mortality trial showed that the capacity of 73 isolates to cause disease ranged from killing all plants (59 days) to plants being symptomless (182 days) [2]. Comparison of branch and root inoculations *in situ* confirmed that branches are a valid option for testing resistance of young jarrah [3]. No jarrah clonal line maintained its resistance level in a series of experiments using different inoculation methods, different environmental conditions and when challenged by individuals from a large range of *P. cinnamomi* isolates [2-4]. Even the most promising RR line had replicates that became diseased with time in various treatments.

To develop robust resistance, further screening work may be required using more isolates varying in their capacity to cause disease and a broader range of environmental conditions that favour the pathogen, particularly at 25-30°C [4]. Jarrah trees are affected by many environmental conditions during their life cycle (500-1000 years). Consequently, clonal lines that survive such rigorous screening may be durably resistant and survive in disease impacted sites.

References

1. McComb *et al.* (1990). *Combined Proceedings of the International Plant Propagators' Society* **40**, 86-90.
2. Hüberli *et al.* (2001). *Mycological Research*, in press.

3. Hüberli *et al. Plant Pathology*, in review.
4. Hüberli *et al.* (2002). *Australasian Plant Pathology*, in press.

VARIATION AMONG 29 SEEDLING FAMILIES OF *CHAMAECYPARIS LAWSONIANA* IN MORTALITY IN A SHORT-TERM TEST OF *PHYTOPHTHORA LATERALIS* RESISTANCE

R. A. Sniezko[1], E. M. Hansen[2,] and J.Hamlin[3]

[1]USDA Forest Service, Dorena Tree Improvement Center, 34963 Shoreview Road, Cottage Grove, Oregon 97424, U.S.A.;
[2]Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, Oregon 97331, U.S.A;
[3]USDA Forest Service, Umpqua National Forest, Roseburg, Oregon

In 1999, 29 seedling families of *Chamaecyparis lawsoniana* (15 controlled crossed, 14 wind-pollinated) were planted in raised beds containing *Phytophthora lateralis*. Twenty-one parent trees were represented among the seedlots, 11 of them represented more than once (in a maximum of six seedlots). Parent trees had been previously selected in 1989 and 1990 in natural stands with moderate to heavy *P. lateralis* infestation, and had been previously evaluated with a preliminary branch inoculation technique. Mortality was observed for 12 seedlings per family for eight months. Significant family differences exist among families, with family means ranging from 0 to 100% mortality (mean = 59%). Selections from within the top ranked families will be added to the breeding arboretum and will be ready for breeding within a few years. Large numbers of additional selections have recently been made in natural stands and will be used to increase the genetic diversity in the breeding population.

VARIATION EXHIBITED BY ISOLATES OF *PHYTOPHTHORA MEGASPERMA* CAUSING SEEDLING AND TREE DECLINE IN S-W AUSTRALIAN COASTAL NATIONAL PARKS

S.E. Bellgard[1], C.E. Crane[2] and B.L. Shearer[2]

[1]Katherine Research Station, Northern Territory Department of Primary Industry and Fisheries, PO Box 1346, Katherine, NT. 0851
[2]CALMScience, Department of Conservation and Land Management, 50 Hayman Road, Como, WA. 6152

Phytophthora megasperma is an active plant pathogen in National Parks directly to the north of Perth, and along the south coast in the Fitzgerald River National Park. Where active, *P. megasperma* has high impact on species contributing to habitat structure, e.g. *Banksia attenuata* in the northern sandplain and *B. speciosa* on the south coast. Eighty three isolates of *P. megasperma* retrieved from diseased native plants exhibiting foliar dieback symptoms were assessed for morphological and isozymic variation. Isozyme analysis of *P. megasperma* isolates from s-w Australia, three from South Australia, and six isolates from overseas representing the six putative taxa within the *P. megasperma* complex were undertaken. Genetic distances were determined according to Rogers (1), and unweighted pair groupings with arithmetic averaging (UPGMA) phenograms were constructed using the computer program BIOSYS-1 (2).

1. Rogers, J.S. (1972). Measures of genetic similarity. *Studies in Genetics* 7, 143-153. University of Texas Publication Number 7213.
2. Swofford, D.L. and Selander, R.K. (1981). A computer program for the analysis of allelic variation in genetics. *Journal of Heredity* 72, 281-283.

LONG TERM SURVIVAL OF *PHYTOPHTHORA CINNAMOMI* IN MATURE *BANKSIA GRANDIS* TREES IN REMNANT JARRAH FOREST

S. Collins[1], B. Shearer[2], J. McComb[1], I. Colquhoun[3], G. Hardy[1]

[1] Murdoch University, South St, Perth, 6150, Western Australia.
[2] Dept. of Conservation and Land Management, 50 Hayman Rd, Perth, 6152, Western Australia.
[3] Alcoa of Australia, GPO 252, Perth, 6153, Western Australia.

Effective management of *Phytophthora cinnamomi* requires knowledge of its ability to survive adverse conditions in soil and plant tissue. We have assessed the long-term survival of *P. cinnamomi* in *Banksia grandis* trees over 18 months in jarrah forest in the Southwest of Western Australia. Thirty-six *B. grandis* trees were killed by underbark inoculation with *P. cinnamomi* 10cm below ground level. To assess distribution and survival of the pathogen, 4 dead trees were harvested at the time of death and a further 4 at each of 12 and 18 months after death. A further 9 standing dead trees were sampled bi-monthly for 18 months by removing 1 cm diameter cores 10cm and 40cm above and below the soil line. *P. cinnamomi* colonisation of standing dead trees declined over time. The pathogen was isolated from 54% of sample cores 2 months after death, and only 2.4% after 12 months. In the early months after death, there was a higher percentage of recovery of the fungus from cores from above, rather than below ground tissue (eg. after 2 months 61.1% of samples above and 46.4% from below the soil line were colonised), while approximately 12 months later the values were 0.3% of colonised samples above and 4.3% from below the soil.

GENETIC VARIATION IN *PHYTOPHTHORA CINNAMOMI* ISOLATED FROM FRASER FIR IN WESTERN NORTH CAROLINA

J. Frampton[1], J.F. Li[1], M. Benson[2] and D. O'Malley[1]

Dept. of [1]Forestry and [2]Plant Pathology, North Carolina State University, Raleigh, N.C., USA

Fraser fir (*Abies fraseri* [Pursh] Poir.) Christmas tree production is an economically important industry to the mountainous western region of North Carolina generating over $US 100 million in annual sales. Root rot disease caused by *Phytophthora cinnamomi* Rands. limits or prevents Fraser fir production on many sites of this region. Genomic DNA was extracted from 34 single zoospore cultures of *P. cinnamomi* and 1 culture of *P. dreschsleri* Tucker isolated from Fraser fir Christmas trees from 5 different counties. DNA fingerprints of these isolates were developed by amplified fragment length polymorphism (AFLP) technique using five primer pair combinations (*EcoR* I-AC with *Mse* I-AG, -CG, -GG-, -CT and -CA). Genetic similarity estimates and cluster analyses were used to group individual *P. cinnamomi* isolates and sub-populations.

SEASONAL VITALITY OF *PHYTOPHTHORA CAMBIVORA* IN SOIL AND CHESTNUT TISSUES

A.M. Vettraino, M. Giubilei, A. Anselmi and A. Vannini

Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia, Via S. Camillo de Lellis, I-01100, Viterbo, Italy.

Phytophthora cambivora is the most frequent species causing Ink disease in Italy. The biological characteristic of this organism and the disequilibrium of mating types evidenced in the Italian population,

limit its ability to survive in adverse condition as resting structure, both in soil and host tissues. Experiences carried put over a 3 year period by sampling soil samples and host infected tissues monthly, found two peaks of vitality of *Phytophthora cambivora* during the year. The pathogen can easily be isolated from soil at soil temperature between 15 to 20 °C following abundant precipitation. Such conditions correspond at Italian latitudes with early spring and fall. Vitality in host tissues is independent to precipitation and is associated with presence of sap flow in the stem, average air temperatures generally close to 20 °C and relatively high values of vapour pressure deficit (VPD), corresponding in Italy to the late spring and early fall.

ASPECTS OF THE INTERACTION BETWEEN *XANTHORRHOEA AUSTRALIS* AND *PHYTOPHTHORA CINNAMOMI* IN VICTORIA, AUSTRALIA

R. Daniel[1], B. Wilson[2] and D. Cahill[1]

[1]School of Biological and Chemical Sciences, Deakin University, Pigdons Road, Waurn Ponds, Victoria, Australia 3217;
[2]School of Ecology and Environment, Deakin University, Pigdons Road, Waurn Ponds, Victoria, Australia 3217

Xanthorrhoea australis, a monocotyledon indigenous to Australia, forms an important component of the eucalypt woodland and heathland ecosystems of southern Victoria. The species is highly susceptible to infection by *Phytophthora cinnamomi*, a destructive soil-borne pathogen of many native Australian species. This project investigated the morphological and genetic variation within and between populations of *P. cinnamomi* in Victoria. A large number of isolates from the Anglesea heathlands were analysed using characteristics such as the morphology of sporangia and oogonia, pathogenicity and growth rates. Victorian isolates were also compared with isolates from Western Australia. Recently, the systemic fungicide potassium phosphonate (phosphite) has been used to control disease caused by *P. cinnamomi* in native ecosystems. The study also examined characteristics of the interaction between *X. australis* and *P. cinnamomi* and the effect of phosphite on the host defence response. Cell suspension cultures of *X. australis* were developed to investigate the mechanisms by which phosphite induces host resistance in the host-pathogen interaction. The effect of phosphite on the host response to pathogen attack was also examined using histological techniques and biochemical analyses. Defence responses were enhanced in tissues treated with phosphite, including elevated production of phenolic compounds, callose and lignin.

Session 3:	**Impact of *Phytophthora* in America**
Chair	Frank Tainter

SUSCEPTIBILITY OF URBAN OAK TREES TO FOUR SPECIES OF *PHYTOPHTHORA*

T. D. Spainhour[1], F. H. Tainter[2], A. K. Wood[1], S. N. Jeffers[3], and E. P. Van Arsdel[4]

[1]Department of Forest Resources, Clemson University, Clemson, SC 29634:
[2]436 Patterson Road, Central, SC 29630;
[3]Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634;
[4]P. O. Box 1870, Tijeras, NM 87059.

Four species of *Phytophthora* were recovered from soil or roots around declining urban oak trees in the states of South Carolina, Florida, Texas, USA and Colima, Mexico: *P. cinnamomi*, *P. citricola*, *P. citrophthora*, and *P. megasperma*. Relative pathogenicity of individual isolates was determined by inoculating stems of potted seedlings of 12 species of *Quercus*, measuring lesion lengths, and then calculating lesion expansion rates. After 40 days, it was apparent that oaks were differentially susceptible to *Phytophthora* spp. Lesion expansion rates varied among species of *Phytophthora* on any one oak species and among oak species inoculated with any one species of *Phytophthora*. The range of lesion expansion rates per day were: 0.5 mm on *Q. ellipsoidalis* to 11.0 mm on *Q. muehlenbergii* for *P. citrophthora*; 1.1 mm on *Q. phellos* to 9.8 mm on *Q. cerris* for *P. cinnamomi*; 0.1 mm on *Q. phellos* to 3.0 mm on *Q. prinus* for *P. citricola*; and 0.0 mm on *Q. cerris* to 1.1 mm on *Q. borealis* for *P. megasperma*, which was the least virulent species in these tests. These four species of *Phytophthora* have potential to attack a variety of oak trees in urban landscapes.

TRANSMISSION AND SURVIVAL OF SUDDEN OAK DEATH *PHYTOPHTHORA* SPECIES NOVUS

J. M. Davidson[1], D. M. Rizzo[1], M. Garbelotto[2], S. Tjosvold[3] and G. W. Slaughter[1]

[1]Department of Plant Pathology, One Shields Ave., University of California, Davis, CA 95616,
[2]Department of Environmental Science, Policy and Management, Ecosystem Science Division, 151 Hilgard Hall, University of California, Berkeley, CA 94720,
[3]University of California Cooperative Extension, 1432 Abbott Street, Salinas, CA 93901

The newly discovered *Phytophthora* canker disease of oak (Sudden Oak Death Syndrome) threatens millions of acres of California woodlands where coast live oak (*Quercus agrifolia*), tanoak (*Lithocarpus densiflorus*), or black oak (*Quercus kelloggii*) are dominant species. An important step in controlling this disease involves understanding how it is spread. The presence of diseased oaks at all elevations on hillsides and the above-ground nature of the disease suggest wind blown rain or rain splash as the most common mechanism for movement of spores. Although spores have yet to be found on infected oak tissue, other hosts may serve as ready sources of rain-dispersed inoculum. In the laboratory, abundant sporangia form on moistened leaves of infected bay (*Umbellularia californica*) and *Rhododendron* spp. within 24 - 48 hours. These sporangia are highly caducous and easily disperse in water. Chlamydospores were also observed on the surface of moistened bay leaves. Consistent with these results, the *Phytophthora* sp. nov. has been recovered from raintraps placed in a woodland next to infected coast live oak and bay trees. Soils samples taken from under these diseased trees also contain colony forming propagules. Experiments are in progress to determine the longevity of spores in both water and soil.

A NEW *PHYTOPHTHORA* INFECTS SEVERAL PLANT SPECIES AND CAUSES EXTENSIVE MORTALITY OF THREE TREE SPECIES IN COASTAL WOODLANDS IN CALIFORNIA

M. Garbelotto [1], D. M. Rizzo [2], J. M. Davidson [2], G. W. Slaughter [2] and S. T. Koike [3]

[1] Department of Environmental Science, Policy and Management, Ecosystem Science Division, 151 Hilgard Hall, University of California, Berkeley, CA 94720
[2] Department of Plant Pathology, One Shields Ave., University of California, Davis, CA 95616
[3] University of California Cooperative Extension, 1432 Abbott Street, Salinas, CA 93901

Since 1994, epidemic level mortality of *Lithocarpus densiflorus*, *Quercus agrifolia*, and *Q. kelloggii* has been reported in a 300 km long stretch within the coastal region of central California. A causal agent was unknown until June 2000, when we isolated a *Phytophthora* sp. from cankers on diseased trees. The morphology and the ITS DNA sequence of the isolated pathogen match a newly described species from ornamental rhododendrons in Europe. Cankers are usually initiated at the basal part of the tree, but do not enlarge below the soil line. On the other hand, the pathogen can be frequently isolated from aerial cankers up to 20 m from the soil line. The pathogenicity of the new *Phytophthora* was confirmed through inoculation experiments on seedlings, saplings, and mature trees of *Q. agrifolia* and *L. densiflorus*. In addition to *Quercus* and *Lithocarpus* spp., the pathogen has also been found infecting ornamental Rhododendron spp., native huckleberry (*Vaccinium ovatum*), California bay laurel (*Umbellularia californica*) and Pacific madrone (*Arbutus menziesii*). On these additional hosts, the pathogen appears to cause a foliar blight often leading to a twig and branch dieback. While these hosts may not necessarily succumb to the disease, they are an important source of inoculum.

PHYTOPHTHORA PALMIVORA, THE CAUSE OF RED FOOT OF BALSA TREES (*OCHROMA PYRAMIDALIS*) IN ECUADOR

F. H. Tainter[1], W. D. Kelly[2], and E. P. Van Arsdel[3]

[1]436 Patterson Road, Central, SC 29630;
[2]711 Knoll Circle, Auburn, AL 36830;
[3]P. O. Box 1870, Tijeras, NM 87059.

A lethal canker disease, known as red foot, limits balsa (*Ochroma pyramidalis*) production in Ecuador. Red foot first appears as a triangular-shaped sunken area at the base of the tree, which is barely visible. Later, the most striking symptom is exudation of bright red watery sap that runs down the stem and dries to produce a rusty powdery residue. Removal of the bark revealed a watery gray lesion in the phloem that quickly changed to dark red-brown. *Phytophthora palmivora* was isolated consistently from the margins of active cankers. Healthy balsa trees were inoculated artificially with an isolate of *P. palmivora* from balsa and cankers identical to those occurring on naturally infected balsa trees were produced within 90 days. *P. palmivora* was re-isolated from these cankers, thus fulfilling Koch's Postulates and identifying a new host for this pathogen. There was no apparent effect of site quality on canker initiation or subsequent development. The fungicide fosetyl-Al reduced the width of phloem lesions by about 50% but had no effect on lesion length.

RETHINKING PHYTOPHTHORA

E. M. Hansen

Department of Botany and Plant Pathology, Oregon State University, Corvallis Oregon 97331, USA

Investigations of *Phytophthora* species in forest and wildland settings by many people around the world raise challenging questions about our perceptions of this genus. Traditionally viewed by pathologists as dangerous pathogens, we increasingly are associating *Phytophthora* species with subtle diseases, and even with saprophytic behavior. Some species apparently play important roles in the fine root dynamics of a number of forest ecosystems. New tools are needed to better understand the behavior of these organisms in complex ecosystems. Reexamining *Phytophthora* from the perspectives of microbial ecology may be fruitful. At the same time we are gaining new appreciation for the devastating consequences of introduction of *Phytophthora* species to new ecosystems. We are approaching a period of taxonomic upheaval in *Phytophthora*, as the number of species increases, and the relationships between species and between related genera are clarified. New species concepts are needed. Morphology seems to be unreliable, host range unpredictable, and increasingly we see evidence that evolution is very active in our time. Hybridization seems to be important in the genus, and perhaps more frequent with new opportunities for mixing of species created by forest nurseries and international trade and travel.

POSTERS

Impact of *Phytophthora*
Chair Andrea Vannini and Jenny Davidson

PHYTOPHTHORA SPECIES INFECTING TYPICAL PLANTS OF THE MEDITERRANEAN REGION

Cacciola S. O.[1], Raudino F.[2], Cooke D. E. L.[3], Duncan J. M.[3], Magnano di San Lio G.[4]

[1] Istituto di Patologia Vegetale, Università degli Studi di Palermo, viale delle Scienze 2, I- 90128 Palermo, Italy
[2] Dipartimento di Scienze e Tecnologie Fitosanitarie, Università degli Studi di Catania, via Valdisavoia 5, I-95125 Catania, Italy
[3] Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA Scotland, UK
[4] Dipartimento di Agrochimica e Agrobiologia, Università degli Studi Mediterranea di Reggio Calabria, piazza S. Francesco di Sales 4, I-89061 Gallina (Reggio Calabria), Italy

Phytophthora species can be spread worldwide through nursery stocks or propagation material of cultivated plant species. In recent years, typical plants of the Mediterranean flora have been used increasingly for reforestation of natural reserves or coastal areas, for ornamental purposes in park and gardens and to form edges lining cultivated fields or motorways. A survey was made of nurseries in Italy to identify the species of *Phytophthora* causing root rot of pot-grown forestry and ornamental plants typical of the Mediterranean flora.
Phytophthora isolates were obtained from either roots or soil, using both selective culture media and plant baiting, and were identified on the basis of morphological and cultural features, the electrophoretic pattern of mycelial proteins (total proteins and isozymes), the polymorphism of DNA sequences amplified by RAPD-PCR as well as the PCR amplification of all or part of the internal transcribed spacers (ITS) of rDNA with restriction digests (ITS-RFLP) of the resultant products combined with limited DNA sequencing.

P. nicotianae Breda de Haan was the most frequently recovered species. It was isolated from many hosts, including hawthorn, laurel, *Cystus* spp., strawberry-tree, lavender, lentisk, myrtle, rosemary, and English ivy. Both mating types (A_1 and A_2) of this species were found. Other species, such as *P. cactorum* (Lebert & Cohn) Schröeter, *P. cryptogea* Pethybr. & Laff. (A_1 and A_2), *P. drechsleri* Tucker (A_1), *P. capsici* Leonian (A_1 and A_2), *P. palmivora* (E. Butler) E. Butler (A_1), *P. gonapodyides* (Petersen) Buisman and *P. citrophthora* (R. E. Sm & E. H. Sm.) Leonian were isolated less frequently. *P. cinnamomi* Rands (A_2), a polyphagous species, reported sporadically in Italy in last years and potentially very dangerous for ornamental and forestry plants, was isolated from potted myrtle, Port Orford cedar and chestnut plants. Most isolates recovered from chestnut were identified as *P. cambivora* (Petri) Buisman, a well-known pathogen of this tree species and widespread in forests and plantations of chestnut in Italy. A number of new or rare host-pathogen combinations were found, including *P. palmivora* on olive and *Pittosporum*, *Phytophthora* sp. "O-group" on *Prunus* and queen palm, *P. drechsleri* on rosemary, *P. capsici* on silverbush and *P. gonapodyides* on *Prunus*. The morphological features of the *P. capsici* isolate from silverbush were very similar to those of *P. tropicalis sensu* Aragaki and Uchida.

ALNUS CORDATA MORTALITY IN ITALY BY A NEW *PHYTOPHTHORA* SPECIES

G.P. Barzanti[2], P. Capretti[2], A. Santini1, A. Vannini[3], N. Anselmi[3], A.M. Vettraino[3].

1Institute for Forest Tree Pathology – C.N.R. Firenze, Italy.
[2]Dip. to Biotecnologie Agrarie Sez. Patologia Vegetale, Università degli Studi di Firenze, Italy
[3]Dip.to Protezione delle piante Università degli studi della Tuscia, Viterbo, Italy.

Alnus cordata Loisel. is largely utilized in central Italy for reforestation of badly drained and wet soils, and for agro-forestry purposes. Recently wilting and mortality of *A. cordata* individuals were observed in a nursery on 1-2 years old seedlings in Northern Tuscany (4) and in a 6 years old plantation in Umbria. Among the different woody species present the latter site (alder, cherry and walnut), only *A. cordata* trees showed symptoms resembling those of Ink disease. They were characterized by sparse yellowish-brown foliage with abnormally small leaves and dark stained necrosis of the bark at collar level (1). In the nursery death of tap root and lateral roots and dying of seedlings were also observed. Tissue isolation from infected parts of the plants yielded a *Phytophthora cambivora-like* species in culture. The morpho-physiological features of the alder isolates from the nursery resembled those of the Swedish variant of the Alder *Phytophthora* (2, 3). Two-year-old alder seedlings (1,3 cm diameter, height 70 cm) grown in pots were wound-inoculated in the trunk with a *Phytophthora* isolate from the nursery. Six weeks later symptoms identical to those described above were observed and from diseased bark tissue yielded fungal colonies resembling those described above.

1. Anselmi N., Vettraino AM., Natalini G. and Vannini A., 2001. Una nuova avversità per gli impianti industriali da legno: il marciume del pedale dell'ontano da *Phytophthora*. (A new disease in woody species plantations: root and collar rot of alder). Informatore fitopatologico 8, 65-67
2. Brasier C. M., J. Rose and J. N. Gibbs, 1995. An unusual *Phytophthora* associated with widespread alder mortality in Britain. Plant Pathology (1995) 44, 999 - 1007.
3. Brasier C. M., D. E. L. Cooke and J. M. Duncan, 1999. Origin of a new *Phytophthora* pathogen through interspecific hybridization. Proc. Natl. Acad. Sci. USA, 96: 5878 - 5883.
4. Santini A., Barzanti G.P. and Capretti P., 2001. A new Phytophthora root disease of Alder in Italy. Plant Disease 85, 560

PHYTOPHTHORA IN OREGON FORESTS

Wendy Sutton and E. M. Hansen

Department of Botany and Plant Pathology, Oregon State University, Corvallis Oregon 97331, USA

Ten or more species of *Phytophthora* are present in Oregon forests; only *P. lateralis* is associated with dramatic disease. Sampling of forest soils and streams, as well as "minor" diseases of several forest plants, continues to produce new reports. *P. cinnamomi* has been recovered for the first time from Oregon forest soils, not always associated with observed disease. *P. cambivora* causes a canker disease of *Castanopsis* in forests, and may be associated with a basal canker of Douglas-fir. *P. citricola* has been recovered from soil and symptomatic *Gaultheria* leaves. Other intriguing finds include *P. ilicis* "like", *P. fragariae* "like", and *Halophytophthora* "like" isolates from soil, without observed disease on surrounding vegetation. Several members of the *P. megasperma, P. gonapodyides* clade have been recovered. We monitored strong seasonal fluctuations in populations of *P. gonapodyides* in stream water. *Phytophthora* is widespread and locally abundant in Oregon forests. Most of its impacts remain unknown. While sampling to determine the full extent and diversity of *Phytophthora* in Oregon forests continues, attention is increasingly focused on behavior of these organisms in the ecosystems where they are found.

THE ROLE OF PHYTOPHTHORAS IN TREE YELLOWING AND DEATH IN TEXAS

E. P. Van Arsdel

USDA Forest Service, Plant Pathologist, P. O. Box 1870, Tijeras, NM 87059.

The major symptom of *Phytophthora* spp. infection was a generalized slight yellowing of leaves, persisting for months or years. Later the color change accelerated, the leaves become orange, and then turned brown and remained attached. Two to four weeks later the tree died. Since 1934, symptoms of foliage discoloration ("yellowing"), retarded growth, and premature death of post oak, live oak, winged elm, and hackberry have been reported in central Texas. These symptoms are distinctly different from those caused by the oak wilt (*Ceratocystis fagacearum*) and oak decline (*Cephalosporium*) fungi. Of the 34 trees sampled, 24 exhibited "yellowing" decline symptoms. All of the symptomatic trees yielded *Phytophthora* in fruit culture and 83% of these yielded *Phytophthora* upon culture on media. 30 percent of the symptomless trees yielded cultures of *Phytophthora*. *P. cinnamomi* was observed in many of the isolates. Symptomatic trees were prevalent in places with frequent standing water, or water flows across the roots where there was exposure to slightly saline or alkali well water. Gas leaks and cattle trampling also increased susceptibility. Soil injections in the root zone with ethazol and metalaxyl provided symptom remission (greener leaves). French drains to carry saline water past low sites also resulted in symptom remission. *Phytophthora* played an important role in tree "yellowing" and subsequent death in Texas. These symptoms could be minimized with control.

THE DISTRIBUTION AND IMPACT OF *PHYTOPHTHORA CINNAMOMI* IN ROYAL NATIONAL PARK, NEW SOUTH WALES.

Jillian Walsh[1], Keith McDougall[2], Rob Whelan[3] and Brett Summerell[4].

[1] Environmental Science Unit, University of Wollongong, Northfields Avenue, Wollongong, NSW, 2522
[2] NSW National Parks & Wildlife Service, PO Box 2115, Queanbeyan, NSW, 2620
[3] Institute for Conservation Biology, University of Wollongong, Northfields Avenue, Wollongong, NSW, 2522
[4] Royal Botanic Gardens, Mrs Macquarie's Road, Sydney, NSW, 2000

Phytophthora cinnamomi was recorded within Royal National Park (New South Wales) more than 30 years ago. However, the distribution of the pathogen within the Park and its impact on vegetation has yet to be established. It is known that *Telopea speciosissima* (the floral emblem of New South Wales) is susceptible to *P cinnamomi*, both in the glasshouse and in cultivation, yet knowledge of the susceptibility of this species in native vegetation is sparse. A range of populations of *T. speciosissima* and *Xanthorrhoea resinifera* (a species known to be in decline within the Park) were tested using *Phytophthora*-selective medium to assess disease presence. No *P. cinnamomi* was detected in any of the five *T. speciosissima* sites sampled but it was present within seven of nine *X. resinifera* sites. It is likely that *P. cinnamomi* is contributing to the decline of *X. resinifera* within the Park, but it is not yet possible to assess the potential susceptibility of *T. speciosissima* in the field, so we are using cuttings of this species in glasshouse susceptibility trials. Currently we are examining whether soils in the Park are conducive to the spread of *P. cinnamomi*, by measuring sporangial production from soil leachate and chemical composition of soils.

NEW ALARM OF *PHYTOPHTHORA* ROOT ROT OF WALNUT IN ITALY

A.M. Vettraino[1], S. Belisario[2], E. Monteleone[2] and A. Vannini[1]

[1]Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia, Via S. Camillo de Lellis, I-01100, Viterbo, Italy;
[2]Istituto Sperimentale per la Patologia Vegetale, Via C.G. Bertero 22 I, I-00156, Roma, Italy.

Root rot caused by *Phytophthora* spp. has been recently recorded in several plantation of *Juglans regia* in Northern and Central Italy. Isolation trials from soil and infected roots confirmed the presence of *Phytophthora* spp. in the collected samples. Symptoms of the disease are very similar to those of Ink disease of chestnut. Morphological and molecular identification evidenced the presence of 5 species. Among them, *P. cinnamomi*, whose presence in Italy has been probably confused with *P. cambivora* in the past; *P. cambivora, P. cactorum, P. citricola*, and *P. cryptogea*. This is the first record of the latter 2 species on walnut in Italy. Pathogenicity tests carried out on 2 years seedlings through soil infestation, confirmed *P. cinnamomi* as the most aggressive species on *J. regia*.

INK DISEASE DISTRIBUTION ON SWEET CHESTNUT IN FRANCE AND ITALY AND *PHYTOPHTHORA* SPECIES ASSOCIATED

A.M. Vettraino[1], O. Morel[2], C. Robin[2] and A. Vannini[1]

[1] Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia, Via S. Camillo de Lellis, I-01100, Viterbo, Italy;
[2] INRA de Bordeaux, UMR Santé végétale, B.P.81, F-33883 Villenave d'Ornon, France.

Ink disease of sweet chestnut (*Castanea sativa*) represents a serious threat to the survival of chestnut groves in several European countries, including France and Italy. In these two countries, the disease is present throughout the range of the host in different stands types, including orchards, coppices and naturalised forests. Recent surveys carried out in representative chestnut areas in France and Italy confirmed a widespread presence of the disease with few exceptions. *Phytophthora cinnamomi* and *Phytophthora cambivora* were the species most frequently isolated from soils in infested groves in France and in Italy respectively. These two species are also considered the most aggressive to chestnut. However, other *Phytophthora* species have been identified from soil in chestnut stands. *P. citricola* and *P. cactorum* were occasionally recovered in France and Italy but their presence is not constantly associated with symptomatic trees. More species have been identified, among which *P. gonapodyides* (mainly associated with seasonal streams crossing chestnut groves) and *P. syringae*. Of particular interest is the detection of *P. cryptogea* previously reported as associated with severe wilting of chestnuts in South Australia.

VARIABILITY IN RESISTANCE TO *PHYTOPHTHORA CAMBIVORA* OF *CASTANEA SATIVA* WILD POPULATION AND SELECTED CULTIVARS IN ITALY AND SPAIN

A.M. Vettraino[1], A. Scalise[2], S. Cherubini[1] and A. Vannini[1]

[1]Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia, Via S. Camillo de Lellis, I-01100, Viterbo, Italy;
[2]A.R.S.S.A. – Ce.D.A. 12 – S.S. 106, I-88050, Cropani (CZ), Italy.

The behaviour of 4 wild population of *Castanea sativa* from Sicily (Southern Italy), Pedmont (Northern Italy), A Coruña (Northern Spain), Málaga (Southern Spain) to *Phytophthora cambivora* was tested on 4 month old half-sib progenies through soil infestation. A number of qualitative and quantitative parameters were assessed at the beginning, during and after the experiment, including growth in height, number of

leaves, dry weight, length of the stem and root necroses, crow condition and mortality. Results showed a wide variability in the response to the pathogen challenge. Some progenies showed a resistance to *Phytophthora cambivora* similar to that of the resistant hybrid Marsol used as control. An additional experiment was carried out through stem inoculation on 87 cultivars of *Castanea* spp., including French hybrids. In this case, a relatively wide variability in susceptibility was assessed among the Italian cultivars, some of which showed comparable behaviour with the French hybrids.

RARE FLORA THREATENED BY *PHYTOPHTHORA CINNAMOMI* IN THE ALBANY AREA, WESTERN AUSTRALIA

Sarah Barrett

Department of Conservation and Land Management, Albany

The plant pathogen *Phytophthora cinnamomi* is the key threatening process for 20 out of 70 threatened plant taxa in the Albany District with some or all populations of these species currently infested by the pathogen. Many of these species are naturally rare with with highly localised distributions and small population sizes which is a feature of many south-western plants.Ten of these taxa are currently ranked 'critically endangered' using IUCN conservation categories, that is these are species facing an extremely high probability of extinction in the immediate future. Several poorly known 'Priority' taxa may also be threatened by *P. cinnamomi* but cannot be categorised as 'threatened' until adequate survey is carried out. Plant taxa threatened by *P. cinnamomi* are managed through the implementation of recovery plans and management programs for threatened flora. Recovery actions include regular monitoring, management of access to threatened flora populations, phosphite application and monitoring, seed collection or collection of other material for propagation by CALM's Threatened Flora Seed Centre , plant propagation by seed or cuttings to re-establish populations of threatened flora in the wild, research into the biology and ecology of threatened taxa, further survey to locate new populations, fire management and community education.

DISTRIBUTION OF *PHYTOPHTHORA* SPECIES IN FOREST SOILS OF UPSTATE SOUTH CAROLINA, USA

A.K. Wood[1], F.H. Tainter[2], S.N. Jeffers[3], and E.P. Van Arsdel[4]

[1]Department of Forest Resources, Clemson University, Clemson, SC 29634;
[2]436 Patterson Road, Central, SC 29630;
[3]Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634;
[4]P.O. Box 1870, Tijeras, NM 87059.

The Jocassee Gorges tract in northwest South Carolina, USA recently has been designated by state and federal agencies as a major conservation and land preservation site. The tract contains an abundance of native plants that are largely unique to the area. Species of *Phytophthora* pose a threat to natural areas because, if present or introduced, they may attack and devastate susceptible plant species. A baiting bioassay (with camellia disks, shore juniper and hemlock needles as baits) was used to assay fresh and air-dried composite soil samples for *Phytopthora* species. *P. heveae* only was detected with hemlock needles whereas *P. cinnamomi* was detected primarily with camellia leaf disks and shore juniper needles. *P. heveae* and *P. cinnamomi* were recovered from 23% and 41%, respectively, of the samples collected. These species of *Phytophthora* are a potential threat to plant biodiversity in this region.

THE SUSCEPTIBILITY OF NANCE, *BYRSONIMA CRASSIFOLIA*, TO *PHYTOPHTHORA CINNAMOMI*

A.K. Wood[1], F.H. Tainter[2], S.N. Jeffers[3], and E.P. Van Arsdel[4]

[1]Department of Forest Resources, Clemson University, Clemson, SC 29634;
[2]436 Patterson Road, Central, SC 29630;
[3]Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634;
[4]P.O. Box 1870, Tijeras, NM 87059.

Prior to 1987, the root pathogen *Phytophthora cinnamomi* Rands was introduced accidentally into a pristine oak forest in the state of Colima, Mexico. Within the affected area most of the oaks were killed. Nance, (*Byrsonima crassifolia* (L.) HBK.), is an understory shrub that disappeared soon after the oak mortality began. To determine susceptibility of *B. crassifolia* to *P. cinnamomi*, 84 Nance seedlings were inoculated at the root collar or lower stem with mycelium from one of two isolates of *P. cinnamomi* (MX-12 from Colima, Mexico or AF-027 from South Carolina). After three months, lesions formed on 100% of the inoculated seedlings; there was no difference in lesion length between isolates. Mean lesion lengths above and below the inoculation point were 95 and 78 mm, respectively; *P. cinnamomi* was reisolated from 43.5% of the lesions. It appears that *B. crassifolia* is susceptible to *P. cinnamomi*, which may explain the disappearance of this understory plant during the early part of the oak mortality epidemic.

INTERACTION OF SUDDEN OAK DEATH PHYTOPHTHORA WITH ASSOCIATED ORGANISMS

Pavel Švihra

University of California Cooperative Extension, Davis

Sudden Oak Death is a new disease that has killed large numbers of oaks (*Quercus agrifolia, Quercus kelloggii, Quercus parvula var. shrevei*) and tanoaks (*Lithocarpus densiflorus*) in some of central California's coastal counties. The name Sudden Oak Death is used because of the rapid color change of leaves from green to brown. In June 2000 an unknown species of *Phytophthora* sp. was discovered as the underlying cause of Sudden Oak Death, which was later identified as a new species, *Phytophthora ramorum*. A tree may be infected with *P. ramorum* for a number of months or years before exhibiting this sudden change in foliage. After the infection begins, attacks by oak bark beetles, *Pseudopityophthorus pubipennis*, and oak ambrosia beetles, *Monarthrum scutellare*, and the growth of *Hypoxylon thouarsianum* also occur, which might contribute to the hastening of the tree's death.

OCCURRENCE, DISTRIBUTION AND SEVERITY OF FOOT ROT FUNGUS (*PHYTOPHTHORA PARASITICA)* IN THE FOREST AND HIGHLAND AGRO-ECOLOGICAL ZONES IN EASTERN AND WESTERN UGANDA

S. Namukyawa [1], P. Ensywa [1] and S.Namada[2]

[1] Madivani group of companies, Kampala, Uganda
[2] Makerere University, Kampala, Uganda

A survey of foot rot fungus on citrus trees was carried out for three consecutive seasons of 2000 (A,B) and 2001(A) in Kakira forest agro-ecological zones and Kabale highlands in eastern and western Uganda

respectively. The results revealed the presence of the disease in all the surveyed locations. The incidence and severity of the disease significantly varied from one climatic zone to another and among the citrus agroecosystems. The highest incidence was recorded in Kabale highlands in western Uganda. However, the disease was less uniformly distributed and intense in the Jinja rainfed forest

Use of molecular tools
Chair Richard Sniezko and Don Goheen

TOWARDS MULTIPLEX PCR DETECTION OF *PHYTOPHTHORA CINNAMOMI* AND *P. CALMBIVORA* FROM FRENCH CHESTNUT GROVE SOILS

O. Morel, C. Robin and S. R. H. Langrell

Laboratoire de Pathologie Forestière, UMR Santé Végétale, Institut National de la Recherche Agronomique, Centre de Recherches de Bordeaux, BP 81, 33883 Villenave d'Ornon Cedex, FRANCE

Soilborne *Phytophthora cinnamomi* and *P. calmbivora* are the most pathogenic species associated with chestnut (*Castanea sativa*) decline in Europe. Mapping their incidence and distribution from French nursery and plantation soils may offer valuable information for limiting spread, especially by commercial routes. As conventional biological baiting and taxonomic confirmation is often unreliable and slow, we have focused on the development of a multiplex PCR approach for the simultaneous detection of both species direct from soil. Pre-existing and novel primers, based on ITS sequences, have been evaluated for their specificity and use in a multiplex capacity in various combinations. Coupled to this we have modified a mechanical lysis procedure (1) for DNA extraction from up to 10 g of naturally or artifically infected chestnut grove/nursery soils. Yields ranged from 6-8 g DNA g^{-1} fresh soil. Using serial dilutions and/or polyvinylpolypyrrolidone chromatography purification to deter PCR inhibitiors, both species have been successfully detected, individually or together, in artificially seeded and naturally infected soils. Levels of detection are comparable to other *Phytophthora* species where PCR based diagnostic systems have been reported. A qualitative evaluation of this approach against conventional baiting will be presented.

1. Cullen & Hirsch (1998). *Soil Biol. Biochem.* 30: 983-993.

HISTOLOGICAL ANALYSIS OF THE EFFECT OF PHOSPHONATE ON THE INTERACTION BETWEEN *PHYTOPHTHORA CINNAMOMI* AND *XANTHORRHOEA AUSTRALIS*

R. Daniel[1], B. Wilson[2] and D. Cahill[1]

[1]School of Biological and Chemical Sciences, Deakin University, Pigdons Road, Waurn Ponds, Victoria, Australia 3217;
[2]School of Ecology and Environment, Deakin University, Pigdons Road, Waurn Ponds, Victoria, Australia 3217

Plants respond to pathogen attack by producing chemical and physical barriers. Where the plant's defence response is sufficient, invasion by the pathogen is successfully prevented and a resistant reaction occurs. Susceptible plants are unable to mount a defence response of sufficient speed or magnitude to overcome the pathogen. The systemic fungicide, potassium phosphonate (phosphite), successfully controls disease caused by Oomycetes. It is believed to have two modes of action: at higher concentrations phosphite directly inhibits pathogen growth, while at lower concentrations it acts indirectly to alter pathogen metabolism and stimulates cellular defence mechanisms. *Xanthorrhoea australis*, an important component of the native vegetation communities of southern Victoria, is highly

susceptible to *Phytophthora cinnamomi*. The mechanisms by which phosphite induces host resistance in the interaction between *X. australis* and *P. cinnamomi* were investigated using light and transmission electron microscopy. Defence responses including lignin, callose and phenolic production were found to be enhanced in tissues treated with phosphonate. Cells in untreated tissues displayed greater disruption of tissue structure, nuclear degeneration and shrinkage of the cytoplasm and cell membrane upon inoculation compared with phosphite treated seedlings. Thickening of the cell wall, particularly in vascular tissues, was also observed following phosphite treatment.

OCCURENCE OF THE ALDER (*ALNUS GLUTINOSA* L.) DECLINE IN SWEDEN AND AFFINITIES OF THE CAUSAL *PHYTOPHTHORA* PATHOGEN AS ASSESSED BY ISOZYME ANALYSIS

Christer H. B. Olsson

Plant Pathology and Biocontrol Unit, SLU, P.O. Box 7035, SE-750 07 Uppsala, Sweden. C/O Botaniska Analysgruppen, Box 461, SE-405 30 Göteborg, Sweden.

In 1996, a *Phytophthora* sp. was isolated from bark lesions on the stem bases of diseased alder trees on the banks of the river Säveån in Gothenburg. The isolated fungus was pathogenic to alder seedlings in pot tests and in its morphology and cultural characteristics, it resembled the alder *Phytophthora* originally isolated from the UK. Although clearly similar to *P. cambivora*, the Swedish alder isolates could be distinguished from this species on the basis of their homothallism, disrupted gametogenesis, growing with only small amounts of aerial mycelium on agar, and a lower maximum growth temperature than *P. cambivora*. In isozyme studies, all but one of six Swedish isolates formed a distinct group with similarities to *P. cambivora* and *P. fragariae* var. *fragariae*. The exception was closely related to a British alder isolate, and both these isolates were attacking alder trees in a more aggressive way. This more aggressive Swedish alder *Phytophthora* was isolated from a dying alder on the shore of the lake Stensjön, Mölndal, not associated with the water of Säveån.

1. Brasier CM, Rose J and Gibbs JN, 1995. An unusual *Phytophthora* associated with Widespread alder mortality in Britain. *Plant Pathology* 44, 999-1007.
2. Olsson CHB, 1999. Occurence of the alder (*Alnus glutinosa* L.) decline in Sweden and affinities of the causal Phytophthora pathogen as assessed by isozyme analysis. In : Agraria 161, Acta Universitatis Agriculturae Sueciae, Diagnosis of root-infecting *Phytophthora* spp.

Use of phosphite to control
Chair Richard Sniezko and Don Goheen

THE DILUTION OF PHOSPHITE IN RAPIDLY GROWING PLANTS AND HOW SOIL AND PLANT PHOSPHATE LEVELS INTERACT WITH PHOSPHITE AND ITS ABILITY TO INDUCE HOST-RESISTANT RESPONSES WHEN CHALLENGED BY *PHYTOPHTHORA CINNAMOMI*.

C . Auckland[1], B .L . Shearer[1,2] and G .E .St .J . Hardy[1]

[1]Biology and Biotechnology, Murdoch University, Murdoch 6150 Western Australia,
[2]CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia..

The soil borne plant pathogen *Phytophthora cinnamomi* has irreversibly altered the make-up and diversity of the plant communities found in Australia. Recently, the fungicide phosphite has been used to effectively reduce the impact of this pathogen in natural plant communities. However, little is known (a) about how rapidly phosphite is diluted in the tissues of rapidly growing plants and (b) how soil and plant phosphate levels interact with phosphite and its ability to induce host-resistant responses when challenged by *P.cinnamomi.* This study examines the effects of phosphite dilution in different size classes of *Banksia grandis* and *B. hookeriana.* It also examines the effects of different soil phosphate levels on *in planta* phosphite and phosphate status in *B.hookeriana,* and its subsequent control of *P.cinnamomi,* and in the glasshouse and *Eucalyptus marginata* forest of Western Australia.

PHOSPHITE REDUCES THE RATE OF SPREAD OF *PHYTOPHTHORA CINNAMONI* IN *BANKSIA* WOODLAND, EVEN AFTER FIRE

B. L. Shearer, C. E. Crane and R. G. Fairman

CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

Within the Department of Conservation and Land Management, phosphite application is an important and effective management tool for the protection of native plant species from infection and death by *Phytophthora cinnamomi.* In 1993, as part of ongoing testing of application strategies, a trial was commenced to test the effect of application of phosphite as a spray of understorey and injection of overstorey species, on the rate of spread of *Phytophthora cinnamomi* along a disease front in *Banksia* woodland. There were 5 treatments: no phosphite, with all the 4 remaining treatments having the overstorey injected with 50 g phosphite/l and the understorey sprayed either once or twice with 2 or 5 g phosphite/l with a backpack sprayer. The treatments were applied in 10 x 15 metre plots along an active disease front in a randomised block design with four replicates. The plots were positioned in healthy vegetation with one edge of the long axis aligned along the disease front. Six months after phosphite application, movement of the disease front was greater in non treated plots than in sprayed and injected plots. The *Banksia* woodland was burnt a year after phosphite application. By 3 years after burning the understorey vegetation had re-established and a disease front was evident. When the disease front was replotted 3 and 4 years after burning and 4 and 5 years after phosphite application, disease extension was least in phosphite treated plots and greatest in the non treated plots. There appears to be some residual effect of phosphite application after fire.

WILL *PHYTOPHTHORA CINNAMOMI* BECOME RESISTANT TO PHOSPHITE WITH ITS INCREASING USE?

M. P. Dobrowolski[1], G. E. St. J. Hardy[1], I. C. Tommerup[2], B. L. Shearer[3], I. Colquhoun[4] and P. A. O'Brien[1]

[1]School of Biological Sciences and Biotechnology, Murdoch University, Murdoch 6150, Western Australia;
[2]Forestry and Forest Products, CSIRO Perth, PO Box 5, Wembley 6913, Western Australia;
[3]Science and Information Division, Department of Conservation and Land Management, Como 6152, Western Australia;
[4]Alcoa World Alumina Australia, Environmental Department, PO Box 252, Applecross 6153, Western Australia.

Phosphite is increasingly being used as a means of control for dieback caused by *Phytophthora cinnamomi*. We wish to study the likelihood of *P. cinnamomi* evolving resistance to phosphite, given the clonal populations of the fungus present in Western Australia. We have collected isolates of *P. cinnamomi* from areas where phosphite has been used intensively for up to 15 years (avocado orchards) as well as areas of less frequent use and no use of phosphite. Our testing involved stem inoculating a clonally propagated host (*Leucadendron* sp.) that was treated with one of three levels of phosphite (0%, 0.25% and 0.5%). We measured the extent of colonisation by each *P. cinnamomi* isolate after eight days of incubation in a controlled temperature plant growth cabinet. Preliminary results suggest that less aggressive isolates are not present in populations obtained from areas where phosphite has been used. Also, the few isolates that colonise the phosphite treated host to a large extent, all come from areas of phosphite use. Research is continuing to replicate these results and investigate their significance to the control of *P. cinnamomi* using phosphite.

FOLIAR APPLICATION OF PHOSPHITE DELAYS AND REDUCES THE RATE OF MORTALITY OF THREE *BANKSIA* SPECIES IN COMMUNITIES INFESTED WITH *PHYTOPHTHORA CINNAMONI* IN

B. L. Shearer, and R. G. Fairman

Science Division, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

Our aim in this study was to determine the efficacy of foliar application of phosphite in controlling mortality of three *Banksia* species in *P. cinnamomi* disease centres. Plots, 5 x 5 m, along *P. cinnamomi* disease fronts in *Banksia brownii* Baxter ex R. Brown, *B. baxteri* R. Brown and *B. coccinea* R. Brown communities were sprayed with 2.5, 5 and 10 g L^{-1} phosphite and surfactant (0.2% Pulse) using a backpack sprayer. Controls were only sprayed with surfactant. Treatments were replicated four times in a randomised block design. Mortality was monitored in the plots for 4 year in *B. brownii*, by which time the controls reached extinction, and 6 year in *B. baxteri* and *B. coccinea* . For both delay and rate of mortality, differences between phosphite concentration and *Banksia* species were highly significantly ($P \leq 0.01$), but the interaction of phosphite and *Banksia* species was not significant. The non-significant interaction suggest a similar action of phosphite occurred in all three communities. In the sprayed plots, 10 g L^{-1} phosphite reduced mortality the greatest, 2.5 g L^{-1} the least with, 5 g L^{-1} being intermediate between the two. One application of phosphite reduced mortality for up to 2.5 year, after which the plots were resprayed. Unacceptable phytotoxic reactions, such as growth retardation and leaf burning, occurred at concentrations $\geq$ 10 g L^{-1}.

PHOSPHITE INHIBITS LESION DEVELOPMENT OF *PHYTOPHTHORA CINNAMOMI* FOR AT LEAST FOUR YEARS FOLLOWING TRUNK INJECTION OF *BANKSIA* SPECIES AND *EUCALYPTUS MARGINATA*

B. L. Shearer, and R. G. Fairman

Science Division, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

We sought to determine the duration of effectiveness of phosphite in limiting lesion development of *P. cinnamomi,* following trunk injection of *Banksia* species and *Eucalyptus marginata* Donn ex Smith. Sufficient numbers of *B. grandis* and *E. marginata* were trunk injected with 50, 100 and 200 g L^{-1} phosphite in 1988 to give estimates of the duration of effectiveness of phosphite over time. For each species, groups of 10 trees were inoculated with *P. cinnamomi* in mid-summer approximately every two years, with a different group being inoculated each time. Control trees nearby were not injected with phosphite. Lesion size was determined 6-weeks after inoculation. At each inoculation time, more groups of ten trees were injected with phosphite to give a range of periods after injection. Along two disease fronts, trees of *B. attenuata* R. Brown close to one another and of similar size were paired and one tree at random injected with 100 g L^{-1} phosphite at the rate of 1 ml/cm trunk circumference and the other tree not treated. There was 41 pairs of trees at one site and 13 at the other. Mortality was monitored during a 8-year-period. Increase in *P. cinnamomi* lesion length with time after injection was greatest for trees injected with 50 g L^{-1} phosphite, least for those injected with 200 g L^{-1} and intermediate for trees injected with 100 g L^{-1} phosphite. All three concentrations of phosphite effectively controlled lesion extension for at least 4 years after injection. Trends in tangential spread of lesions were similar to those described for linear extension. Injection of 200 g L^{-1} phosphite caused tissue necrosis at the site of injection and inhibited canopy growth. Mortality of trees injected with 100 g L^{-1} phosphite was significantly less than trees receiving no phosphite in both disease fronts. One injection protected trees for at least 4 years, after which mortality of injected trees increased. This period of effectiveness was similar to that obtained from controlled inoculation.The results suggest that the period of effectiveness of phosphite against *P. cinnamomi* in the low phosphate environment of native communities in south-western Australia is considerably greater than that found in the high phosphate, frequently harvested horticultural situation.

Pathogenicity
Chair Wendy Sutton and Jen McComb

PATHOGENICITY OF *PHYTOPHTHORA* SPECIES ON *QUERCUS* SEEDLINGS

M. C. Bianco, D. Di Brisco, N. Luisi and P. Lerario

Dipartimento di Biologia e Patologia vegetale, Università degli Studi di Bari, Via G. Amendola 165/A, 70126 Bari, Italy

Phytophthora species are soilborne pathogens often associated with several declining oak woods in Europe and Mediterranean regions as well as in most temperate forests of North and South America and in few tropical forests.

Some *Phytophthora* species isolated in Italian oak woods were tested for pathogenicity, by inoculation, at the collar, on seedlings of *Q. ilex, Q. frainetto, Q. pubescens, Q. cerris* and *Q. robur*. The following ten isolates were used: 1 of *P. cactorum*, 1 of *P. cambivora*, 2 of *P. cinnamomi*, 1 of *P. citricola*, 1 of *P. gonapodyides*, 3 of *P. quercina* and 1 of *Phytophthora* sp.

The evaluation of infection, based on the stem darkening length and on *Phytophthora* reisolation, occurred 3 months after inoculation.

The tests indicated that the inoculated *Phytophthora* species are differently aggressive towards the five oak species. In fact, *P. cambivora* and *P. cinnamomi* were the most pathogenic, *P. citricola* and *P. gonapodyides* moderately pathogenic and *P. quercina* generally not pathogenic. In addition, the investigated oak species showed a different susceptibility to *Phytophthora* spp.: *Q. ilex* was the most susceptible, followed by *Q. robur*, while the other 3 oak species did not evidence considerable differences among themselves.

Management of *Phytophthora*
Chair Richard Sniezko and Don Goheen

THE USE OF MULCHES AS A METHOD OF CONTROLLING *PHYTOPHTHORA CINNAMOMI* IN AVOCADOS

S. Fraser[1], R. Hill[2], R. Farrell[1], R. Janson[1], J. Croskery[3]

[1]University of Waikato, Private Bag 3105 Hamilton, NZ;
[2]HortResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, NZ
[3]NZ Organic Avocado Growers Group, 405 Kauri Point Road, RD1 Katikati, NZ

Phytophthora cinnamomi is a major pathogen of avocado trees grown commercially in New Zealand. It attacks the feeder roots that lie near the surface in the topsoil and litter layers. Soil microorganisms may have an important role in controlling *P. cinnamomi* (1). The application in avocado orchards of different mulches and composted materials has been reported to be disease suppressive by contributing to a proliferation and presence of controlling microorganisms with appropriate biological activity, although the mechanisms by which this occurs are not well understood. A study is being conducted into the effects of various organic mulches on the incidence of Phytophthora root rot on six-year-old plantings of Hass avocados in an orchard under certified organic management in the Bay of Plenty, New Zealand. Four different mulches have been applied and compared to a control without mulch on a total of 91 trees. Changes to various parameters of tree health are being monitored. In addition to assessing tree responses, an understanding of possible mechanisms of disease suppression is being sought with using molecular and biochemical methods as well as traditional culturing techniques.

1. You M.P. and Sivasithamparam K. 1994. Hydrolysis of FDA in an Avocado Plantation Suppressive to *P. cinnamomi* and its Relationship with Certain Biotic and Abiotic Factors. Soil Biology and Biochemistry 26:10, 1355-1361

BIOLOGICAL CONTROL OF *PHYTOPHTHORA CINNAMOMI*: THE POTENTIAL OF FIVE WESTERN AUSTRALIAN NATIVE *ACACIA* SPECIES TO PROTECT *BANKSIA GRANDIS*.

N. K. D'Souza[1,2], I. J. Colquhoun[3], B. L. Shearer[1,2] and G. E. St. J. Hardy[1]

[1]Biology and Biotechnology, Murdoch University, Murdoch 6150 Western Australia,
[2]CALMScience Division, Department of Conservation and Land Management, Locked Bag 104 Bentley Delivery Centre, Bentley 6983 Western Australia,
[3]Alcoa World Alumina Australia, Environmental Department, PO Box 252, Applecross 6153, Western Australia.

Mortality of *Eucalyptus marginata* seedlings following infection by *Phytophthora cinnamomi* was lower when planted with *Acacia pulchella* than when planted with *Banksia grandis* (1). The protective effects of native legumes other than *A. pulchella* against *P. cinnamomi* have not been determined. Field and glasshouse inoculation trials were set up to investigate the protective potential of five Western Australian native *Acacia* species for *B. grandis*. In the field only *A. pulchella* protected *B. grandis* against *P. cinnamomi* infection. Mortality of *B. grandis* planted with *A. pulchella* was as low as uninoculated *B. grandis* planted alone. Mortality of *B. grandis* planted with *A. urophylla*, *A. extensa*, *A. latericola* or *A. drummondii* was high and similar to inoculated *B. grandis* planted alone. In the glasshouse none of the *Acacia* species definitively protected *B. grandis*. Mean mortality due to infection by *P. cinnamomi* of *B. grandis* planted with *A. pulchella* or *A. latericola* was less than the control. However the remaining *B. grandis* seedlings died following infection by an unidentified fungus, hence protection could not be concluded.

1. Malajczuk, N. (1979). Biological suppression of *Phytophthora cinnamomi* in eucalypts and avocado in Australia. In Soil Borne Plant Pathogens. (eds.) B. Schippers and W. Grams. Academic Press Sydney, pg 635-652.

BIOLOGICAL CONTROL OF *PHYTOPHTHORA CINNAMOMI*: THE POTENTIAL OF WESTERN AUSTRALIAN NATIVE LEGUME SPECIES TO REDUCE INOCULUM LEVELS IN SOIL.

N. K. D'Souza[1,2], I. J. Colquhoun[3], B. L. Shearer[1,2] and G. E. St. J. Hardy[1]

[1]Biology and Biotechnology, Murdoch University, Murdoch 6150 Western Australia,
[2]CALMScience Division, Department of Conservation and Land Management, Locked Bag 104 Bentley Delivery Centre, Bentley 6983 Western Australia,
[3]Alcoa World Alumina Australia, Environmental Department, PO Box 252, Applecross 6153, Western Australia.

Sporulation by *Phytophthora cinnamomi* is significantly suppressed in forest sites dominated by *Acacia pulchella* compared to forest sites dominated by species of Proteaceae (1). In this investigation an inoculation trial was conducted to determine the effect of 14 other Western Australian native legumes on population levels of *P. cinnamomi* in the soil compared to *Banksia grandis*. Direct plating of soil onto *Phytophthora* selective agar was used to quantify inoculum levels. *A. alata, A. extensa A. latericola, A. pulchella, A. stenoptera, Kennedia coccinea* and *K. prostrata* showed low mortality and decreased inoculum of *P. cinnamomi* in soil compared to *B. grandis*. *A. drummondii, A. urophylla* and *Viminaria juncea* also showed low mortality but had no effect on inoculum of *P. cinnamomi. Bossiaea aquifolium, Daviesia decurrens, Hovea chorizemifolia, Labichea punctata, Mirbelia dilatata* and *B. grandis* showed high mortality due to *P. cinnamomi* infection. Of these species population levels were only quantified from *B. grandis* pots for comparison.

1. Shea, S.R., Gillen, K.J. and Kitt, R.J. (1978). Variation in sporangial production of *Phytophthora cinnamomi* Rands on jarrah (*Eucalyptus marginata* Sm.) forest sites with different understorey compositions. Australian Forestry Research, 8:219-226.

THE VEGETATION HEALTH SERVICE: A RESOURCE FOR RESEARCHERS AND MANAGERS OF *PHYTOPHTHORA* DISEASE.

N. K. D'Souza[1], J. L. Webster[1], F. C. S. Tay[1] and M. J. C. Stukely [1]

[1]Vegetation Health Service, CALMScience Division, Department of Conservation and Land Management
Locked Bag 104 Bentley Delivery Centre, Bentley 6983.

The mapping of disease caused by *Phytophthora cinnamomi* in Western Australian native forest is a major component of the Department of Conservation and Land Management's (CALM's) management responsibilities prior to logging and mining activities. The Vegetation Health Service (VHS) within the CALMScience Division is currently responsible for accurate detection and identification of *Phytophthora* species for disease mapping. Since 1984 the VHS has managed a comprehensive database of every sample assessed for *Phytophthora*. To date there are approximately 21,000 records from areas ranging from Eneabba north of Perth to Albany south east of Perth. Records include 6,759 positive detections of *P. cinnamomi* and 1,430 of other species of *Phytophthora* including the first report of *P. boehmeriae* in Western Australia. A culture collection of *Phytophthora* species is maintained by the VHS with currently 830 cultures of *Phytophthora*, 377 of which are *P. cinnamomi*. Other species include *P. cactorum, P. citricola, P. cryptogea, P. drechsleri, P. megasperma* and *P. nicotianae*. The database and culture collection are maintained as a resource for internal and external groups involved in *Phytophthora* research and management.

PHYTOPHTHORA IN SOUTH AUSTRALIA – A QUANTUM SHIFT IN AWARENESS

Renate Velzeboer and Kylie Moritz

National Parks and Wildlife South Australia (NP&WSA)

Mainland South Australia has seen a quantum shift in its level of *Phytophthora* awareness over the past 18 months. A *Phytophthora* Project Officer is leading a statewide campaign that is generating a ground swell of interest in, and action against, *Phytophthora*. The campaign has centred on education and training, with a multitude of workshops and presentations undertaken, a quarterly newsletter distributed and information articles, posters and brochures produced. Distribution mapping and sampling has also occurred and *Phytophthora* Management Plans and hygiene strategies have been developed for key groups including Local Councils, Friends of Parks, Transport SA and forestry industries. A diversity of other activities have been undertaken including assisting the Country Fire Service to incorporate *Phytophthora* management into its fire fighting operations, Local Councils have taken on responsibility for threat mitigation and community education and a set of Standard Operating Procedures has been developed for National Parks and Wildlife SA for implementation across the state. Maintaining communication links between these groups, and encouraging a collaborative approach to *Phytophthora* management will be the key to the success of this program in South Australia.

THE HOLISTIC APPROACH TO *PHYTOPHTHORA* MANAGEMENT ON KANGAROO ISLAND, SA

Kylie Moritz

Bush Management Adviser, Kangaroo Island ,National Parks and Wildlife South Australia (NP&WSA)

Kangaroo Island is a unique natural environment with approximately 47% of its native vegetation still intact. The Island's habitats support the largest number of endemic species of any region in SA and many species of state and national conservation significance. The Island's isolation has saved it from the impact of foxes and rabbits, but unfortunately, not the introduction of *Phytophthora.* Loss of native vegetation and animal habitat through *Phytophthora* infestation is a major threatening process that has had devastating impacts on Kangaroo Island's biodiversity.

Kangaroo Island is at the forefront of *Phytophthora* management in South Australia. The Island's isolation, distinct boundary, and presence of only one port for vehicle access, has enabled a very holistic and unique approach to *Phytophthora* management.

While our management approach focuses on maintaining hygienic practices, we are broadening our efforts to understanding and actively managing outbreaks, particularly in regards to the protection of threatened species. To do this we are undertaking the following activities:

- mapping the distribution and extent of *Phytophthora*;
- developing a set of ecological criteria and monitoring sites to predict *Phytophthora* distribution, rate of spread and potential for infection;
- developing a strategy for prioritising areas in need of protection given the proximity and degree of threat from *Phytophthora*;
- determining the impact of *Phytophthora* on nationally threatened species, and developing Management Plans for and initiating threat abatement strategies; and
- determining the effectiveness of Phosphite as a means of preventing *Phytophthora* infection in SA.

With this integrated approach, we hope to better manege *Phytophthora* on Kangaroo Island, and maintain the region as an area of high conservation significance.

DEVELOPMENT OF AN INTEGRATED DISEASE MANAGEMENT (IDM) PACKAGE FOR LATE BLIGHT ON POTATOES ACROSS DIFFERENT AGRO-ECOLOGICAL ZONES IN UGANDA

J. Nabirye [1], P. Ensywa [1] and P.J. Hakiza[2]

[1] Madivani group of companies, Kampala, Uganda
[2] Makerere University, Kampala, Uganda

Multilocational trials were conducted in the forest and forest/Savannah agro-ecological zone of Uganda during 1999 and 2000 to develop an economic package for late blight in Uganda. Results indicate that there were significant ($P < 0.005$) differences among the agro-ecological zones for yield and late blight readings. Analysis of the disease progress curves revealed that in plots managed according the integrated management concepts, late blight was surpressed as good as in plots treated with specific fungicides against *Phytophthora infestans*. The highest yields were recorded in plots intecropped with sugarcane, receiving three well timed spray of protectant fungicide alternated with systemic fungicide.

Biology of *Phytophthora*
Chair Wendy Sutton and Jen McComb

SUMMER RAINFALL AND THE DEVELOPMENT OF DISEASE CAUSED BY *PHYTOPHTHORA CINNAMOMI* IN DROUGHTED *EUCALYPTUS MARGINATA* PLANTS.

A. Lucas[1], J.A. McComb[1], I.J. Colquhoun[2] and G.E.St.J. Hardy[1]

[1]School of Biology and Biotechnology, Murdoch University, Perth, Western Australia 6150
[2]Alcoa World Alumina, P.O. Box 252, Applecross, Western Australia 6153

Summer rainfall seldom occurs in the south-west of Western Australia. Flora of the region has evolved under a Mediterranean climate having hot dry summers with rare thunder storms, and cool wet winters. The consequence of high summer rainfall is significant because the resulting conditions can favour an outbreak of the introduced soil pathogen, *Phytophthora cinnamomi*, to which many plant species in the south-west forests are susceptible.

A glasshouse experiment compared the response of drought stressed and non-stressed *Eucalyptus marginata* (jarrah) plants when inoculated with *P. cinnamomi* after a simulated summer rainfall event. Clonal plants, resistant or susceptible to *P. cinnamomi,* were tested. The moisture content of the container substrate for inoculated and non-inoculated plants was either kept at container capacity or at a pre-determined level just above that of the wilting point of each plant for 3 weeks. Sudden restoration to container capacity simulated summer rainfall and plants were inoculated immediately. Higher proportions of non-stressed clonal plants, both resistant and susceptible, became infected and were more extensively colonized by the pathogen than plants subjected to drought. Results supported our hypothesis : tissue of drought affected *E. marginata* plants is less susceptible to infection by *P. cinnamomi* than tissue of plants which have recently experienced no water deficit.

PHYTOPHTHORA SPP. ASSOCIATED WITH *EUCALYPTUS SMITHII* DIEBACK IN SOUTH AFRICA

B.O.Z Maseko[1], T. Burgess[2], T.A Coutinho[1] and M.J Wingfield[1]

[1] Forestry and Agricultural Biotechnology Institute (FABI), Tree Pathology Co-operative Programme (TPCP), Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria, 0002. Republic of South Africa.
[2] School of Biological Sciences and Biotechnology, Murdoch University, Murdoch 6150

Eucalyptus smithii is cold tolerant and thus ideal for commercial propagation in high altitude areas of South Africa. It grows fast and has superior pulping properties compared to other commercially grown eucalypts. *Phytophthora* dieback, however, limits the afforestation potential of this species. In this study, a survey was conducted in newly established *E. smithii* stands in the KwaZulu/Natal province of South Africa to identify and map the occurrence of *Phytophthora* spp. Soil and plant samples were collected from diseased trees and their Global Positioning System (GPS) co-ordinates recorded. *Phytophthora* spp. recovered from the soil and diseased plant material were identified using morphological characteristics and sequence data from the ITS region of the rDNA operon. Three *Phytophthora* spp., namely *P. cinnamomi*, *P. citricola* and *P. nicotianae* were recovered from soil and diseased plant material. Our results suggest that *P. nicotianae* is the most common species associated with *E. smithii* death. This is in contrast the previous view that *P. cinnamoni* is the dominant pathogen in this environment.

LONG-TERM SURVIVAL OF *PHYTOPHTHORA CINNAMOMI* IN ORGANIC MATTER UNDER DIFFERENT SOIL MOISTURE CONDITIONS

S. Collins[1], B. Shearer[2], J. McComb[1], I. Colquhoun[3], G. Hardy[1]

[1] Murdoch University, South St, Perth, 6150, Western Australia.
[2] Dept. of Conservation and Land Management, 50 Hayman Rd, Perth, 6152, Western Australia.
[3] Alcoa of Australia, GPO 252, Perth, 6153, Western Australia.

It has been suggested that *Phytophthora cinnamomi* does not survive freely in soil for long periods of time under adverse environmental conditions. The pathogen is, however, believed to survive for extended periods under adverse conditions within organic matter. This experiment assessed the long-term survival of *P. cinnamomi* in different types of organic matter buried in two soil types at different moisture conditions.

Young *Banksia grandis* stems and young actively growing root tips of *Eucalyptus marginata* (jarrah) were inoculated with *P. cinnamomi*, incubated, and then placed into pots filled with sieved soil collected from either the jarrah forest or an adjacent rehabilitated mine site. The colonised root tips or plugs were buried in each soil type and either *a)* maintained at container capacity, or *b)* allowed to dry-out slowly from container capacity. Treatments were harvested 0, 7, 14, 28, 42, 70, 112, 154 and 210 days after inoculation and assessed for *P. cinnamomi* survival.

P. cinnamomi was recovered after 210 days from banksia stems (98% colonisation) and eucalypt root tips (45% colonisation) for both soil types when the soil was maintained at container capacity. However, when the soils were allowed to dry, the pathogen was not recovered after 112 days from either banksia stems or eucalyptus roots.

THE INFLUENCE OF SOIL FROM A TOPOGRAPHIC GRADIENT IN THE FITZGERALD RIVER NATIONAL PARK ON MORTALITY OF *BANKSIA BAXTERI* FOLLOWING INFECTION BY *PHYTOPHTHORA CINNAMONI*

B. L. Shearer and C. E. Crane

CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

The Fitzgerald River National Park is an international biome in which *Phytophthora cinnamomi* is destroying *Banksia baxteri-Lambertia* scrub-heath in a disease centre over 6 km long in the middle of the park. Current assessment of the vulnerability of healthy areas to infestation by *P. cinnamomi* depends on estimating the probable susceptibility of component plants within the vegetation associations, without knowledge of the potential for the pathogen to develop within the major soil types of the park. Intact soil cores were removed from 5 major soil associations of the park (a relatively fertile loam from the floor of the gorges to the more infertile sandy soils of the plains and uplands) and placed in free draining pots. Cores were also taken from a red loam from incised drainage systems and a gravel and sandy soil from the nearby Ravensthorpe Range for comparison. The cores were planted with seedlings of *B. baxteri* and maintained in a shadehouse. Following establishment of the plants, the cores were inoculated in summer with an isolate of *P. cinnamomi* from the only disease centre in the park. The rate of mortality was greatest in the infertile sandy soils and the soils of the Ravensthorpe Range and lowest in the red loam. The rate of mortality for the Perkin Loam from the gorge floor was intermediate between that of the sands and red loam. While the results of pot experiments have limitations in predicting disease development and must be used with caution, the results do identify the soil types most conducive for disease development.

TIME COURSE STUDIES OF THE EFFECT OF TEMPERATURE AND STIMULATION OF SOIL AT DIFFERENT DEPTHS ON SPORANGIUM PRODUCTION BY *PHYTOPHTHORA CINNAMONI*

B. L. Shearer

CALMScience, Department of Conservation and Land Management 50 Hayman Rd, Como 6152, Western Australia.

Time course studies of the effect of temperature on sporangium production of *Phytophthora cinnamomi* have not been reported. Little is understood of the soil's capacity to stimulate sporulation at different depths from the surface. Sporangium production was counted on sterilised *Banksia grandis* discs colonised by mycelium of *P. cinnamomi* and incubated in soil extracts on a temperature plate between 10-30 °C. Soil was collected from two sites; only surface soil at one site and soil from the surface and 20, 60 and 90 cm depth from the other site. Extracts were incubated at the different temperatures for 2, 4, 6, 8 and 12 days. Time and temperature were combined in the one equation using the procedure of Pegelow *et al.* (1977). The predicted response surfaces show that numbers of sporangia increase rapidly as temperatures rise from 16-28 °C and incubation periods increase from 2-12 days. There was a more rapid response of sporangium production to temperature in extracts from surface soils than soils collected at depth.

1. Pegelow, E.J. Jr., Taylor, B.B., Horrocks, R.D., Buxton, D.R., Marx, D.B. and Wanjura, D.F. (1977). The gompertz function as a model for cotton hypocotyl elongation. *Agronomy Journal* **69**, 875-878.

THE IMPACT OF PHYTOPHTHORA DISEASE ON RIPARIAN POPULATIONS OF COMMON ALDER (*ALNUS GLUTINOSA*) ALONG THE MOSELLE RIVER (NORTH-EASTERN FRANCE)

J-C Streito [1], M. Alioua[1] and B. Marçais[2]

[1]Laboratoire National de la Protection des Végétaux – Unité de Mycologie agricole et Forestière (LNPV-UMAF) 38 rue Sainte Catherine 54043 Nancy cedex. jean-claude.streito@agriculture.gouv.fr

[2]Institut National de la Recherche Agronomique, laboratoire de pathologie forestière BP35 54280 Champenoux cedex. marcais@nancy.inra.fr

Alder *Phytophthora* caused significant damages in north-eastern France in the last years. A survey was established in August 2000 along the Moselle river, to obtain informations on the disease. Its severity was investigated and will be discussed in relation to several environmental and tree parameters. Results show that the disease is very frequent on the Moselle river (13% of alders with crown symptoms and 17% with tarry spots). The effect of distance from water on incidence of the disease is confirmed. The disease shows aggregation pattern. Stem diameter shows no significant relationship with disease.

FIELD TRIP SUNDAY 30th SEPTEMBER

Sunday Bus Tour to Pemberton

Welcome aboard. This morning we will give you an overview of the woodland and forest types around Perth and the impact of *Phytophthora cinnamomi*. We will also cover mining activities and management of *P. cinnamomi* in mining and forest operations.

Brief Description of Geology and Soils

Most of Western Australia is covered by **The Yilgarn Block** composed of ancient granite over 2 500 million years old. This granite is one of the oldest rocks in the world with many of the soils derived from it also among the oldest in the world.

Between 120-250 million years ago, the land along the western edge of the Yilgarn Block gradually sank as the Indian land mass pulled away, causing the **Darling Fault**. The differences in levels of the original rock surfaces is now 10-15 kilometers, although continual erosion of the inland block and coastal deposits have reduced the difference between it and the coastal plain today to only about 400 metres.

Between 40-120 million years ago the Indian continent finally separated from the west coast and Antarctica separated from the South coast with flooding by sea and deposition of sediments along the coastal areas. Prolonged erosion of the Yigarn block was wearing away the peaks and filling in the valleys.

During the last 40 million years the Yigarn Block and coastal strips were raised and the sea eroded the sediments back to the hard granite of the Darling Fault to form the **Darling Scarp** which we will climb and travel along the top of later this morning. In the more humid climate, a thick soil covering called laterite formed over the granite and the coastal sediments as they decomposed. More will be said about the relationships between the laterite profile and the activity of *P. cinnamomi* at the stop after morning tea and there will be chances to view the profile on the mine tour.

Between the Darling Scarp and the Indian Ocean is a strip of land 25-35 kilometres wide called the **Swan Coastal Plain**. The soils of the Swan Coastal Plain were formed in different ways. Near and running parallel to the coast is a series of three dune systems. On the coast and the youngest of the three systems is the **Quindalup** Dune System which extends less than a kilometer inland and supports heathlands. East of the Quindalup System is the relatively fertile **Spearwood** Dune System formed after the sea retreated after the last ice age and supporting Tuart forest and *Banksia* woodland. East of the Spearwood System is the **Bassendean** dune system of leached white sand supporting diverse *Banksia* woodlands. To the east of the Bassendean System is the **Pinjarra Plain** and **Ridge Hill Shelf** formed by outwashings from the Darling Range.

The Tour (see Figure 3 for map of route)

On departure from Fremantle we head South along the Quindalup and Spearwood Dune Systems with glimpses of the Indian Ocean, coastal heathland and Tuart Forest. There is little impact of *P. cinnamomi* on these dune systems.

After joining Thomas Rd we travel east across the Spearwood Dune System and onto the Bassendean Dune System. There will be some good examples of *Banksia* woodland. If you are quick there will be a good example of impact of *P. cinnamomi* in *Banksia* woodland (Fig. 1) on your right just before we cross over into the Pinjarra Plain. Unfortunately it is too dangerous to stop the buses on this busy road to view this disease centre, but hopefully you will get an idea from Fig. 1.

Figure 1. High impact of *Phytophthora cinnamomi* in *Banksia* woodland on the Bassendean

Dune System. The line of recently dead trees mark the disease front. Note the lack of susceptible species in the disease centre in the foreground.

The Pinjarra Plain is crossed as we progress east and join South West Highway on the Ridge Hill Shelf when we travel south to climb the Darling Scarp on Kingsbury Drive. On reaching the top of the Scarp we travel south along Scarp Road through jarrah forest affected by *P. cinnamomi* to the North Dandalup Dam for morning tea. There are good views across the Swan Coastal Plain to your right as the bus travels over the dam wall.

Thirty minutes for morning tea on top of the dam wall, departing at 10:15 for a high impact *P. cinnamomi* disease centre in jarrah forest just south of the dam (Fig. 2). Overviews will be given at this site of the impact/development, interpretation and management of *P. cinnamomi* in the jarrah forest.

Figure 2. High impact of *Phytophthora cinnamomi* in jarrah forest. The line of recently dead *Eucalyptus marginata* and *Banksia grandis* trees mark the disease front (tagged in bright pink for the tour). Note the lack of susceptible species in the disease centre in the foreground.

Depart the high impact area at 11.00 am and arrive at the main entrance of the Huntley Bauxite mine at 11.15 am. Overview of the laterite profile, mining and *P. cinnamomi* management in the mine environment.

Arrive at the Marrinup nursery at 12.15 pm for lunch. Depart the nursery at 1 pm and travel down the Scarp along North Spur Road. There will be some examples of high impact of *P. cinnamomi* on your right as the bus travels along North Spur Road and some good views of the Swan Coastal Plain as the bus descends the Scarp to South West Highway.

On the way to Pemberton a video of impact of *P. cinnamomi* on the South Coast will be run several times. There will be a stop mid-afternoon. Hopefully arrive in Pemberton around 5 ish.

Figure 3. Southwestern Australia showing route to Albany. Sunday: Fremantle to Pemberton. Monday: Pemberton to Albany

FIELD TRIP MONDAY 1st OCTOBER

Monday Bus Tour to Albany

Welcome aboard. This morning we will give you an overview of karri forest types en route to Walpole. We will also see *Armillaria* in regrowth karri. Then visit costal heath to discuss the impact of *Phytophthora cinnamomi*. We will also cover open woodland and view impact of *P. cinnamomi*.

The Tour (see Figure 3 of Sunday's tour for map of route)

Stop 1. Visit *Armillaria luteobubalina* in *Eucalyptus diversicolor* (Karri Forest).

Stop 2. Visit coastal heathland impacted by *Phytophthora cinnamomi*

Stop 3. Visit open woodland impacted by *Phytophthora cinnamomi*

Stop 4. Treetop walk in the Valley of the Giants
This walk goes up to 40 metres above the forest floor. You will also have the opportunity to walk at ground level on the Ancient Empire Walk and explore the rich diversity of flora a ground level.

The Valley of the Giants now part of Walpole-Nornalup National Park, gets its name from the large red tingle trees, *Eucalyptus jacksonii*, that are found there. It is the easternmost occurrence of this forest type, which is only found within 15 kilometres of Walpole. Some of the trees in the Ancient Empire are up to 16 metres in circumference at the base.

Stop 5. Albany

FIELD TRIP WEDNESDAY 3rd OCTOBER

Brief Description of Geology, Vegetation and Soils

Please read in the front of the book:

BOTANICAL HISTORY, GEOLOGY, VEGETATION AND FLORA OF THE ALBANY AREA
Sarah Barrett

TOUR PROGRAMME

Depart Albany for Gull Rock: 12.30

Stop 1. Rate of spread trial - dieback front, 20 min
Speakers:
Malcom Grant:
- Impact of *Phytophthora cinnamomi* on *Banksia* woodland
- Use of aerial photography for interpreting and mapping *P. cinnamomi*
- Aerial canker

Bryan Shearer:
- Phosphite trunk injection technique

Stop 2 (stay on bus)
Speaker : Malcom Grant (S. Barrett 2nd bus:)
- Dieback interpretation of long infested plant community

Stop3 Phosphite trial site, 20 min
Speakers
Russell Smith, Paul Blechynden:
- Aerial phosphite application techniques
- Monitoring spread of dieback front – sprayed and control

Stop 4 (stay on bus)
Speaker: Malcom Grant (S. Barrett 2nd bus)
- View of old infestation in *Banksia* woodland on hill side

Stop 5 car park area Ledge Beach west, afternoon tea, 30 min
Speakers: Kevin Vear
- Management of *P. cinnamomi*
- Management of access – vehicle and pedestrian, signage
- Hygiene procedures
- Public education – brochures, interpretative panels

Stop 6 car park area Ledge Beach east – enjoy views of coastline

Arrive Albany 5.30