

The
Nicholson
Centenary
Meeting

PROGRAM
&
ABSTRACTS

Frontiers
of
Population
Ecology



18th - 22nd April

1995

Canberra Australia

Organised by
CSIRO Division of Entomology
On behalf of the
Australian Academy of Science
the Australian Entomological Society
the Ecological Society of Australia and CSIRO



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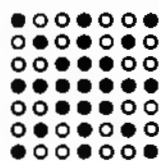
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WELCOME
TO THE NICHOLSON CENTENARY MEETING
FRONTIERS OF POPULATION ECOLOGY

The Organising Committee takes great pleasure in welcoming you to the Nicholson Centenary Meeting. We hope the time you spend in Canberra at the conference venue on the Australian National University Campus and around town will be enjoyable and productive. Take the opportunity to meet with old friends and make new ones.

The Meeting has been convened to celebrate the centenary of the birth of A.J. Nicholson on 25 March, 1895. His career is of special significance to the CSIRO Division of Entomology. He was Chief from 1933-1960 and developed an international scientific reputation which sees his work and ideas still discussed and argued about today. The Committee hopes that the high standard of the invited speakers and the contributed presentations will do much to enhance both the standing of, and future research in, population ecology. The research presented and the discussion generated should provide inspiration for all participants whatever their area of interest.

THE ORGANISING COMMITTEE

Dr Paul Wellings (Convenor)
Dr Joanne Daly
Dr Rob Floyd
Dr Andy Shepherd
Ms Louise Lawrence
Dr Paul De Barro



ACKNOWLEDGMENTS

The Organising Committee would like to take this opportunity to thank the many people who have helped make this meeting possible.

In particular, we would like to thank the sponsors below who have provided generous financial support for the conference. Without their backing, it would not have been possible to put on a meeting of this scale while keeping our registration costs low.

We are grateful for the support of other members of the CSIRO Division of Entomology who have contributed to the organisation and running of the conference in many ways. Particular thanks are due to Sharon Corey who has provided strong support for the Committee, Stephney Bergl who arranged the travel for the AIDAB sponsored participants as well as dealing with many other travel problems and queries, Ros Schumacher for keeping the original database and other support, members of the Graphics Unit (Christopher Hunt and Soussanith Nokham) for their preparation of the art work, the Finance Group (Mark Hardwick, Robyn Noel and Joyce Hutchings) for assistance with conference financial arrangements and all our colleagues who have helped in various ways from distributing publicity to providing advice. We also appreciate the assistance provided by the CSIRO Information Services (Paul Reekie and Kevin Jeans) in relation to publishing the conference proceedings.

Thanks are also due to the Functions Consultants at the Students' Union, Burton and Garran Hall and University House at the Australian National University and the Lakeside International Hotel, for their help with social functions and accommodation arrangements.

CONFERENCE SPONSORS AND SUPPORTERS

The Nicholson Centenary meeting has been organised by the CSIRO Division of Entomology on behalf of CSIRO, the Australian Academy of Science, the Australian Entomological Society and the Ecological Society of Australia, all of whom also provided financial support. The Academy provided substantial funding to subsidise the attendance of students at the conference.

Further financial assistance to support invited speakers and participants has been provided by the following:

Australian International Development Assistance Bureau

The British Council

The Cooperative Research Centre for Sustainable Cotton Production

The Cooperative Research Centre for the Biological Control of Vertebrate Pest Populations

The Cooperative Research Centre for Tropical Pest Management

The Cotton Research and Development Corporation

MEETING DIARY

TUESDAY 18 APRIL

- 1400-1600 REGISTRATION at the CSIRO Division of Entomology, Divisional Conference Room (second floor), Clunies Ross St.
- 1800-2000 RECEPTION and REGISTRATION in the Karmel Room, ANU Union. Drinks and finger food will be provided.

WEDNESDAY 19 APRIL

- 0830-0900 REGISTRATION in the foyer of the Manning Clark Theatre Centre.
- 0915-0940 OFFICIAL OPENING
- 0940-1220 INVITED SPEAKERS
- 1330-1610 CONTRIBUTED PAPERS. For details on venues and speakers see program.
- 1610-1730 INVITED SPEAKERS
EVENING FREE for dinner at local restaurants.

THURSDAY 20 APRIL

- 0900-1020 INVITED SPEAKERS
- 1020-1200 POSTER SESSION in the foyer of the Manning Clark Theatre Centre. Contributors will be available to answer questions on their display.
- 1200-1700 INVITED SPEAKERS
- 1930-2330 The CONFERENCE DINNER will be held in the FIRST FLOOR FUNCTION ROOM of The Lakeside International Hotel. Parking is available under the building.

FRIDAY 21 APRIL

- 0900-1020 INVITED SPEAKERS
- 1100-1430 CONTRIBUTED PAPERS
- 1430-1700 INVITED SPEAKERS
EVENING FREE for dinner at local restaurants.

SATURDAY 22 APRIL

- 0900-1220 INVITED SPEAKERS
- 1220-1230 CLOSING COMMENTS
- 1230-1400 COMPLIMENTARY LUNCH in the Karmel Room, ANU Union.

MEALS UNIVERSITY HOUSE: *Boffins a la Carte* Breakfast Mon-Fri 0715-0900
Sat-Sun 0730-0930
Dinner 7 days 1800-2100
Cellar Bar Brasserie Dinner 7 days 1730-2000

BURTON AND GARRAN: If you would like the evening meal in College please purchase casual meal tickets from the front office. Cash will also be accepted. The caterers would appreciate it if, when at all possible, you notify them that you will be dining in.

| Tuesday <i>18/4/95</i> | | Wednesday <i>19/4/95</i> | | Thursday <i>20/4/95</i> | | Friday <i>21/4/95</i> | | Saturday <i>22/4/95</i> | |
|----------------------------------|-------------------------------------|------------------------------------|---------------------------|-----------------------------------|----------------------------------|---------------------------------|---------------------------|-----------------------------------|--------------------|
| | | 0830-0900 | Registration | | | | | 0900-0940 | Walker |
| | | 0915-0940 | Introduction | 0900-0940 | Cockburn | 0900-0940 | Harwood | 0940-1020 | Morton |
| | | 0940-1020 | Kingsland | 0940-1020 | Vet | 0940-1020 | Sainsbury | <i>1020-1100</i> | <i>Morning Tea</i> |
| | | <i>1020-1100</i> | <i>Morning Tea</i> | <i>1020</i> | <i>Morning Tea & Posters</i> | <i>1020-1100</i> | <i>Morning Tea</i> | 1100-1140 | Moritz |
| | | 1100-1140 | Sinclair | 1200 | | 1100 | Contributed papers | 1140-1220 | Murdoch |
| | | 1140-1220 | Underwood | 1200-1240 | Chesson | -1220 | | 1220-1230 | Closing comments |
| | | <i>1220-1330</i> | <i>Lunch</i> | <i>1240-1350</i> | <i>Lunch</i> | <i>1220-1330</i> | <i>Lunch</i> | <i>1230-1400</i> | <i>Free Lunch</i> |
| | | 1330 | Contributed papers | 1350-1430 | Mahon | 1330 | Contributed papers (cont) | | End |
| <i>1400-</i> | <i>Registration</i> | -1450 | | 1430-1510 | Wratten | -1430 | | | |
| | CSIRO Entomology | <i>1450-1510</i> | <i>A'noon Tea</i> | <i>1510-1540</i> | <i>A'noon Tea</i> | 1430-1510 | Burdon | | |
| <i>-1600</i> | | 1510 | Contributed papers (cont) | 1540-1620 | Myerscough | <i>1510-1540</i> | <i>A'noon Tea</i> | | |
| | | -1610 | | 1620-1700 | de la Mare | 1540-1620 | Crawley | | |
| | | 1610-1650 | Lonsdale | | | 1620-1700 | Daly | | |
| | | 1650-1730 | Possingham | | | | | | |
| <i>1800-2000</i> | <i>Reception & Registration</i> | | | <i>1930-2330</i> | <i>Dinner</i> | | | | |

CONFERENCE PROGRAM AT A GLANCE



VENUES FOR SCIENTIFIC SESSIONS

All presentations by INVITED SPEAKERS will be in Manning Clark Theatre 1. CONTRIBUTED PAPERS will be presented in Theatres 1 and 4 (see pages 14-17 for details).

POSTERS will be displayed in the foyer of the Manning Clark Theatre Centre (see map at end of book). There will be one official poster session from 1020-1200 on Thursday 20 April. They will also be available for viewing between sessions and during tea and lunch breaks.

All registrants are reminded that smoking, eating and drinking are not allowed in the lecture theatres of the university. Smoking is also not permitted in any building at the CSIRO Division of Entomology.



PRESENTATIONS

INVITED SPEAKERS AND CONTRIBUTED PRESENTATIONS: Please introduce yourself to the session Chair at least 10 minutes before the beginning of the session and check whether there are changes to the program. You should also give the projectionist your slides at this time. They will be available for collection at the end of the session. Please ensure your talk fits into the allotted time to ensure smooth running of the program.

POSTERS: Contributors are asked to arrange their displays during the afternoon of Tuesday 18 April to ensure maximum exposure during the conference. Please use the board allocated to you. All poster presenters are asked to ensure that they are present during the official poster session. Poster displays should be dismantled during the afternoon of Friday 21 April.

SCIENTIFIC PROGRAM

Wednesday 19 April 1995

Lecture Theatre 1, Manning Clark Centre

- 0915-0940 *Conference Welcome* - Paul Wellings
Introduction to A.J. Nicholson - Garth Nicholson
Chair: Paul Wellings, CSIRO Entomology, Canberra
- 0940-1020 **Sharon Kingsland**, Johns Hopkins University, USA
Evolutionary theory and the foundations of population ecology: The work of A.J. Nicholson
- 1020-1100 *Morning Tea*
Chair: Hugh Tyndale-Biscoe, Vertebrate Biocontrol Centre, Canberra
- 1100-1140 **Tony Sinclair**, University of British Columbia, Canada
Mammal populations: Regulation and conservation
- 1140-1220 **Tony Underwood**, University of Sydney, NSW
Interactions in spatial and temporal patterns of intertidal populations
- 1220-1330 *Lunch*
- 1330-1450 **Contributed Papers** (for details see pages 14,15)
- Session A**
Chair: Joel Brown, CSIRO Tropical Crops & Pastures, Qld
Venue: Theatre 1
- Session B**
Chair: Andy Austin, University of Adelaide, SA
Venue: Theatre 4
- 1450-1510 *Afternoon Tea*
- 1510-1610 **Contributed Papers continued**
Chair: Andy Taylor, University of Hawaii, USA
- 1610-1650 **Mark Lonsdale**, CSIRO Entomology, Darwin, NT
The balance of weed populations
- 1650-1730 **Hugh Possingham**, University of Adelaide, SA
Decision theory and biodiversity management: How to manage a metapopulation

SCIENTIFIC PROGRAM (Continued)**Thursday 20 April 1995****Lecture Theatre 1, Manning Clark Centre**

- Chair:** Charles Krebs, University of British Columbia, Canada
- 0900-0940 **Andrew Cockburn**, Australian National University, Canberra
Why do Australian birds cooperate: The phylogeny of life tables?
- 0940-1020 **Louise Vet**, Agricultural University, Wageningen, The Netherlands
Parasitoid foraging: The importance of variation in individual behaviour for population dynamics
- 1020-1200 **Poster Session** (includes Morning Tea)
- Chair:** Naomi Cappuccino, University of Texas at Austin, USA
- 1200-1240 **Peter Chesson**, Australian National University, Canberra
Matters of scale in the dynamics of populations and communities
- 1240-1350 *Lunch*
- 1350-1430 **Rod Mahon**, CSIRO Entomology, Malaysia
Frequency dependent competitiveness and the sterile insect release method
- 1430-1510 **Steve Wratten & Dr Nigel Barlow**, Lincoln University, New Zealand
Ecology of predator/prey and parasitoid/host systems: Progress since Nicholson
- 1510-1540 *Afternoon Tea*
- Chair:** Michael Begon, University of Liverpool, UK
- 1540-1620 **Mary Myerscough**, University of Sydney, NSW
Bifurcations, structural stability and persistent populations - New insights into classical models with harvesting and stocking
- 1620-1700 **Bill de la Mare**, Australian Antarctic Survey, Hobart, Tas
Some recent developments in the management of marine living resources
- 1930-2330 *Conference Dinner*
Lakeside International Hotel



SCIENTIFIC PROGRAM (Continued)**Friday 21 April 1995****Lecture Theatre 1, Manning Clark Centre**

- Chair:** Jean Chesson, Bureau of Resource Sciences, Canberra
- 0900-0940 **John Harwood**, British Antarctic Survey, Cambridge, UK
The population biology of marine mammals
- 0940-1020 **Keith Sainsbury & Nic Bax**, CSIRO Fisheries, Tas
Ecology in fisheries: Some conclusions from long-term research on exploited and managed marine fish populations
- 1020-1100 *Morning Tea*
- 1100-1220 **Contributed Papers** (for details see pages 16,17)
- Session C**
Chair: David Penman, Landcare Research, NZ
Venue: Theatre 1
- Session D**
Chair: Myron Zalucki, University of Queensland
Venue: Theatre 4
- 1220-1330 *Lunch*
- 1330-1430 **Contributed Papers continued**
- Chair:** Dr Andrew Watkinson, University of East Anglia, UK
- 1430-1510 **Jeremy Burdon**, CSIRO Plant Industry, Canberra
The dynamics of disease in plant populations
- 1510-1540 *Afternoon Tea*
- 1540-1620 **Mick Crawley & Mark Rees**, Imperial College, UK
The balance of plant populations
- 1620-1700 **Joanne Daly & Paul Wellings**, CSIRO Entomology, Canberra
Ecological constraints to the deployment of arthropod resistant crop plants: A cautionary tale

SCIENTIFIC PROGRAM (Continued)

Saturday 22 April 1995

Lecture Theatre 1, Manning Clark Centre

- Chair:** Rhondda Jones, James Cook University, Qld
- 0900-0940 **Paul Walker**, CSIRO Wildlife and Ecology, Canberra
Spatial modelling and population ecology
- 0940-1020 **Steve Morton**, CSIRO Wildlife & Ecology, Canberra
Land management and population ecology
- 1020-1100 *Morning Tea*
- Chair:** Max Whitten, CSIRO Entomology, Canberra
- 1100-1140 **Craig Moritz & Shane Lavery**, University of Queensland
Molecular ecology: Contributions from molecular biology to population ecology
- 1140-1220 **Bill Murdoch & Roger Nisbet**, University of California at Santa Barbara, USA
Frontiers of population ecology
- 1220-1230 **Closing comments:** Max Whitten, CSIRO Entomology, Canberra
- 1230-1400 *Complimentary Lunch*
Karmel Room, ANU Union



SESSION A

PROGRAM OF CONTRIBUTED PAPERS

Wednesday 19 April 1995

Venue: Theatre 1, Manning Clark Centre

Chair: Joel Brown, CSIRO Tropical Crops & Pastures, Qld

1330-1350

T. Cilgi, G. Frampton & S. Wratten

University of Southampton, UK

Long-term trends in invertebrate populations in contrasting pesticide regimes

1350-1410

D. Fox & T. Ridsdill-Smith

CSIRO Entomology, Perth, WA

Testing for density dependence

1410-1430

N. Cappuccino & S. Harrison

University of Texas at Austin, USA

Density perturbation experiments for understanding population regulation

1430-1450

M. Ritchie

Utah State University, Logan, USA

*Interaction of temperature and resources in population dynamics: An experimental test of theory*1450-1510 *Afternoon Tea*

1510-1530

A. Grice & J. Brown

CSIRO Tropical Crops & Pastures, Aitkenvale, Qld

Fire and the population ecology of invasive shrubs in the tropical woodlands

1530-1550

A. Sheppard & T. Woodburn

CSIRO Entomology, Canberra

*Does escape from predation improve the effectiveness of biocontrol agents against the thistle *Carduus nutans**

1550-1610

A. Watkinson

University of East Anglia, Norwich, UK

The role of mutualisms in plant population dynamics

SESSION B

PROGRAM OF CONTRIBUTED PAPERS (Continued)

Wednesday 19 April 1995

Venue: Theatre 4, Manning Clark Centre

Chair: Andy Austin, University of Adelaide, SA

1330-1350

V. Drake & A. Gatehouse

University of New South Wales, Canberra

Population trajectories through space and time: A holistic approach to insect migration

1350-1410

R. Fleming

Canadian Forestry Service, Sault Ste Marie, Canada

Insect defoliator populations in Canada's forests in a warming climate

1410-1430

G. Floater & M. Zalucki

University of Queensland, Brisbane, Qld

Mortality of the bunny-tailed moth, Ochrogaster lunifer, at different spatial scales

1430-1450

R. Farrow & R. Floyd

CSIRO Entomology, Canberra

*Influence of variable host tree qualities on the population dynamics of sap-feeding forest and woodland insects*1450-1510 *Afternoon Tea*

1510-1530

R. Sequira & T. Dixon

University of East Anglia, Norwich, UK

Population dynamics of tree-dwelling aphids: The importance of seasonality and time scale

1530-1550

R. McGarvey

South Australian Research & Development Institute, Adelaide, SA

Is long term persistence of harvested populations proof of density dependence?

SESSION C**PROGRAM OF CONTRIBUTED PAPERS (Continued)****Friday 21 April 1995****Venue:** Theatre 1, Manning Clark Centre**Chair:** David Penman, Landcare Research, NZ**1100-1120****B. Ballard & N. Galway**

CSIRO Entomology, Canberra

*Assessing evolutionary inferences generated from mitochondrial DNA: inferences from Drosophila***1120-1140****P. Sunnucks & G. Stone**

Macquarie University, Sydney, NSW

*Molecular ecology of an invading gallforming insect***1140-1200****P. De Barro, T. Sherratt & N. Maclean**

University of Southampton, UK

*The genetic and environmental components of host dependent stratification of herbivorous insect populations***1200-1220****D. Choquenot & N. Dexter**

NSW Agriculture, Orange, NSW

*Spatial variation in food limitation: The effects of foraging constraints on the distribution and abundance of feral pigs in the rangelands*1220-1330 *Lunch***1330-1350****M. Efford**

Landcare Research, Dunedin, New Zealand

*Simulating spatially distributed populations***1350-1410****K. Williams & L. Twigg**

CSIRO Wildlife & Ecology, Canberra

*Responses of wild rabbit populations to imposed sterility***1410-1430****C. Krebs & A. Sinclair**

University of British Columbia, Vancouver, Canada

Vertebrate community organisation in the boreal forests of Canada's Yukon

SESSION D**PROGRAM OF CONTRIBUTED PAPERS (Continued)****Friday 21 April 1995****Venue:** Theatre 4, Manning Clark Centre**Chair:** Dr Myron Zalucki, University of Queensland**1100-1120****M. Begon, R. Bowers, S. Sait & D. Thompson**

University of Liverpool, UK

*Population dynamics beyond two species: Hosts, parasitoids and pathogens***1120-1140****P. Kindlmann**

University of South Bohemia, Ceske Budejovice, Czech Republic

*Density dependence versus migration in aphids: An individual-based model***1140-1200****R. Knell, M. Begon & D. Thompson**

University of Liverpool, UK

*Comparative transmission dynamics of two insect pathogens***1200-1220****M. McCarthy**University of Melbourne, Vic & Centre for Resource & Environmental Studies, ANU,
Canberra*Natal dispersal under the influence of competition*1220-1330 *Lunch***1330-1350****R. Norman & P. Hudson**

University of Liverpool, UK

*A theoretical study of nematodes as biological pest control agents***1350-1410****A. Taylor**

University of Hawaii, USA

*Sources of stability in host-parasitoid dynamics***1410-1430****M. Anderson**

University of Sydney, NSW

Indirect effects of grazing gastropods on recruitment of Sydney rock oysters

VENUES AND TIMES FOR PLATFORM PRESENTATIONS

| Speaker | Date | Time | Theatre |
|------------------|------------|------|-----------|
| Marti Anderson | Fri 21/4 | 1410 | Theatre 4 |
| Michael Begon | Fri 21/4 | 1100 | Theatre 4 |
| Jeremy Burdon | Fri 21/4 | 1430 | Theatre 1 |
| Naomi Cappuccino | Wed 19/4 | 1410 | Theatre 1 |
| Peter Chesson | Thurs 20/4 | 1200 | Theatre 1 |
| David Choquenot | Fri 21/4 | 1200 | Theatre 1 |
| Tamer Cilgi | Wed 19/4 | 1330 | Theatre 1 |
| Andrew Cockburn | Thurs 20/4 | 0900 | Theatre 1 |
| Mick Crawley | Fri 21/4 | 1540 | Theatre 1 |
| Joanne Daly | Fri 21/4 | 1620 | Theatre 1 |
| Paul De Barro | Fri 21/4 | 1140 | Theatre 1 |
| Bill de la Mare | Thurs 20/4 | 1620 | Theatre 1 |
| Tony Dixon | Wed 19/4 | 1510 | Theatre 4 |
| Alastair Drake | Wed 19/4 | 1330 | Theatre 4 |
| Murray Efford | Fri 21/4 | 1330 | Theatre 1 |
| Roger Farrow | Wed 19/4 | 1430 | Theatre 4 |
| Richard Fleming | Wed 19/4 | 1350 | Theatre 4 |
| Graham Floater | Wed 19/4 | 1410 | Theatre 4 |
| David Fox | Wed 19/4 | 1350 | Theatre 1 |
| Nora Galway | Fri 21/4 | 1100 | Theatre 1 |
| Tony Grice | Wed 19/4 | 1510 | Theatre 1 |
| John Harwood | Fri 21/4 | 0900 | Theatre 1 |
| Pavel Kindlmann | Fri 21/4 | 1120 | Theatre 4 |
| Sharon Kingsland | Wed 19/4 | 0940 | Theatre 1 |
| Robert Knell | Fri 21/4 | 1140 | Theatre 4 |
| Charles Krebs | Fri 21/4 | 1410 | Theatre 1 |
| Mark Lonsdale | Wed 19/4 | 1610 | Theatre 1 |
| Rod Mahon | Thurs 20/4 | 1350 | Theatre 1 |
| Michael McCarthy | Fri 21/4 | 1200 | Theatre 4 |
| Rick McGarvey | Wed 19/4 | 1530 | Theatre 4 |
| Craig Moritz | Sat 22/4 | 1100 | Theatre 1 |
| Steve Morton | Sat 22/4 | 0940 | Theatre 1 |
| Bill Murdoch | Sat 22/4 | 1140 | Theatre 1 |
| Mary Myerscough | Thurs 20/4 | 1540 | Theatre 1 |
| Rachel Norman | Fri 21/4 | 1330 | Theatre 4 |
| Hugh Possingham | Wed 19/4 | 1650 | Theatre 1 |
| Mark Ritchie | Wed 19/4 | 1430 | Theatre 1 |
| Keith Sainsbury | Fri 21/4 | 0940 | Theatre 1 |
| Andy Sheppard | Wed 19/4 | 1530 | Theatre 1 |
| Tony Sinclair | Wed 19/4 | 1100 | Theatre 1 |
| Paul Sunnucks | Fri 21/4 | 1120 | Theatre 1 |
| Andy Taylor | Fri 21/4 | 1350 | Theatre 4 |
| Tony Underwood | Wed 19/4 | 1140 | Theatre 1 |
| Louise Vet | Thurs 20/4 | 0940 | Theatre 1 |
| Paul Walker | Sat 22/4 | 0900 | Theatre 1 |
| Andrew Watkinson | Wed 19/4 | 1550 | Theatre 1 |
| Kent Williams | Fri 21/4 | 1350 | Theatre 1 |
| Steve Wratten | Thurs 20/4 | 1430 | Theatre 1 |

LIST OF POSTERS

1. Systematics - How it Underpins Ecological Studies on Parasitic Wasps Used in Biological Control
A.D. Austin & P.C. Dangerfield
2. Ecology and Control of Introduced Helicid Snails in Australia *G.H. Baker & J.B. Coupland*
3. The Population Dynamics of the Grouse - Hare - Tick - Louping Ill System *R.G. Bowers, R. Norman & M. Begon*
4. Population Ecology as a Basis for *Acacia nilotica* Control Strategies *J.R. Brown & J. Carter*
5. Native Tasmanian Vertebrate Populations and Browsing Damage in Timber Plantations *J. Bulinski*
6. Locust Infestation in Central Luzon, Philippines *B.F. Cayabyab, D.R. Santiago, & M.D. Ebuenga*
7. IPM Advisory for Eggplant, *Solanum melongena* Linn Pests *B.F. Cayabyab, M.R. Maronilla, M.D. Ebuenga, R.G. Bayot & M.R. Cariaso*
8. Yield Loss Assessment of *Pomacea* spp. Damage in Lowland Rice *M.D. Ebuenga, A.V. de Lara, B.F. Cayabyab & R.G. Bayot*
9. RESMAN - A Simulation Model Incorporating Pesticide Resistance Management *A.D. Clift, G. Herron & M.A. Terras*
10. Contrasting Effects of Habitat Fragmentation on Populations of Carabid Beetles (Coleoptera: Carabidae) *K.F. Davies & C.R. Margules*
11. Explicit Patch Structures in Metapopulation Models - Consequences for Extinction *J. Day & H. Possingham*
12. Effect of leaf beetle populations on eucalypt plantations *J. Elek, A. Greener and N. Ramsden*
13. Fox Management and Impact on Lambs, Rabbits and Native Animals on Agricultural Lands and Remnant Habitats *C. Greentree*
14. Applied Ecology. A Short History of Ecological Ideas and their Application *J. Hone*
15. The Effect of Food-Web Structure on the Population Dynamics of the Web's Component Species *J.C. Hyde*
16. Population Study Using Capture without Replacement Estimates for the Endangered Species, *Aprasia parapulchella* *S.R. Jones*
17. The impacts on *Acacia xanthophloea* woodlands by the introduced Rothschild's giraffe in lake Nakuru National Park *J.K. Kairu*
18. Patterns of Sex Allocation in the Solitary Parasitic Wasp, *Cotesia rubecula* *M.A. Keller*
19. Male Characteristics and Female Choice in Collared Flycatcher, *Ficedula albicollis* *R. Kőnczey*
20. Distinguishing between Historical and Ecological Causes of Variation among Parapatric Populations in a Polymorphic Plant Species *S.L. Krauss*
21. GENSECT - A generic approach to constructing population models *G.F. Maywald, R.W. Sutherst & S.M. Richardson*
22. Susceptibility of Leguminous Pasture Species to Spotted Clover Aphid and Spotted Alfalfa Aphid *W.M. Milne & M.M. Court*
23. Conservation Biology of the Pipi, *Donax deltooides* *S.E. Murray-Jones*
24. Mallee (*Eucalyptus* spp.) Population Regulation by Fire *J.C. Noble*
25. The Use of Endophytic Fungi as Biological Control Agents of New Zealand Pastoral Pests *R.A. Prestidge & O.J.-P. Ball*
26. Characterising the Large Scale Spatial Dynamics of the Moths, *Helicoverpa punctigera* and *H. armigera* in Inland and Eastern Australia *W.A. Rochester, M.L. Dillon, G.P. Fitt, P.C. Gregg & M.P. Zalucki*
27. The Dawesville Channel Experiment: An End to Eutrophication? *T.H. Rose*
28. Comparison of Genetic Variability in Remnant and Widespread Rainforest Understorey Species of *Austromyrtus* (Myrtaceae) *A. Shapcott & J. Playford*
29. Biological Management of Pests in India *R.K. Sinha*
30. Conservation of Endangered Wildlife Populations in India *R.K. Sinha*
31. Impact of Modern Anthelmintics on the Dung Fauna *K.G. Wardhaugh*
32. The Population Ecology of *Oryza rufipogon* Griff. on the South Alligator River Floodplain, Kakadu National Park *P.A.S. Wurm*



ABSTRACTS
OF
INVITED PAPERS



THE DYNAMICS OF DISEASE IN PLANT POPULATIONS

J.J. Burdon

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Plant pathogens are major, although often overlooked, forces affecting the size and genetic structure of plant populations and the composition of whole communities. Studies that focus on the consequences of disease for individual populations generate valuable information regarding the single-plant fitness effects of pathogen epidemics. However, the interactions that occur between individual plant species and their pathogens typically show considerable temporal and spatial variability and only when studies are extended to incorporate several populations simultaneously does the full complexity of such interactions become apparent. Population fragmentation, complemented by restricted movement of host and pathogen may set off a cascade of demographic effects that are impossible to predict from single population studies but which have profound consequences for both the short and long-term dynamics of host-pathogen associations. This is most readily apparent in pathogen populations that are typically more ephemeral than that of their hosts, frequently being reduced to low levels by adverse environmental factors. Such periodic crashes with their inevitable accompaniment of genetic drift or even complete extinction followed by decolonisation, play a vital role in determining the genetic structure of the individual pathogen populations that sequentially utilise a given host patch. In these circumstances, individual host patches may be subject to selective pressures that vary substantially in direction and intensity as distinct pathogen populations follow one another through time. The sum effect of such interactions across many local populations within a metapopulation suggests that the long-term dynamics of host-pathogen associations and their coevolutionary development is a product of local and regional processes in which spatial and temporal variability are of vital importance.

MATTERS OF SCALE IN THE DYNAMICS OF POPULATIONS AND COMMUNITIES

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It is now well established theoretically that the stability of a population or community on a large spatial scale may depend on heterogeneities, fluctuations or instabilities on smaller scales. Small scale variation is averaged over on larger scales, but because local population dynamics are nonlinear, the variance on the small scale affects the average at the larger scale. Knowledge of the important nonlinearities and heterogeneities is essential to the process of scaling up small scale phenomena to the large scale. Moreover, the nonlinear averaging that links the small and larger scales may have stabilising or diversity promoting effects in many systems. Theoretical examples cover marine and terrestrial systems, vertebrate, invertebrate and plant communities, with theoretical mechanisms having various names such as intermediate disturbance, aggregation, competitive lottery and storage effect. The consideration of such nonlinear averaging processes and the relationships between phenomena on different scales, helps clarify important ecological concepts such as density dependence, competition, stability, and coexistence.

WHY DO AUSTRALIAN BIRDS COOPERATE: THE PHYLOGENY OF LIFE TABLES?

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The most widely accepted models which attempt to account for both the diversity of avian mating systems, and the occurrence of cooperative breeding, attribute importance to variation in habitat quality. Social systems are viewed as labile responses to the availability of breeding resources for females, availability of mates, and availability of breeding vacancies to young birds. Recent demonstrations that both mating systems and cooperative breeding have a phylogenetic basis challenge this view, and suggest that the lability of reproductive behaviour is strongly constrained by phylogenetic history. Phylogenetic bias is most pronounced among the Corvi, a large group of oscine passerines that radiated in Australia, and which has since spread throughout the world. Cooperative breeding and complex mating systems are massively overrepresented among this group. However, detailed studies reveal extraordinary diversity in the forms of social systems. Contrary to previous comparative studies, I argue that the problem is to explain the tendency to develop complexity, rather to view cooperative breeding and other complex systems as unitary phenomena. I show how the extreme lifespan of the Corvi makes retention of a small group of offspring in the natal territory extremely advantageous to parents, but leads to conflicts of interest which generate diverse evolutionary outcomes. As in the social insects, the evolution of complex social systems in birds may have a demographic basis.

THE BALANCE OF PLANT POPULATIONS

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Nicholson made lasting and fundamental contributions to theoretical ecology and experimental entomology. Here we show how his approach can foster an improved understanding of plant dynamics. The traditional model centres on the spatially uniform difference equation $N(t+1)=N(t).f(N(t))$ where the shape of the density dependence function $f(N(t))$ generally reflects the stabilising, contest type of competition typically associated with plants grown in experimental, high density populations. It is something of a struggle, however, to find real plant species whose life histories and ecological circumstances fit them comfortably into this mould. Non-clonal trees are fine, but their life cycles are too long to allow time-based demographic studies, and spatial studies are a less than perfect substitute. Annual plants are great, but most species live in such ephemeral, early successional communities, that their populations don't usually exhibit time-series dynamics of the standard, textbook kind; instead their brief periods of increase tend to be dictated by the disturbance regime, and their rapid declines are brought about by inter- rather than intra-specific competition, as a dense carpet of perennial vegetation becomes re-established and seedling recruitment is precluded. In other habitats, the rate of disturbance may be so high that seed produced by local reproduction becomes relatively unimportant, compared with the amount of seed that is imported from beyond the boundary of the study area. Here, local extinctions and local establishment become a prominent feature of the dynamics; these processes are hard, if not impossible, to handle with standard techniques. We doubt conventional metapopulation models, where the response variable is the proportion of patches occupied, are the best solution in cases of this kind. Instead, we use 2 recent case studies (communities of dune annuals and feral populations of oilseed rape) to introduce a new approach to modelling plant dynamics, which is Nicholsonian in its focus on mechanisms but which focuses explicitly on colonisation and extinction.

ECOLOGICAL CONSTRAINTS TO THE DEPLOYMENT OF ARTHROPOD RESISTANT CROP PLANTS: A CAUTIONARY TALE

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Recent advances in plant molecular biology have the potential to change the way that insect-resistant crop varieties are produced. In this paper we explore a range of ecological issues that need to be addressed if the potential of these new resistant host plants is to be fully exploited.

About 300 insect-resistant crop varieties are grown in different parts of the world and the majority of these are used in major cereal production systems. Traditionally, these cultivars have been the product of selection programs that use germplasm derived from geographical regions where the insect is endemic or the plant originated. Molecular technology offers the opportunity to insert novel sources of insect resistance in the host plant through the introduction of foreign primary gene products. This technology will influence both the rate at which new cultivars can be developed and, eventually, the range of novel resistance characteristics that can be incorporated into plants. These changes could have a profound effect on pest management practices. However, the impact of the synchronous use of resistant cultivars based on one or a few genes, across large regions and in different crop plants, will require careful management if this approach is to be sustainable. In addition, transgenic plants are only one component of integrated management practices and their influence on preferred agronomic characters and beneficial organisms needs careful evaluation.

In this paper we examine 1) how to develop deployment strategies that maintain susceptibility in the pest population, 2) the potential consequences of ontogenetic, seasonal and environmentally mediated expression of resistance traits, 3) the impact of the introduced foreign genes on plant fitness and the way "costs of resistance" and pest dynamics interact and 4) the potential consequences for multi-trophic interactions. These questions are explored through examination of the literature on insect-plant interactions and models of the dynamics of insect populations.

SOME RECENT DEVELOPMENTS IN THE MANAGEMENT OF MARINE LIVING RESOURCES

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Some recent developments in the management of marine living resources are reviewed to examine the changing relationship between ecological knowledge, including uncertainty, and the formulation of scientific advice on catch limits and other management measures. Two case studies are used to illustrate these developments. The first is the case of whaling where the Scientific Committee of the International Whaling Commission has developed a revised management procedure. Computer simulation modelling was extensively used to develop a procedure which was robust to the many uncertainties which had previously undermined scientific assessments in whaling management. The principles underlying this development are discussed, along with the methodology, and an outline of the way in which the procedure works, despite the inability to resolve major biological uncertainties. The second case study is for krill in the Antarctic for which the Scientific Committee for the Conservation of Antarctic Marine Living Resources has calculated precautionary catch limits for the South Atlantic and Western Indian Ocean sectors of the Southern Ocean. This development also relies heavily on computer simulations. The implications of these approaches are discussed, particularly in the interaction between resource management, computer modelling and ecological knowledge.

THE POPULATION BIOLOGY OF MARINE MAMMALS

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A number of features make the population dynamics of the approximately 110 extant species of pinnipeds and cetaceans unusual. Most pinnipeds and many large cetaceans have been subject to extensive commercial exploitation in the past. Their potential rate of increase varies by an order of magnitude between species: from nearly 20% per annum in some fur seals to 1-2% for some large whales. In the few cases where density dependent processes have been identified, these have only a weak effect on the dynamics of their populations. Recent events have suggested that rare, episodic mass mortalities (caused by disease or failure in the food supply) may have an important effect on population dynamics. Some species are hovering on the verge of extinction despite strenuous conservation attempts, whereas others have increased from a handful of individuals to population sizes of hundreds of thousands following the cessation of exploitation. Finally, there is growing public concern about the potential effect of pollution (in all its forms), over-fishing and climate change on the conservation status of marine mammals. In this paper, I shall describe the insights which theoretical population biology and detailed studies of the reproductive histories of individual whales and seals have provided into the importance of these features.

**EVOLUTIONARY THEORY AND THE FOUNDATIONS OF POPULATION
ECOLOGY: THE WORK OF A.J. NICHOLSON**

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A.J. Nicholson's work in evolutionary ecology is set in the context of the modern evolutionary synthesis. From early studies of mimicry in the 1920s to experimental investigations of natural selection in laboratory populations in the 1960s, Nicholson tried to clarify Darwin's theory, emphasising the ecological rather than the genetic standpoint. His contributions to evolutionary theory can be boiled down to three ideas. First, all purposive language had to be avoided when assessing the role of natural selection. Second, in order to understand the effects of natural selection on species survival, one had to understand how populations were regulated. Third, competition within the species was the key to understanding how populations were governed. Nicholson's arguments about population regulation greatly influenced David Lack at the University of Oxford, but his concept of the population as a self-regulating entity and his ideas about competition drew criticism from entomologists, in particular W.R. Thompson, H.G. Andrewartha, and L.C. Birch. Whether or not all of Nicholson's conclusions are accepted as valid, his point of view can be seen as still pertinent to modern debates about adaptation and to current concerns in conservation biology.

THE BALANCE OF WEED POPULATIONS

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The Nicholsonian themes of density dependence, competition, and host-parasitoid interactions, which have shaped animal population ecology, also loom large for population ecologists studying the biological control of weeds. Indeed, density dependence and competition are perhaps more easily investigated in plants than in insects. Examples are given of situations where disturbance has allowed weeds to flourish, and where strong density dependence has then regulated the weed population at its new higher abundance. Furthermore, some of the insights gained from the theory of arthropod host-parasitoid interactions can enhance our understanding of success and failure in the biological control of weeds. It is argued however that it will always be extremely difficult to make reliable predictions of success in biological control of weeds. This is because critical aspects of the interaction between the population of the weed and that of the control agent can only be known from field measurements following the release of the agent. What theory can do for us is indicate the level of performance our control agents will need to give in order to control the weed population.

FREQUENCY DEPENDENT COMPETITIVENESS AND THE STERILE INSECT RELEASE METHOD

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The competitiveness (C) of released, mass-reared *Lucilia cuprina* has been shown to vary as their frequency in the mating population changes. C declines as the frequency of released males increases. While the male *L. cuprina* carried a Y-autosome translocation, reanalysis of published data on certain sterile insect release method SIRM programs suggest that this effect is exhibited by other mass reared insects, and is not restricted to this particular *Lucilia* strain. Simple stochastic models are employed to determine the consequences of this phenomena to the efficacy of the SIRM. When C is frequency dependent, the overall cost of SIRM programs to eradicate target populations is increased as 1) it is necessary to release for a longer period, and 2) additional sterile males are required. This effect is especially evident when initial released : wild ratios are high which is commonly the approach employed. However, by monitoring the native population through the course of the release program and adjusting release numbers accordingly, acceptable competitiveness levels may be maintained. The financial benefits of such a strategy depend on the relative cost of rearing and releasing flies, but considerable savings can be expected for typical SIRM programs.

MOLECULAR ECOLOGY: CONTRIBUTIONS FROM MOLECULAR BIOLOGY TO POPULATION ECOLOGY

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Using traditional ecological methods, it is usually difficult to identify the boundaries of functionally independent populations and to measure the amount of migration between these. On a finer scale, estimates of relatedness based on observations are time-consuming and prone to error. Molecular ecology employs the tools of molecular biology to address these and other questions in population ecology. DNA fingerprinting provides precise identification of parentage, particularly where hypotheses derived from observations can be tested. It remains difficult, however, to pedigree unknown populations. The analysis of population structure from the geographic distribution of alleles has a long history; with DNA sequences we can now infer allelic relationships as well as distribution. The uses of this information are still being explored through development of theory and application to real populations. Preliminary indications are that inclusion of molecular differences between alleles may increase power to detect population subdivision, but may also reflect historical more than contemporary population processes. The combination of traditional ecological and genetic methods and the newer molecular approaches may therefore allow comparisons between long-term and current trends in migration and population size, providing a new perspective for ecologists.

LAND MANAGEMENT AND POPULATION ECOLOGY

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Land management is an increasingly all-inclusive concept widely discussed in today's scientific circles and in society, but whose breadth would have appeared unfamiliar to A.J. Nicholson and his colleagues. Population ecology in Nicholson's day concentrated on the factors causing population growth and limitation. In many cases, the search for understanding about these issues sprang from applied questions: how could this or that pest be controlled given better knowledge of its population dynamics? Today, we are trying hard not only to grasp fundamentals of the population ecology of many different types of organisms, but also to mesh that knowledge into a demanding framework of sustainable management and the conservation of biodiversity. How successful have Australian scientists been at achieving that goal? I ask this question, as an outsider to the particular research programs, with reference to several species constituting either pests or desirable resources: red kangaroos, *Macropus rufus*; plague locusts, *Chortoicetes terminifera*; Leadbeater's possum, *Gymnobelideus leadbeateri*; and perennial grasses of the pastoral lands.

FRONTIERS OF POPULATION ECOLOGY

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Population ecology has seen rapid advances on many fronts in recent years, especially on the theoretical side. Great improvements have been made, for example, in the modelling of the dynamics of disease, the spread of genetically altered organisms, the probability of persistence of rare and endangered species, the potential response of population and communities to large-scale environmental change, and the interaction of species in several trophic levels. We have chosen to emphasise two areas from among the many that could be discussed: modelling of population dynamics based directly on the properties of individual organisms, and spatially distributed populations, based again on interactions among individual organisms. The advantage of individual-based models is their potential for providing direct insight into real systems and for facilitating experimental tests of ideas about processes affecting population dynamics. We illustrate this potential with stage-structured models of parasitoid-host interactions in insects, and discuss advances needed to connect spatial models with real systems. The advances in modelling need to be matched with equivalent progress in experimental and observational analysis of real systems. This is perhaps more difficult to achieve. We discuss some promising examples and outline possible future research.

BIFURCATIONS, STRUCTURAL STABILITY AND PERSISTENT POPULATIONS - NEW INSIGHTS INTO CLASSICAL MODELS WITH HARVESTING AND STOCKING

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The construction and use of any mathematical or theoretical model in population biology requires assumptions about the populations which are being modelled. Changing the assumptions slightly or including extra assumptions may dramatically alter either the quantitative or qualitative outcomes of the model or both. Thus it is important to know whether a model is structurally stable; that is, how much its outcomes are likely to change with minor changes in formulation.

This question is explored for a group of classical predator-prey models of the MacArthur-Rosenzweig type. In particular it is shown how including harvesting or stocking of either predator or prey or both in the model can make the model behave in more complex ways than in the unharvested case. This behaviour can be hard to predict intuitively even in these very simple and well-known models. The effect of using different predator response functions in harvested predator-prey equations is also examined.

DECISION THEORY AND BIODIVERSITY MANAGEMENT: HOW TO MANAGE A METAPOPOPULATION

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Many ecological theories and concepts supposedly help us in applied nature conservation: island biogeography theory, metapopulation theory, theories of coexistence, and the notion of a minimum viable population size. Unfortunately these theories are not particularly useful because they are not couched within a management framework. Specifically, they only tell us which tactics are useful but they do not enable us to rank those tactics. Where resources are limited, we must be able to make the best decisions within the constraints of time and money. Those responsible for nature conservation have the task of making the decisions that will maximise conservation objectives. Logically then, we need to marry existing theories with decision theory tools to assist the management process. This marriage will lead to a theory of applied conservation management.

In this paper, I explore examples where decision theory is used to make nature conservation decisions. In particular, I consider the management of a metapopulation. In this case, the objective is to minimise the likelihood of extinction. Two real management options for minimising the likelihood of metapopulation extinction are to make more patches or recolonise empty patches. I show how Markov decision theory can be used to choose between these two management options and enable us to make optimal management decisions in a stochastic environment. Other problems to which this method is amenable, like optimal fires regimes for biodiversity, will be discussed.

ECOLOGY IN FISHERIES: SOME CONCLUSIONS FROM LONG-TERM RESEARCH ON EXPLOITED AND MANAGED MARINE FISH POPULATIONS

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Fisheries management involves a repeated sequence of assessment of the state of the population, prediction of the consequences of management options, selection of an option, implementation of the selected option, and monitoring the result. In an extreme application of Ockham's Razor fisheries scientists have applied simplified ecological concepts to understand the dynamics of exploited fish populations, and used these concepts in simple but mathematically precise formulations so as to withstand the rigours of adversarial inquiry. This approach has not been universally successful. The simplified ecological concepts have hindered further understanding of the spatial and temporal heterogeneity of marine populations and the interactions between them. Moreover, restrictions on the detail and quality of data collected from fisheries, and the far from ideal 'experimental design' provided by commercial fishing regimes, fundamentally limit the ability to identify population control processes. Nonetheless, fisheries research provides one of the very few means of observing the long-term response of whole marine populations to significant perturbations in population size, as the time and space scale of perturbation and observation are not usually feasible in other areas of marine ecological research. In particular, fisheries provides the results of repeated testing of predictions based on models of varying levels of ecological complexity, together with and long-term data sets from which some ecological hypotheses can be examined.

This paper summarises and discusses the fisheries experience regarding density dependent population parameters, ecosystem effects on population dynamics (the role of habitat, predation and competition) and environmental forcing. We then present current approaches in adaptive management and procedure based management; approaches that are designed to advance our knowledge of marine populations and improve the performance of scientific management advice. We argue that future success in fisheries management will not come from simplifying ecology to provide a single best estimate, but by embracing the perceived complexity of ecological systems and designing management strategies that are robust to the ramifications of that complexity.

MAMMAL POPULATIONS: REGULATION AND CONSERVATION

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Mammal populations have traditionally been seen as typically stable in comparison to other animal groups. Longterm observations and experiments now show that mammal populations can show a range of behaviours from extreme stability, regular limit cycles, chaotic oscillations, to climatically induced fluctuations. Evidence has accumulated on the mechanisms of regulation and limitation of populations as proposed by A.J. Nicholson, and also on causes of these mechanisms, particularly intraspecific competition and predation. Examples are chosen from a range of environments in tropical, temperate and arctic regions, and from small to large species. The important work in future lies in how this understanding can be applied to conservation by counteracting disturbance (human predation), habitat destruction and small populations.

PARASITOID FORAGING: THE EFFECTS OF VARIATION IN INDIVIDUAL BEHAVIOUR ON POPULATIONS

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The concept of 'searching efficiency' as introduced by Nicholson (1933) greatly influenced both the field of parasitoid searching behaviour and that of population dynamics. This paper will highlight recent considerations from empirical behavioural work on parasitoid foraging that have been rather neglected by theorists working at the population level, but that are fundamental to searching efficiency of parasitoids and so to parasitoid-host interactions. The first consideration is that parasitoids have evolved and function within a multitrophic context. It is becoming increasingly clear that the food plant of the host not only influences the development and behaviour of the herbivore but also that of the third trophic level, the parasitoid. The second consideration is that the behaviour of a parasitoid is a very dynamic characteristic, that is influenced both by the physiological state of the animal and by its experience. Here I will focus on learning as an important source of variability between and within individuals. First, I will show that learning by parasitoids is much directed towards the food plant of the host, which has ecological and evolutionary consequences for all three trophic levels. Second, I present evidence that learning essentially changes random search into highly directed search, thereby reducing interpatch travel times. I will also briefly discuss the assumption of 'omniscience' (eg. used in optimal foraging models) and the role of learning in the parasitoid's assessment of the profitability at the habitat and patch level. A final consideration deals with spatial aspects of parasitoid search. Although predator-prey models show that dispersal and movement between patches has great population dynamic consequences, the exact underlying behavioural mechanisms are rarely known. An example of our present work suggests that parasitoids adapt their searching strategy to specific host distribution patterns, which demonstrates that host population dynamics can affect the optimality of foraging decisions by the individual parasitoid. I will finish with a plea for incorporating tritrophic aspects and behavioural variation into population level studies. If nothing else, it would please Nicholson.

INTERACTIONS IN SPATIAL AND TEMPORAL PATTERNS OF INTERTIDAL POPULATIONS

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Abundances of many populations fluctuate from time to time and often these temporal fluctuations are very different from one patch of habitat to another. The statistical interaction between temporal and spatial variability is the focus of attention for detecting or estimating the magnitude of environmental perturbations. It deserves better understanding and the development of predictive capacity for environmental and theoretical studies.

Examples of patterns in space and time in the abundances of marine invertebrates will be discussed. These include the spatial variability in barnacles on sheltered and wave-exposed shores, the spatial and temporal patterns for several sessile species on exposed shores over several hundred kilometres of coast and the densities of littorinid snails, particularly at small spatial scales.

Analysis of patterns of variability is leading to explanatory models and the construction of testable hypotheses about scales and processes influencing patchy populations. Where appropriate, these will be discussed in the context of development of better tools for assessing anthropogenic environmental changes to natural populations.

SPATIAL MODELLING AND POPULATION ECOLOGY

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Geographers are usually concerned with spatial patterns and processes. They have developed techniques for analysing spatial data and for searching for spatial patterns. Among the set of tools that they routinely use are geographic information systems. Increasingly, this tool is being supplemented with a range of techniques for modelling spatial data.

As an outsider to research in population ecology, it appears to me many researchers in this field are unfamiliar with the range of these possibilities for analysing their data. Giving greater emphasis to temporal and spatial considerations may refine or even broaden the questions that they are addressing. How, for instance, would a spatial modeller address questions concerned with the dynamics of population relationships and how these might change over time, with a requirement to identify spatial relationships, for instance, between habitat and species composition, with questions concerned with environmental corridors or taxonomic structure. What lessons would a spatial modeller communicate about the spatial implications of scale and measurement techniques or about the implications of sampling method and survey bias on delineating species distributions and abundance.

Spatial modelling involves finding the right tool to answer the right question. As a spatial modeller, I would not presume to tell an ecologist what the right ecological questions are or indeed presume that as a group of ecologists, that you would even agree about these questions. As a spatial modeller, however, I see data sets which, because of the lack of appreciation of spatial considerations or about spatial modelling, lie under-utilised. This paper seeks to identify some of the analytical modelling options available to researchers in population ecology.

ECOLOGY OF PREDATOR/PREY AND PARASITOID/HOST SYSTEMS: PROGRESS SINCE NICHOLSON

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Nicholson's major influential work on parasitoid/host 'stability' modelling highlighted the importance of immigration as a factor likely to help avoid local extinction and aggregative behaviour by the parasitoid as a means of stabilising an otherwise unstable interaction. Subsequent detailed work on kairomones to attract searching parasitoids, host marking to avoid super-parasitism, host mortality from host-feeding, oviposition-induced host sterility etc all indicate a clear non-linear effect of host density on parasitoid foraging success illustrate the range of density dependent processes that may be active in host/parasitoid interactions.

The legacy of Nicholson in terms of predator-prey dynamics is evident in the concept of a 'balance of nature' derived from Nicholson's famous 1933 paper and from Smith's (1935) refinements. Nicholson also identified the role of spatial effects in stabilising inherently unstable models.

The relevance and importance of Nicholson's models to biological control is discussed. This paper will end by giving practical field examples which illustrate the persistence and relevance of Nicholsonian ideas to biological control as a component of integrated pest management.

ABSTRACTS
OF
CONTRIBUTED PAPERS



INDIRECT EFFECTS OF GRAZING GASTROPODS ON RECRUITMENT IN POPULATIONS OF SYDNEY ROCK OYSTERS

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Populations do not exist in isolation but commonly interact with other species in an assemblage. Indirect effects can occur if the presence and/or activity of a third species or taxon changes the effect that one species has on another. Although oyster farmers in New South Wales depend upon the natural recruitment of Sydney rock oysters, *Saccostrea commercialis*, the population ecology of this species in the context of the assemblage of organisms colonising oyster leases is poorly understood. In this study, grazing gastropods (*Austrocochlea constricta*, *Bembicium auratum*, *Patelloida mimula*) were experimentally excluded from areas during periods of recruitment of Sydney rock oysters. The presence of grazers significantly increased recruitment of oysters in experiments initiated in October 1993. The growth of algae inhibited settlement of oysters by pre-empting available space, therefore grazers indirectly increased oyster settlement by removing this algae. This effect did not occur in experiments initiated in January 1994, when algae did not grow enough to pre-empt much of the space before oysters recruited in February/March 1994. These results showed not only that grazers can have important indirect effects on oyster populations, but also that the detection of such effects depends upon the timing of the initiation of experiments with respect to oyster settlement.

ASSESSING EVOLUTIONARY INFERENCES GENERATED FROM MITOCHONDRIAL DNA: INFERENCES FROM *DROSOPHILA*

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Mitochondrial genes have been used extensively in evolutionary studies because of their uniparental mode of inheritance, high rate of evolution and relative simplicity of enzymatic amplification. They have also been widely used in population studies owing to the widespread belief that most of the variation within a species is selectively neutral and that its fate is governed primarily by the process of genetic drift. In this talk we critically examine evidence for the selective neutrality of mitochondrial variation and conclude that there is no compelling evidence for neutral evolution of mtDNA. We then review a recent battery of papers that challenges the assumption that mtDNA is evolving as a strictly neutral marker focusing on two parallel studies in *Drosophila*. We conclude by suggesting that researchers employing mtDNA as a marker for population ecology should incorporate a series of statistical tests into their analyses to investigate some of the forces shaping the evolution of the taxa under investigation.

POPULATION DYNAMICS BEYOND TWO SPECIES: HOSTS, PARASITOIDS AND PATHOGENS

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Population biology has been almost entirely concerned with single species and two-species interactions, in spite of a presumably universal recognition that no single species, nor any species-pair, exists in isolation. It is becoming increasingly clear, however, that a species' dynamic in a more realistic, three- or four-species setting is often only poorly predicted even by the dynamics of component two-species interactions. Hence, the study of three and four species systems, or 'community modules', offers the opportunity not only to improve our understanding of the dynamics of populations, but also to bridge the gap between population and community ecology by building a path directly from one towards the other. Moreover, recent advances mean that the study of these community modules can proceed, in tandem, both empirically and theoretically. These ideas are illustrated by empirical work on a system comprising two host insects, *Plodia interpunctella* and *Corcyra cephalonica*, their shared parasitoid, *Venturia canescens*, and the *P. interpunctella* granulosis virus (PiGV), and by theoretical work directed at this system. Particular attention is drawn to the underlying inseparability, despite convention, of predatory and competitive interactions, to the importance of the sequence of introduction of species into multi-species interactions, and to both the fundamental and the practical importance of work on community modules.

DENSITY PERTURBATION EXPERIMENTS FOR UNDERSTANDING POPULATION REGULATION

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We review the use of experimental manipulations of population density to test for the existence and causes of regulation. Relatively few such studies have been performed, but they typically show clearer evidence for regulation than do the far more abundant census and life-table studies. Potentially regulating density dependence is nearly always exerted by the lower trophic level (food quality as well as quantity), rather than by predators or parasitoids. Such bottom-up effects were prevalent even among herbivorous insects, albeit at a lower frequency than in other taxa. Unfortunately, many studies finding density dependence lack critical information that would allow us to infer regulation. We discuss the "ideal" experimental design for detecting regulation and examine the difficult issue of when temporal density dependence may be inferred from the results of spatial manipulations of density.

SPATIAL VARIATION IN FOOD LIMITATION: THE EFFECTS OF FORAGING CONSTRAINTS ON THE DISTRIBUTION AND ABUNDANCE OF FERAL PIGS IN THE RANGELANDS

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While the distribution and abundance of animals is a consequence of factors which affect density both temporally and spatially, models which describe variation in animal abundance have clearly focussed on temporal variation. In contrast, models of variation in individual fitness have emphasised the influence of spatial components of the animals environment on reproductive success/survival. Spatial factors which affect the fate of individual animals should logically have spatial consequences for the populations they constitute. In this paper we argue that spatial effects have consequences for (1) the probability of a species occurrence and persistence at a given location, and (2) the prevailing density of a species where it does occur. The influence of spatial environmental variation on distribution and abundance is demonstrated for feral pigs inhabiting inland river systems in Australia's rangelands. A habitat-related constraint on the movements of pigs during hot, dry weather appears to affect their foraging efficiency, compounding the rate at which populations decline when food is short wherever shade and water is scarce. Further, stochastic simulation modelling indicates that the spatial distribution of shade and water in this environment ultimately determines the average density of pig populations and whether these populations (1) persist indefinitely, (2) occur periodically, or (3) are non-viable (ie: undergo deterministic extinction).

LONG-TERM TRENDS IN INVERTEBRATE POPULATIONS IN CONTRASTING PESTICIDE REGIMES: PERTURBATIONS TO NICHOLSONIAN TRENDS?

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Nicholson addressed, the issue of fluctuations, cycles and persistence in single-species and parasite-host populations. The use of laboratory arenas and his six assumptions about parasitoid-host dynamics produced models which led to a long-lasting paradigm within which some population ecologists are still working. Those assumptions did, however, limit the domain within which population ecology could operate, confining progress to simplistic interactions between monophagous parasitoids and populations of their hosts which did not seem to exhibit density-dependence through intraspecific competition. This paper contrasts this population framework with the very different population processes operating within an ecosystem comprising hundreds of species of parasitoids and predators, of which many are polyphagous and whose populations are regularly perturbed by agricultural practices.

Long-term population experiments in arable ecosystems in the UK began in the early 1980s. They have revealed counter-intuitive effects of population disturbances, in which predator-prey dynamics have changed markedly in the long term, with some predator species' becoming extinct over a wide area and others of the same "guild" seeming to take over their ecological niche. Data from the long-term UK "Boxworth" and "SCARAB" projects will be used to illustrate the assertion that Nicholsonian theory has little to contribute to the understanding of population dynamics of the scale of large field "arenas" comprising a diverse community of competing herbivores and polyphagous predators, whose populations are regularly perturbed by agricultural practices.

THE GENETIC AND ENVIRONMENTAL COMPONENTS OF HOST DEPENDANT STRATIFICATION OF HERBIVOROUS INSECT POPULATIONS

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Numerous studies on the biology of various species of herbivorous insect have demonstrated marked variability in fitness among different genotypes with respect to different species of host. However, a firm link between biological variation and population structure at the genetic level has not yet been demonstrated. Here, we firstly describe the evidence from various studies of herbivorous insects for genetic variation in population structure based on host utilisation. We then explore the underlying genetic and environmental causes of this variation and discuss the evidence for trade-offs in host utilisation and conditioning. Finally, we discuss our own evidence from studies of the grain aphid, *Sitobion avenae* (F.) using DNA fingerprinting and reciprocal host transfer studies, for the roles of trade-offs in host utilisation and conditioning in creating the host based population stratification found between wheat and wild grasses in southern England.

POPULATION TRAJECTORIES THROUGH SPACE AND TIME: A HOLISTIC APPROACH TO INSECT MIGRATION

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The capacity of mobile organisms to migrate adds a new dimension to Nicholson's concept of population regulation through density dependence. Migrants can vacate a habitat as conditions become limiting, and colonise another that may provide, at least temporarily, a better environment for population growth. Such processes occur frequently and have been well documented for migratory insect species that are serious pests. Concerted research on insect migration over the last 2-3 decades has provided a series of insights which can now be synthesised into a holistic description of a "migration system".

Migration occurs within a physical and biotic "arena" that changes in quality in both space and time; it results not only in the relocation of populations but also often in their subdivision and later recombination; it is a behavioural process often strongly influenced by environmental factors; and it is maintained by a genetic complex and the action of contemporary natural selection upon it. A conceptual model incorporating all these components forms a convenient basis for an examination of the role of mobility in population ecology.

SIMULATING SPATIALLY DISTRIBUTED POPULATIONS

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An approach to spatial population modelling that attempts to combine pragmatism and conceptual clarity is outlined. The model is motivated by a need to understand the dynamics of the Australian brushtail possum (*Trichosurus vulpecula*) introduced to New Zealand where it now seriously affects native plants and animals and transmits bovine tuberculosis to cattle and farmed deer. Since global eradication is currently impossible, management practices aim to achieve sufficient local reductions in density to protect selected conservation values, to reduce disease transmission to livestock, and to prevent disease spread.

Attempts to model complex scenarios of patchy control of possums encountered the fundamental problem of how to represent a population of dispersed individuals. A map of point locations is inadequate as each animal has a home range in which it interacts with its resource base and other animals. Population density may be represented as a continuous surface, but this loses the 'particulate' nature of individuals required for modelling stochastic birth, death and dispersal processes. Models which assign individuals to grid squares larger than the average home range are inadequate because they impose an arbitrary metapopulation structure and spatial resolution is lost. I chose to store a map of individual point locations, but to relate density-dependent processes to a density surface constructed by summing the parametric home range utilisation distributions of individual animals. Point locations and the density surface are stored as raster GIS files using a pixel size much less than the home range so as to retain spatial resolution. Maps of intrinsic growth rate and local carrying capacity are also stored. The simulation model allows individuals to breed, die or disperse with probabilities dependent on the relationship between local density and local carrying capacity. The model forms the core of a system for rational pest management on scales exceeding 2000 km².

INFLUENCE OF VARIABLE HOST TREE QUALITIES ON THE POPULATION DYNAMICS OF SAP-FEEDING FOREST AND WOODLAND INSECTS

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Host plant qualities affecting psyllid population dynamics on eucalypts in Australia are compared with a number of northern hemisphere sap-feeding pests of forest trees. Temporal variation in the population size of *Cardiaspina* spp feeding on red gums in Australia is greatly affected by leaf phenology while spatial variation can be affected by leaf cuticle properties and nitrogen content. The role of nitrogen content as a cause or result of intense insect feeding is discussed. The relative importance of physical, chemical and nutritional qualities and phenology of host trees is reviewed for sap feeding insects on forest or woodland trees.

INSECT DEFOLIATOR POPULATION PROCESSES IN CANADA'S FORESTS IN A WARMING CLIMATE

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Insect defoliator populations are a dominating disturbance factor in Canada's forests and during outbreaks, trees are often killed over vast areas. If the predicted climate shifts occur, the damage patterns caused by insects may be substantially changed, particularly for insects with temporal and spatial distributions that are very dependent on climatic factors.

Available information is examined and scenarios developed describing how key processes in outbreak systems involving forest insect defoliators might respond to climate warming. Spruce budworm, *Choristoneura fumiferana* Clem. (Lepidoptera: Tortricidae), is used as an illustrative case study. Recent research indicates that climate warming may already be influencing some insect lifecycles and it is suggested that natural selection may be a significant process in the response of insects to climate warming. The importance of threshold effects, rare but extreme events, phenological synchrony, and transient dynamics is emphasised, and the inadequacy of 'equilibrium' models for forest pest systems is discussed. Some thoughts on improving forecasts of insect responses to climate warming are presented.

MORTALITY OF THE BUNNY-TAILED MOTH, *OCHROGASTER LUNIFER*, AT DIFFERENT SPATIAL SCALES

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Studies of the effect of mortality factors on population size are usually carried out in one or, at best, a few localities. In this study, mortality and development were measured at various life stages of the bunny-tailed moth (*Ochrogaster lunifer* Herrich-Schaeffer) across an area of 5600 km² in SE Queensland. Egg batches and larval cohorts were monitored on 2050 acacia plants at 70 sites in 35 localities, with 3 - 52 plants sampled at each site. An additional 2000 acacias were sampled growing on mining rehabilitation areas on North Stradbroke Island. Greatest mortalities occurred at the egg and early larval instar stages at all localities, however total mortality varied considerably from plant to plant and from site to site. Caterpillar development was also highly variable. Mortality factors that were quantified included egg predators, and egg and larval parasitoids, with the majority of mortalities due to unknown factors. Egg predation by dermestid beetles was heavy on the mined areas (41% mortality) but the effect of this predator was not found at other sites on Stradbroke Island or on the mainland. Egg parasitoids were extremely patchy and varied from site to site and from plant to plant within the same site. Unlike the dermestid beetles, parasitoids were found at sites over a large geographic area. Caterpillar deaths due to a tachinid parasitoid were similarly patchy on local and geographic scales. This study shows that spatial variation in factors affecting survival and development can be considerable, and highlights the need for multi-scale studies in population ecology.

DETECTING DENSITY DEPENDENCE

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Recently, there have been a number of papers comparing the performance of tests of density dependence. It appears that the difficulties of designing a comparative study, and of searching for an optimal test to perform with a range of different conditions, frequently result in fuzzy conclusions. There does not appear to be a globally optimal test for density dependence, and claims of the superiority of one test over another are usually true only under certain prescribed circumstances. We advocate the use of Bulmer's first test as a standard because it makes few assumptions about the data and is robust to departures from normality. It is simple to compute the values of both test statistics and critical values on a hand calculator, and it performs well under a wide range of conditions. It is essentially a test of the autocorrelation in the log transformed abundance data. Bulmer's test is adversely affected by temporal trends in data, but these can be induced by atypical initial values. Methods of detecting aberrant starting values are suggested, and we suggest removing them prior to analysis. Bulmer's test has been criticised for its poor performance in the presence of autocorrelated errors. We show that this is a consequence of structural changes to the assumed model and will therefore be a characteristic of any test which relies on autocorrelation to detect density dependence.

FIRE AND THE POPULATION ECOLOGY OF INVASIVE SHRUBS IN TROPICAL WOODLANDS

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Fire has been an important factor in the evolution and ecology of Australian tropical woodlands. The advent of pastoralism saw the continued use of fire but, in recent decades, fire frequency has apparently diminished in many areas due to reduced fuel availability. Also notable, particularly in the eastern tropical woodlands, has been the spread and increase of exotic shrubs such as *Cryptostegia grandiflora* and *Ziziphus mauritiana*. Both species cause problems for pastoral industries and are likely to induce significant change in woodland communities.

What is the potential for using fire as a tool in the management of exotic shrubs in the extensive tropical woodlands? Fire could influence any of several stages in a shrub's life cycle and so alter the population structure and rates of increase and spread. It is conceivable that fire could reduce the population of recently dispersed seeds on the soil surface; the survival rates of seedlings, juvenile and established plants; and the seed output of established plants. This paper will report on work at Lansdown Research Station south of Townsville, that is examining responses of these life stages to single and repeated fires and the prospects for using fire in control and containment strategies for these and other invasive shrubs in the tropical woodlands.

DENSITY DEPENDENCE VERSUS MIGRATION IN APHIDS: AN INDIVIDUAL - BASED MODEL

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An individual based model is presented, which incorporates all that is known about the biology of tree-dwelling aphids. It simulates most of the observed features of their population dynamics: a sharp increase in numbers during the first 15-40 days, followed by a sharp decline to a plateau of low numbers in summer and a recovery in autumn, in some years. The larger the numbers at the beginning of the season, the larger and earlier the peak. Migration is shown to be the most important factor determining the summer decline in abundance, while changes in aphid size and food quality account for the autumnal increase being less steep than in spring. Finally, the model suggests a possibility of a negative correlation between spring and autumn peak numbers in some cases. The predictions and conclusions are compared with an extensive data set on the population dynamics of the Turkey oak aphid *Myzocallis boerneri*.

The model outputs indicate that migration is important in shaping the population dynamics. This increases linearly with density and declines with improving food quality. The strong effect of migration on the overall population dynamics results in the density dependent effects on fecundity and mortality being minimal.

COMPARATIVE POPULATION DYNAMICS OF TWO INSECT PATHOGENS

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In a series of long term population cages it was noticed that the incidence of the Granulosis virus (GV) of *Plodia interpunctella*, the Indian Meal Moth, was generally much higher than that of *Bacillus thuringiensis* (Bt) infecting the same host. Moreover, the age classes of individuals infected were different depending on the pathogen, with Bt typically infecting the later host instars and GV the earlier.

It was thought that the comparative transmission dynamics of the two pathogens would provide an explanation for this, and to this end the transmission coefficient was measured for each pathogen at a variety of densities of susceptible and infected hosts and for a number of different age classes, and was found to correspond with the previously observed pattern. The transmission coefficient also varied considerably with density of both susceptible and infected hosts, which has implications for many theoretical studies, which assume it to be constant at all densities.

VERTEBRATE COMMUNITY ORGANISATION IN THE BOREAL FORESTS OF CANADA'S YUKON

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The snowshoe hare (*Lepus americanus*) is a keystone species in the boreal forests of northern Canada. Because populations of snowshoe hares cycle with a 9-10 year period, the entire vertebrate community is subjected to a massive change in prey abundance. In this study we have been attempting to understand the impacts of the hare cycle on the other herbivores and the predators in this community. The major herbivores are the red squirrel and the arctic ground squirrel. The major predators are the Canada lynx, the coyote, and the great-horned owl. Since 1986, we have manipulated both predation using large electrified exclosures and plant production using aerial fertilisation. The results are largely consistent with the top-down model of community organisation in which predators control the snowshoe hare cycle. Not all the alternate prey in the forest are as strongly affected by predation as are the hares, and we are attempting to see how much of this community can be described by the conventional models of community organisation and how much is a unique combination of the individualistic species in the community. What is certain is that interspecific competition plays no role in the changes we have studied. We have completed 8 years of a 10 years study and will summarise our current understanding in this presentation.

NATAL DISPERSAL UNDER THE INFLUENCE OF COMPETITION

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Previous attempts to model effects of competition on natal dispersal distance have considered effects of competition between territorial residents and dispersers and effects of competition among nest-mates. Such models may be expressed in terms of an exponential model of dispersal, in which an individual moves in a straight line to the first encountered vacancy, where vacancies are arranged randomly in space. These models suggest that competition will increase dispersal distances, but they do not include competition among dispersers from multiple nests. In this paper, the exponential model of dispersal is modified to incorporate competition among individuals that disperse simultaneously or sequentially from multiple nests. Analytical solutions of these models demonstrate that competition among identical dispersers may have a significant influence on dispersal patterns and that competition alone may cause large variation in dispersal distances. A novel and somewhat counter-intuitive result is that competition among individuals may increase or decrease dispersal distances depending on the nature and magnitude of competition. When individuals disperse simultaneously from multiple nests and the number of dispersers exceeds the number of vacant territories, individuals that are close to vacancies are more likely to successfully disperse and dispersal distances will decline. Competition among dispersers can help to explain observed dispersal distances in banner-tailed kangaroo rats.

IS LONG-TERM PERSISTENCE OF HARVESTED POPULATIONS PROOF OF DENSITY DEPENDENCE?

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In exploited populations, which may be understood as inadvertent long-term manipulation experiments, life span and lifetime egg production of an average female are truncated. These populations persist over many generations, and may be considered to be in a new steady state. Under assumptions of steady state, lifetime egg production per female may be estimated in two ways: (1) For an unexploited population, it is deduced from age structure derived from estimates of natural mortality, combined with age-specific fecundity. (2) For exploited populations, it is shown to equal average annual recruitment divided by average annual egg production as measured by survey. Comparing the cases of pre- and post-exploitation in the Georges Bank scallop population yields a survival rate estimate from egg to age 2 that is 100-600 times greater under harvesting. Higher average survival of spawn in the population subject to rapid removal of adults implies density dependence.

A THEORETICAL STUDY OF NEMATODES AS BIOLOGICAL PEST CONTROL AGENTS

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There has been a great deal of interest in the use of entomopathogenic nematodes (*Steinernematidae* and *Heterorhabditidae*) in the control of agricultural pests. So far, the work in this area has been empirical, either in the form of laboratory experiments or field trials. The current work involves the use of a simple mathematical model to explore the conditions under which nematodes could be viable control agents. These conditions are given in terms of the biological parameter values used to describe the dynamics of both populations.

INTERACTION OF TEMPERATURE AND RESOURCES IN POPULATION DYNAMICS: THEORY AND AN EXPERIMENTAL TEST

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Much debate in ecology has focused on the roles of density-independent factors (e.g. temperature) and density-dependent factors (e.g. resources) in regulating populations of animals, particularly ectotherms. A simple mechanistic model of population growth with parameters expressed as general functions of temperature is presented. The model predicts that, under most conditions, increased temperature should lead to greater maximum growth rates, lower equilibrium densities, and a greater likelihood of unstable dynamics. I tested these predictions by monitoring mortality in grasshopper (Orthoptera: Acrididae) populations stocked at different densities in replicate field cages and subjected to one of three different temperature treatments (shaded, unshaded control, and unshaded greenhouse). Populations differed among treatments in density-dependent mortality but not density-independent mortality. Equilibrium densities were significantly lower and per capita mortality rates were significantly higher with increased temperature. Unshaded treatments led to per capita mortality rates large enough to produce chaos in a simple mechanistic model of population growth. These results support the predictions of the model and suggest that population dynamics of ectotherms can be better understood by considering the effect of temperature on important population growth mechanisms.

POPULATION DYNAMICS OF TREE-DWELLING APHIDS: THE IMPORTANCE OF SEASONALITY AND TIME SCALE

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Long-term census data of the annual abundances of aphids have been analysed with the objective of determining the incidence and nature of the density dependence acting on these species (Turchin & Taylor, 1992; Woivod & Hanski, 1992). Aphids develop very quickly, have a very high rate of increase and their abundance is greatly affected by seasonal changes in the quality of their host plants. The use of annual abundances avoids the curse of seasonality but obscures the time scale over which the density dependence acts.

Changes in the weekly abundance of the Turkey-oak aphid, *Myzocallis beorneri*, from 1975-1992 have been analysed. The time scale used in the analysis and seasonality determined the kinds of dynamical relationships extracted from the census data. Analysis of the weekly density data and the corresponding monthly aggregates, without adjustment for seasonal changes, indicated the presence of time-delayed density feedback loops. Analysis of the monthly data adjusted for seasonal effects indicated regulation around a seasonal mean density without any significant contribution of time-delayed density effects.

DOES ESCAPE FROM PREDATION IMPROVE THE EFFECTIVENESS OF BIOCONTROL AGENTS AGAINST THE THISTLE *CARDUUS NUTANS*?

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It is largely accepted that biological control agents are more effective when free of their natural enemies. This implies that natural enemies play a key role in the population dynamics of agents in their native range and therefore release from this mortality will lead to a rapid increase in population growth.

This paper presents data on the population dynamics, from both native and introduced regions, of two biological control agents released against the thistle *Carduus nutans*. *Rhinocyllus conicus*, a receptacle weevil that has successfully controlled the target weed in North America, suffers high levels of infection by a microsporidian disease, *Nosema* sp., in the native range, which reduces fecundity and survivorship. Parasitoids also account for an average of 25% (range 0-100) mortality of eggs and an average of 8% (range 0-100) mortality of mature larvae. *Urophora solstitialis*, a receptacle galling tephritid fly released only recently also suffers 30 to 90% larval parasitism in the native range. Data suggest that *R. conicus* is having no greater an impact on its host where introduced than in the native range. In this species it appears that increased scramble competition between larval stages following escape from natural enemies has prevented a significant increase in population growth rate. This example is compared with data from *U. solstitialis* and put in context via a mini-review of empirical studies showing that biological control has benefited from predator release.

MOLECULAR ECOLOGY OF AN INVADING GALLFORMING INSECT

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Over the last 300-400 years, the host-alternating cynipid gallwasp *Andricus quercuscalicis* has invaded northern and western Europe following human introduction of an obligate host plant, the Turkey oak (*Quercus cerris*) from south eastern Europe. In the introduced range, Turkey oak patches are relatively few, and far apart. A total of nearly 1400 gallwasps from 60 populations were scored for 8 polymorphic allozymes. Both allelic diversity and mean heterozygosity decreased significantly with distance from the native range. Genetic distance from hypothesised ancestral states increased linearly with distance from the native range. Genetic subdivision was substantially greater in the invaded- than native range. This conclusion was supported by autocorrelation analyses of allele frequencies, used in this study for the first time to demonstrate variation in levels of genetic substructuring through the range of an invading species. We suggest that patterns of genetic variation are the results of strong directional migration followed by limited gene flow between populations. We hypothesise that across western Europe, populations of *A. quercuscalicis* have been founded sequentially from the east through a process of serial random genetic subsampling through very small numbers of founders.

SOURCES OF STABILITY IN HOST-PARASITOID DYNAMICS

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The initial challenge for the theory of host-parasitoid dynamics was to discover possible sources of stability to counteract the seemingly intrinsic instability of these systems. The current challenge, however, is to make sense of the wide variety of possible stabilising mechanisms which have been suggested. Realistic modifications of every part of the Nicholson-Bailey model have been proposed and shown to be stabilising. These stabilising mechanisms not only are not mutually exclusive, but often interact with one another; the effect of one factor may depend on the value of some other factor. Furthermore, seemingly similar biological phenomena can have fundamentally different dynamical effects. These points will be illustrated using models of "aggregation of risk," of superparasitism and "within-host competition," and of non-lethal parasitism.

The task facing theoreticians is to integrate these various parts into a coherent whole; the task for empirical research is to determine which factors are important in particular natural systems. It will be suggested that the key to meeting both these challenges will be to focus on the fundamental Nicholsonian concept of temporally density-dependent population regulation.

THE ROLE OF MUTUALISMS IN PLANT POPULATION DYNAMICS

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The flux of individuals within populations is dependent upon six controlling processes: the intrinsic rate of increase of the plant, intraspecific competition for resources, interspecific competition, natural enemies, mutualisms and refuge effects such as the immigration of seeds from other populations. In considering the role of population interactions as determinants of population size, most attention has focussed on competition and natural enemies, such as herbivores and pathogens, while the role of mutualists has been largely ignored. There is not even a sound theoretical framework for the treatment of mutualistic interactions. The lack of a theoretical framework is, though, perhaps the least of our problems. Demonstrating empirically that mutualistic interactions play a part in the population dynamics of plants is a major problem in itself. For mycorrhizal fungi, which are generally regarded to be mutualistic plants, there are severe technical problems in studying the dynamics of an interaction that occurs below ground and of experimentally manipulating the system.

In this paper, the results from a series of experiments are described, in which the fungicide benomyl has been used to investigate the role that arbuscular mycorrhizal (AM) fungi play in the population dynamics of the winter grass annual, *Vulpia ciliata*. Inevitably using benomyl to reduce AM colonisation also has consequences for other fungi, such as pathogens, that infect the roots. Reduction in AM colonisation at different sites and in different years has variable consequences for the finite rate of population increase in the plant. Initial estimates indicated that the benefit of AM fungi to the fitness of the plant might be in excess of 30%. It has subsequently been shown that the reduction in AM colonisation has no consequences for the mineral nutrition of the plant, and that the chief benefit of mycorrhizal fungi to the plant might be through providing protection against pathogens, which have been shown to reduce fecundity by up to 50%. Recent transplant experiments, with infected and non-infected plants, have confirmed that AM fungi do indeed protect plants from pathogen attack and may play a major role in plant population dynamics. Quantifying the role of mycorrhizal plants in the population dynamics of plants, nevertheless, remains a daunting problem as the fungal flora, just as the plant population, shows considerable variation both in time and space.

RESPONSES OF WILD RABBIT POPULATIONS TO IMPOSED STERILITY**K. Williams¹ & L. Twigg²**¹ CSIRO Division of Wildlife and Ecology, GPO Box 84, Lyneham, ACT 2601, Australia² Agriculture Protection Board, Western Australia

Wild European rabbits continue to impact on Australian agriculture and native biota. Research seeking to reduce the impact includes an attempt to reduce rabbit fertility by contagious transmission of a genetically modified myxoma virus that induces immunocontraception.

The efficacy of reducing fertility in wild rabbit populations as a means of reducing rabbit abundance is being examined in two similar experiments in south-western and south-eastern Australia, each on 12 discrete populations. In the first year, proportions of 0%, 40%, 60% or 80% of all females in the respective populations were sterilised randomly by surgical ligation of fallopian tubes. In the second year the female recruits were sterilised at the same levels.

Results from the first year indicate that some processes tend to constrain reduction in wild rabbit abundance. At the end of the first breeding season following the imposition of sterility, the populations with higher levels of sterility contained significantly fewer rabbits, but abundances became similar among treatment levels after the period of summer mortality. For adult rabbits, measures of survival, loss and immigration were unaffected by the level of sterility. However, populations with higher levels of sterility produced fewer juveniles, but a higher proportion of these were recruited by the end of summer. Thereby, a reduction in mortality of juveniles compensated for the reduction in production of young caused by sterilisation. These results suggest that resources limited the rabbit populations during summer when an excess of young produced was lost. It is too early to assess the implications for fertility control as a means of reducing abundance of wild rabbits because any responses in survival and abundance of adult rabbits to sterility are likely to be more protracted than for kittens and are yet to be documented.



**ABSTRACTS
OF
POSTERS**



SYSTEMATICS - HOW IT UNDERPINS ECOLOGICAL STUDIES ON PARASITIC WASPS USED IN BIOLOGICAL CONTROL

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The parasitic Hymenoptera is a huge assemblage of species which contribute the majority of biological control agents used against insect pests in agricultural systems. The accurate identification of potential agents represents a critical element in any ecological study. This is particularly so in biological control where long-term and costly studies are involved prior to release of parasitoids, and the results of misidentification are serious. Further, basic research on the phylogenetics of critical groups provide an evolutionary framework which guide comparative research on the ecology and behaviour of parasitoids and related studies on their host relationships and specificity. Most importantly, fully resolved phylogenies provide a powerful tool by which biological predictions can be made about the relationships and biology of undescribed taxa. Here we outline current research on the molecular phylogeny of the parasitic Hymenoptera, and projects aimed at revising the taxonomy of critical groups of parasitoids associated with such pests as locusts, heliothine moths, *Etiella*, *Phylacteophaga* and *Phoracantha* in support of biological control projects in Australia and overseas.

ECOLOGY AND CONTROL OF INTRODUCED HELICID SNAILS IN AUSTRALIA

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Mediterranean white and conical snails (*Theba pisana*, *Ceriuella virgata*, *Cochlicella acuta* and *C. barbara*) (Mollusca: Helicidae) are important introduced pests of cereals and legume crops, pastures and vineyards in southern Australia. The snails cause feeding damage to plants, foul herbage with their slime and, because of their habit of aestivating on the stalks, heads and pods of cereals and legumes and amongst bunches of grapes, also clog farm machinery and contaminate crops at harvest. The distributions of the snails are increasing in Australia.

Broad-acre chemical control of snails is generally uneconomic. Barrier treatments with molluscicides may be used to reduce invasions of snails from heavily infested areas (e.g. pastures and road-sides into adjacent "clean crops"). Burning fields prior to sowing crops can be very efficient in reducing snail numbers. However, regular burning of fields is unsustainable because of the loss of stock fodder and seed bank, reduction in nutrient return to the soil and increased risk of erosion (particularly in sandy soils where the snails are most abundant).

Surveys for potential biological control agents have been conducted within the snails' native distribution, the western Mediterranean. Several insect parasitoids have been identified (e.g. calliphorid, sarcophagid, phorid and sciomyzid flies). Two sarcophagids, *Sarcophaga uncicurva* which attacks *Theba* and *Ceriuella* and *S. penicillata* which attacks *Cochlicella*, appear promising as control agents. These flies can parasitise large numbers of their host snails in Europe but are in turn heavily hyper-parasitised there (e.g. by the pteromalid wasp, *Novitzkyanus cryptogaster*). *S. uncicurva* and *S. penicillata* are being imported into Australia for host-specificity testing against native Australian snails.

THE POPULATION DYNAMICS OF THE GROUSE - HARE - TICK - LOUPING ILL SYSTEM

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Louping ill is a tick-borne disease which occurs in Scotland and the North of England. Only sheep and red grouse (*Lagopus lagopus scoticus*) show clinical signs of the disease and produce high enough levels of viraemia to transmit the disease to the tick (*Ixodes ricinus*) which acts as a vector. However, many other vertebrate species can be host to the tick and hence help to maintain the disease by amplifying the tick population. In particular, whilst the disease has been controlled in sheep via a vaccine, it is a major problem on grouse moors and it appears that this is partly due to the large numbers of mountain hares (*Lepus timidus*) which are present.

Several mathematical models have been formulated to study the population dynamics of the grouse - hare - tick - louping ill system. They show that the long term outcome of the system depends on two basic reproductive rates, one for the ticks and one for louping ill. The conditions determining which outcome occurs (for example whether the disease regulates the grouse population) can be expressed using joint (grouse - hare) threshold density curves. One important application is to the evaluation of the indirect impact of a tick host (the hare) which does not suffer from the tick-borne disease on a tick host (the grouse) which does.

POPULATION ECOLOGY AS A BASIS FOR *ACACIA NILOTICA* CONTROL STRATEGIES

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Acacia nilotica is an introduced, leguminous shrub rapidly increasing in the Mitchell Grasslands of western Queensland. The result has been the conversion of an open, treeless grassland to a shrub woodland. However, much of the region remains open or occupied at low densities and it is important that strategies to contain the invasion be implemented. We examined the temporal patterns of increase over the past three decades using aerial photography to determine if climatic events explained recent population expansions and could be used to predict future increases. Two periods of above average precipitation for consecutive years have occurred in the past half century. From 1955 to 1960 precipitation exceeded average (460 mm) every year. During the ensuing period (1960 to 1974) there was no significant increase in either area occupied or density. However, there were significant increases in both area occupied (93%) and in density (2.2 vs 81.1 trees/ha) between 1974 and 1994 following a five-year period of above average rainfall (1971-1976). Our observations of glasshouse and field planted populations suggest that *Acacia* is capable of germinating, establishing and surviving in well below normal seasons. Concurrent with the observed increase over the past 25 years was a shift in the dominant grazing animal from sheep (poor dispersal vectors) to cattle (effective dispersal vectors). In addition, our observations of glasshouse and field populations suggest that *Acacia* is capable of germinating, establishing and surviving in periods of years of below average rainfall and under high levels of competition from herbaceous vegetation. We conclude that the recent increases in density and extent of *Acacia nilotica* are the result of a change in dispersal vectors and that control of livestock movements should be a basic element of a strategy designed to contain populations.

NATIVE TASMANIAN VERTEBRATE POPULATIONS AND BROWSING DAMAGE IN TIMBER PLANTATIONS

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In Tasmania a number of browsing animals including the Brush-tailed possum (*Trichosurus vulpecula*), Bennets wallaby (*Macropus rufogriseus*) and Tasmanian pademelon (*Thylogale billardierrri*) are known to cause considerable damage to commercial timber plantations. To limit this damage, forestry bodies have generally aimed to reduce the local population densities of these species. Unfortunately managers are largely unable to predict the population density of browsing species at any given site. Consequently population control tends to be carried out as a matter of course at new plantations. It is uneconomic and not in accord with conservation values to adopt such a strategy in areas where population density, and presumably the potential for damage, is already low. In this paper I report on a work in progress which aims to elucidate the relationships between levels of browsing damage, local wallaby population densities and site characteristics. It is hoped that a predictive model can be developed for use as a 'risk assessment' tool. Such a model has direct applications for refining current damage control practices.

LOCUST INFESTATION IN CENTRAL LUZON, PHILIPPINES

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Records show that the Philippines has been experiencing locust infestation at intervals of 10 to 11 years on the average since 1569-1572. The last infestation of *Locusta migratoria manilensis* Meyen in Central Luzon, prior to the present occurred in 1932.

Recently an outbreak of locust infestation occurred in Central Luzon, Philippines. This infestation initially affected 29 barangays in 5 municipalities of Bataan and Zambales with infested area totalling 1,009ha in 1993. It now affects 151 barangays in 30 municipalities involving 4,232ha with the inclusion of Pampanga and Tarlac as of 8 June 1994 and shows no signs of waning. Mount Redondo in Cawag, Subic Zambales apparently is the origin or outbreak area of the locust population. The El Nino phenomenon and the Mt Pinatubo eruption are the most logical factors that may have induced the present outbreak.

IPM ADVISORY FOR EGGPLANT, *SOLANUM MELONGENA* LINN PESTS

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An IPM advisory for eggplant pests was done using the Personal Consultant Easy (PC Easy) software program. Four arthropod pests and six diseases were considered. IPM advisories from sowing to harvesting were laid out. These advisories are now being tested in the field.

YIELD LOSS ASSESSMENT OF *POMACEA* SPP. DAMAGE IN LOWLAND RICE

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An experiment to determine the effect of time of transplanting and snail size on the pest's damage potential versus young rice plants was conducted in UPLB from January to March 1993. Treatments were the combination of three snail sizes (big, medium and small) and two transplanting times (early and late). Plots consisted of 2.74sq.m. inverted plastic mosquito nets with snail-free soil and planted with 54-66 hills of IR 72 rice variety.

Results showed that in all treatments, yield was drastically reduced compared with the control. Yield loss could be as high as 49.38% in plots with medium sized-early planted plots and as low as 15.88% in small sized-late planted treatments.

A voracious medium sized snail could consume an average of 5.47 leaflets per hill per day, while a small sized individuals in late planted rice plants could only inflict an average of 0.87 leaflets per hill per day.

Late planted rice seedlings could withstand lower damage than the early plants ones. The experimental data also showed evidence of some degree of recovery of 100% damaged hills i.e. although all leaflets in a hill were already consumed or damaged, some shoots for new leaflets still grow from such hills after some time.

RESMAN - A SIMULATION MODEL INCORPORATING PESTICIDE RESISTANCE MANAGEMENT

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Pesticide resistance is occurring with increasing frequency, both in terms of numbers of species of insects/mites involved and in the range of pesticides affected. Management of pesticide resistance is an option that is being considered more often, but requires considerable knowledge of the pest's biology and population dynamics. In an attempt to predict effects of various pesticide regimes on the frequency of the resistance gene(s), we have written a simulation model that includes pesticide resistance and gene frequencies.

The model, presently based on the saw-toothed grain beetle, *Oryzaephilus surinamensis*, is written in the program VENSIM[®]. The model allows for density dependent effects on reproductive rate, different reproductive rates on different types of grain, effects of farm hygiene and different mortalities between the susceptible, heterozygous and homozygous resistant beetles. The relative fitness of the various genotypes can be set as one, reduced fitness of the resistant or improved fitness. Four chemicals, three organophosphates and one insect growth regulator are included for grain treatment; the simulated farm has three main silos, several bins and two spills. These latter can be removed, but are replaced after each harvest. Data from a farm survey were used to estimate various parameters and the model will be validated against an independent data set.

CONTRASTING EFFECTS OF HABITAT FRAGMENTATION ON POPULATIONS OF CARABID BEETLES (COLEOPTERA: CARABIDAE).

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The Wog Wog habitat fragmentation experiment aims to 1) contribute to an empirical basis from which conservation ecologists may develop generalisations about which traits make species susceptible to extinction on habitat fragments, and 2) test the predictions of existing theory extrapolated to habitat fragments. This paper examines the responses of eight carabid populations to habitat fragmentation in response to these aims. We derive statistical models of the response of individual species, to: isolation on habitat fragments, three sizes of habitat fragments, and edge effects within habitat fragments.

The responses of individual species to isolation on habitat fragments were varied. Three species decreased in abundance, three species increased in abundance or probability of occurrence, and two species did not respond. Changes to habitat on fragments as a result of changes to ecosystem processes may be important in determining these responses. The responses of individual species to three sizes of habitat fragments were complex. For three species that responded to size, more individuals occurred on small fragments than expected. For two species that responded to edge effects, more individuals occurred in fragment cores than near to fragment edges.

EXPLICIT PATCH STRUCTURES IN METAPOPULATION MODELS - CONSEQUENCES FOR EXTINCTION

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Patchy habitat structure can have important effects on population dynamics and extinction probabilities for many species. Many metapopulation models fail to explicitly model patch size and the physical arrangement of patches. We present a metapopulation model which incorporates both of these features, and use it to look at questions of patch occupancy and metapopulation extinction. We illustrate the model with a metapopulation of malleefowl (*Leipoa ocellata*) inhabiting a system of patches in the Bakara region of South Australia. We compare the relative effects of explicitly modelling variation in patch size and isolation of patches for this system.

EFFECT OF LEAF BEETLE POPULATIONS ON EUCALYPT PLANTATIONS

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Studying effects of populations of leaf beetles in eucalypt plantations is a major project in the Intensive Forest Management program of the Forests and Forest Industry Council. Both adult and larval *Chrysophtharta bimaculata* (Olivier) (Coleoptera: Chrysomelidae) feed on the current season's foliage of several *Eucalyptus* species favoured for commercial plantations. Regular defoliation by these beetles significantly retards growth of young trees. The relationship between population assessments and growth increment is being investigated in a plantation of *E. regnans* planted in 1988 in the Florentine valley, Tasmania.

Defoliation by *C. bimaculata* reduced height of two-year-old trees by 45%, stem diameter by 31% after three years and by 36% after six years, compared with trees that were protected from insect defoliation. Although the quality of the food source appears to be relatively uniform and the quantity unlimited, the population of *C. bimaculata* in plantations is patchy. This results in fluctuations in numbers of eggs and larvae on foliage at one site both within and between seasons.

FOX MANAGEMENT AND IMPACT ON LAMBS, RABBITS AND NATIVE ANIMALS ON AGRICULTURAL LANDS AND REMNANT HABITATS

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The impact of fox predation and management on lambs, rabbits and native animals is being investigated. This study aims to quantify the impact of fox predation in association with three different levels of fox control, no treatment, baiting once a year prior to lambing and baiting three times a year. Each treatment has two replicates. The study also aims to identify levels of fox control to optimize returns for landholder investments and to determine if the marked increase in 1080 bait use, from 3000 to 300 000 in the past 10 years, is justified environmentally and economically. Economic benefits will be calculated based on differences in lambs marked from ultrasounded flocks at 6 sites covering three treatments in the Central Tablelands of NSW and the responses of rabbit and native animal numbers to fox control will be investigated. Preliminary results are presented and discussed briefly.

APPLIED ECOLOGY: A SHORT HISTORY OF ECOLOGICAL IDEAS AND THEIR APPLICATION

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Applied ecology comprises many areas of research including conservation of biodiversity, sustainable use and pest control. The historical development, from the distant past to the present, of key theories, hypotheses and events that have shaped these areas of applied ecology, are summarised and presented. Alternative theories and hypotheses are shown for specific topics of population regulation, conservation of biodiversity, island biogeography, diversity and stability of communities, and succession. The historical development of ecological methods of observation, experiment and mathematical analysis are also shown. The key ideas are listed with authors' names and dates of publication.

THE EFFECT OF FOOD-WEB STRUCTURE ON THE POPULATION DYNAMICS OF THE WEB'S COMPONENT SPECIES

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The structure of a community inevitably affects the dynamics produced from the interaction between the various species present. By constructing very simple food-webs and varying the number of trophic levels, the degree of connectance and other variables, qualitative and quantitative differences in the species dynamics may be observed. These observations may have implications for field research, both enabling the identification of possible experimental systems, and explaining the failure of ecological tests to detect the underlying causes of population fluctuation in many systems. From knowledge of the dynamics produced when density-dependent processes are acting upon a species within this model environment, improved methods of detecting density-dependence are also suggested.

POPULATION STUDY USING CAPTURE WITHOUT REPLACEMENT ESTIMATES FOR THE ENDANGERED SPECIES, *APRASIA PARAPULCHELLA*.

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With many rare or endangered species it is very difficult to provide an accurate assessment of population sizes and ecology because numbers are small and recapture rates are generally low. *Aprasia parapulchella* (pink-tailed legless lizard) is one species where this situation is true. It is a small fossorial legless lizard (family Pygopodidae) which has previously been classified as nationally endangered. The species has a close ecological relationship with ants, feeding exclusively on their eggs and larvae and living for extended periods beneath rocks in ant nests. Survey for these lizards involves turning rocks and previous studies have demonstrated that abundances are low, generally with 1 or 2 specimens recorded at a site. The maximum number of animals found during any one survey was 20, despite more than 2000 rocks being turned. It is as yet uncertain if single surveys of sites in optimum weather conditions provide a useful index to population size. Recently a population of this species was threatened with habitat loss. The subsequent relocation exercise, provided the opportunity to determine the relationship between estimates of relative abundance and absolute density. The study was carried out using repeated surveys of a defined area and capture without replacement estimates. Results indicate that population sizes were much higher than previously estimated, and larger than any single population of *A. parapulchella* previously recorded. These results have implications for the conservation status and management of this species.

**THE IMPACTS ON *ACACIA XANTHOPHLOEA* WOODLANDS BY THE INTRODUCED
ROTHSCHILD'S GIRAFFE IN LAKE NAKURU NATIONAL PARK**

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The Rothschild's giraffe (*Giraffa camelopardalis rothschildi*), having been severely affected by human development activities, was translocated in 1977 from Soy area of Eldoret, Kenya, into Lake Nakuru National Park. By September 1993, the population had increased from the initial population of 18 individuals to 170. This study examined giraffe food and feeding habits, available browse and giraffe distribution pattern. The giraffe distribution was relatively uneven, mainly occupying the southern part of the park, creating local overpopulation. They had heavily debarked yellow fever *Acacia xanthophoea* trees, their principle food source. Of the dead acacia trees, 75.6 % were attributed to debarking by giraffe. Intensive browsing of young acacia trees resulted in stunted growth of the regenerating trees. Giraffes have the potential to influence the density of acacia trees in the Park thereby affecting the habitat for other woodland fauna, consequently jeopardising the Park's potential as a conservation area. It is suggested that more data should be gathered to identify the most crucial factors to be manipulated to minimise detrimental effects.

**PATTERNS OF SEX ALLOCATION IN THE SOLITARY PARASITIC WASP *COTESIA*
*RUBECULA***

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Cotesia rubecula (Hymenoptera: Braconidae) is a solitary parasitoid of larval *Pieris rapae* (Lepidoptera: Pieridae). Females typically lay eggs with a sex ratio of 2 females to 1 male. Experiments have shown that sex allocation is not affected by host stage, rate of oviposition, or the presence of competing females. Implications of this behaviour for population dynamics and the theory of sex allocation will be discussed.

**MALE CHARACTERISTICS AND FEMALE CHOICE IN COLLARED FLYCATCHER
*FICEDULA ALBICOLLIS***

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Differences in plumage colour occur widely in Passerines, amongst sexes, and between different age groups. For example, sub-adult birds usually have paler plumage than older individuals. The latter can be explained by different biochemical constraints, female mimicry, delayed maturation, individual recognition and signal quality.

Collared flycatcher females have greyish/brownish plumage, while plumage of males is black and white with a variation in dullness of the black. Males of older than two years (2Y+) are brighter than two year old males (2Y). There is no overlap between 2Y and 2Y+ male colour classes, but colour gradients exist in young and in old male groups as well. We present an analysis of female preference on male age and colour in a Hungarian collared flycatcher population.

Mate choice was not independent of mate age. The 2Y and 2Y+ females preferred males of different colour. Adult females showed an age-dependent preference towards darker males. No difference was detected in female preference between immigrant or returned males.

**DISTINGUISHING BETWEEN HISTORICAL AND ECOLOGICAL CAUSES OF
VARIATION AMONG PARAPATRIC POPULATIONS IN A POLYMORPHIC PLANT
SPECIES**

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Variation amongst parapatric populations can be due to long-term historical (i.e. phylogenetic) processes and/or to more immediate ecological processes (e.g. gene flow, natural selection, etc.). Distinguishing between these possible causes has been notoriously difficult, yet is essential for the resolution of the primary or secondary origin of hybrid zones. This in turn has implications for models of speciation. I address the causes of narrow hybrid zones between subspecies within the extremely variable, but monophyletic, species *Persoonia mollis* (Proteaceae). Allozyme frequency data were collected from 18 populations. These data were firstly analysed under the assumption that any effect of phylogeny was negligible. Comparisons to Hardy-Weinberg expectations suggested that these loci were selectively neutral. Indirect estimates of gene flow within subspecies and across subspecies boundaries showed that in only 1 of 9 hybrid zones investigated was gene flow significantly less extensive across the zone than within subspecies either side of the zone. Therefore, restricted gene flow may be a factor contributing to the presence of this 1 zone, but the others are maintained despite gene flow. However, phylogenetic analysis of these same allozyme frequency data, under the assumption that current ecological processes have no effect, revealed that this hybrid zone is a consequence of (relatively) recent secondary contact. The differences in allozyme frequency between these two subspecies reflect a period of isolation rather than any actual restriction in gene flow between them. Consequently, conclusions regarding the causes of geographic variation may be incorrect if both historical and ecological causes are not considered.

GENSECT - A GENERIC APPROACH TO CONSTRUCTING POPULATION MODELS

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Many ecologists would like to use population models, either to test hypotheses, or to design management strategies. However, the construction of models is often beyond the resources of most ecologists without access to a computer programmer. GENSECT is being developed to address this need by providing a research, pest management and teaching tool that can be used to construct a model of any species without the need for computer programming.

A major consideration in the design of GENSECT is to provide a user-friendly tool to make the process of constructing a model easy and enjoyable, with concepts being presented in language familiar to biologists. A lifecycle is assembled from a 'toolbox' of components such as lifestages, processes and functions. Other components, such as microclimate models or data file readers, are also available as modules, and can be easily coupled to the lifecycle. All internal model variables are available for output as graphs or tables, thus simplifying the construction and error-checking of a new model. Models of different species can be saved as files, which will serve as an important means of summarising and exchanging information about a species' population dynamics. After the model is constructed, GENSECT provides a user-friendly environment in which to run the model, and display selected results. A limited version of GENSECT will be available for the Microsoft Windows platform in late 1995.

SUSCEPTIBILITY OF LEGUMINOUS PASTURE SPECIES TO SPOTTED CLOVER APHID AND SPOTTED ALFALFA APHID

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The spotted clover aphid appears to be a new pest of clover pastures in Australia and is causing substantial yield loss in south-western Australia, southern NSW and northern Victoria. It is morphologically identical to the spotted alfalfa aphid (*Therioaphis trifolii* (Monell) f. *maculata*) but is genetically different and appears to have a very different host plant range.

The performance of spotted clover aphid (SCA) and spotted alfalfa aphid (SAA) was compared on 16 potential host plant cultivars (12 clovers and 4 medics) in the laboratory, using excised leaflets on agar. Parameters measured included host acceptance by the parent aphid, survival and development time of the offspring, proportion of alatae produced, adult weight and 4-day fecundity. Results showed that SCA performed well on all 12 clover cultivars and on Hunter River lucerne. SAA outperformed SCA on the three lucerne varieties but only on Hunter River lucerne did it perform very well. Barrel medic was a relatively unfavourable host for both aphids.

CONSERVATION BIOLOGY OF THE PIPI, *DONAX DELTOIDES*

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The pipi, *Donax deltoides*, has been harvested on the Australian East Coast for at least 10,000 years. In more recent times the pipi forms the basis of a commercial harvest worth over half a million dollars per year in NSW alone, as well as a large recreational fishery for bait and food. Even as long ago as 1950, various authors were complaining that pipis were becoming increasingly scarce on accessible beaches. Management is difficult due to the lack of information available about the species.

Population genetics can be used to infer the mechanisms of larval production as well as the scale and/or direction of dispersal. Allozyme electrophoresis has been used to detect variation in allele frequencies among and between populations. This study looked at the genotypic variation in populations of *D. deltoides* from four regions on the East Australian coast in order to infer the source of recruitment. Gene frequencies were used to investigate the degree of connectedness of local populations. Little genetic differentiation was found between populations separated by up to 1200 km. A standardised genetic variance (F_{ST}) of 0.009 was obtained over this distance. This indicates high levels of gene flow and a relatively long planktonic phase, which agrees with available suggestions about the reproductive habits of *D. deltoides*.

MALLEE (*EUCALYPTUS* SPP.) POPULATION REGULATION BY FIRE.

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The extensive mallee (*Eucalyptus* spp.) shrublands found across some 30 000 km² of central and southern Australia are the most inflammable ecosystems to be found in the semi-arid and arid zones. These multi-stemmed eucalypts have traditionally been held to be among the archetypal "fire-adapted" plant species, primarily because they possess a woody rootstock located in the surface soil containing numerous dormant meristems. These enable rapid stem and canopy regeneration after they have been activated by fire. Furthermore, in common with other serotinous elements of the native flora, successful recruitment of mallee seedlings also depends on episodic fire to induce mass release of seeds from canopy seedbanks to offset seed predation by harvester ants. To assist in the development of sustainable management systems for these unique communities, detailed investigations were undertaken to examine the survival of mallee eucalypts subjected to contrasting fire regimes characterised by differences in season and frequency of prescribed fire treatments. This paper presents data on survival of adult populations taken, in one experiment, continuously over a 15-year period. Both non-parametric and parametric models were fitted to the data using generalised linear model methodology similar to a proportional hazards model. Less than 10% survival was recorded in populations receiving more than two consecutive autumn decapitations by fire whereas 30% of individuals were still surviving after eight consecutive spring fires.

THE USE OF ENDOPHYTIC FUNGI AS BIOLOGICAL CONTROL AGENTS OF NEW ZEALAND PASTORAL PESTS

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The endophyte, *Acremonium lolii* forms a mutualistic relationship with its host grass, *Lolium perenne*. *A. lolii* - infected ryegrasses are usually at a selective advantage over endophyte - free counterparts because the endophyte protects the host plant from attack by plant feeding insects. As a result the incidence of endophyte infection in pasture increases from the time of sowing to equilibrate near 100% within two to three years due to selective feeding on *A. lolii* - free ryegrasses. This defence can be utilised as a biological control mechanism to protect the grass from insect attack. Research has indicated that *A. lolii* - conferred resistance is effective against a number of different species in several different insect Orders but, with one possible exception, only against the life stages that feed above ground. The majority of insects that are adversely affected by *A. lolii* feed at the base of the plant where the concentrations of fungal mycelium and metabolites are generally higher. The mechanism of this resistance is caused by a number of different alkaloids including peramine, lolitrems and related indole diterpenes, and ergot alkaloids. Insect feeding studies incorporating these alkaloids into artificial diets has shown that some of these compounds are highly toxic to insects. Some of these alkaloids are also involved with animal health problems in grazing livestock. Current research is attempting to develop a grass/endophyte combination with nil animal health effects but which utilises the pest management aspects of the association.

CHARACTERISING THE LARGE SCALE SPATIAL DYNAMICS OF THE MOTHS *HELICOVERPA PUNCTIGERA* AND *H. ARMIGERA* IN INLAND AND EASTERN AUSTRALIA

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The changing abundance on a large spatial scale of the moths *Helicoverpa punctigera* and *H. armigera* in Australia is being characterised in detail to enable forecasts of migrations of moths into the summer cropping areas of eastern Australia. The two species are important pests of a range of crops in Australia, including cotton, field peas, lupins and tomatoes, due to the damage that the larvae inflict by feeding on the leaves and fruiting structures of the crop plants. They have a number of features that contribute to their ability to locate and infest crops and other host vegetation over a wide area of the Australian continent: they are highly mobile, have high fecundity and are capable of utilising a wide range of host plants.

The changing abundance of the moths is being characterised by analysing and generating models from the large quantity of survey and monitoring data that have been collected on the species in recent years. The population dynamics of these highly mobile insects over the Australian continent includes important effects of spatial variations in the environment and spatial processes such as migration. A special emphasis has been placed on considering these effects in the analysis, by explicitly representing the spatial structure of the landscape using such databases as habitat maps and climate surfaces, and by modelling key spatial processes such as long-distance wind-assisted migration.

THE DAWESVILLE CHANNEL EXPERIMENT: AN END TO EUTROPHICATION?

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The Dawesville Channel cost \$53million and was completed in April, 1994. It is a 2.5km long, 4-6m deep and 200m wide channel which now artificially connects the northern Harvey Estuary with the Indian Ocean. The Peel-Harvey Estuary in south-western Australia is a 135 km² water body which has been experiencing extreme eutrophication since the late 1960s. Before the Channel was completed, the estuary experienced green macroalgae and toxic blue-green *Nodularia spumigena* blooms as a result of excessive inputs of phosphorous leaching from sources found in the rural and urban catchment. *Nodularia* and phytoplankton blooms tended to dominate water quality in the Harvey Estuary and green macroalgae growth in the Peel Inlet. The benthic fauna was dominated by opportunistic short-lived small capitellids, amphipods and micro bivalves. Large populations of invertebrates (e.g. amphipods and grass shrimp) also inhabit floating wracks of *Chaetomorpha*, *Ulva* and *Enteromorpha*. Floating macroalgae is extensively utilised by juvenile fish and crabs with the fishery dominated by catches of mullet, penaeid prawns, crabs and, until recently, a plotosid cobbler. The Peel Inlet Management Authority, a public body serviced by officers from the Waterways Commission of WA, manages the macroalgae growth through floating conveyor and beach harvesting. It conducts several monitoring programs investigating water quality and macroalgae/seagrass growth. The WA government has encouraged the Commission to help co-ordinate research efforts conducted by other state agencies. A Social Impacts assessment with extensive public involvement was conducted and an active education program is in place. The Dawesville Channel is expected to increase flushing. With nutrient laden waters flowing out to sea more quickly during winter, *Nodularia* blooms will disappear, macroalgae growth will be reduced over time, the fish community will become more dominated by marine visitors and exposure and flooding of the extensive shallows will create a new environment for birds, mosquitoes and other benthic invertebrates, samphire and other peripheral vegetation.

COMPARISON OF GENETIC VARIABILITY IN REMNANT AND WIDESPREAD RAINFOREST UNDERSTOREY SPECIES OF *AUSTROMYRTUS* (MYRTACEAE)

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This study investigated the genetic variability, stand structure and reproductive activity of four species of *Austromyrtus* which showed differing levels of rarity and patterns of distribution. The focus of the study was *A. gonoclada* which is extremely rare due to extensive urban expansion in Brisbane, Australia. The total number of known individuals in the species is only 27. The purpose of the comparison with other species was to provide a context for *A. gonoclada* results. *A. gonoclada* showed maximum genetic variability in comparison to the other species of *Austromyrtus*, despite the small population size. Most variable loci were in Hardy-Weinberg equilibrium in *A. gonoclada* populations, in contrast to populations of the other species which were mostly inbred. It is suggested that self incompatibility mechanisms and higher variability may have reduced selfing. The current population showed few seedlings, in contrast to the other species of *Austromyrtus*, and the seeds produced, fell from the tree while still green and were unable to be germinated. Population structure and levels of reproductive activity however, were not correlated to species rarity or distribution. *A. gonoclada* is under continuing threat from development and has low reproductive success. Active programs for recovery of this species will be necessary as its continued survival is dependent on population increase. Management of the genetic resources of the species will enable survival with long-term evolutionary potential

BIOLOGICAL MANAGEMENT OF PESTS IN INDIA

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The intercropping of diverse plant species works as a "diversionary host" for pests protecting other more susceptible and economically valuable crops from serious damage without recourse to chemical pesticides. Indian farmers encourage the growth of *Lupinus* spp. within their corn fields as they attract scarab beetles. Cabbage and peas are grown with wild mustard. While the mustard is attacked by fungus the cabbage is disease free. Parrots eat mustard and the peas are left. Similarly, castor is grown with cotton to reduce pest attack on the latter. Extracts from margosa, tobacco, custard apple and castor, latex of *Euphorbia* and sap from *Colocasia* and several other plant species have been used in India for centuries to control pests. Tribes of India use smoke from madhuca oil cake to control "paddy blight". Indian farmers grow sunflower among wheat crops. Owls sit on its strong branches and eat the rats at night. The wild mustard and marigold plants are grown with several crops. Their roots secrete a toxin which destroys soil nematodes. Information such as this, on biocontrol of pests, is being accumulated from the traditional experiences of farmers in India.

CONSERVATION OF ENDANGERED WILDLIFE POPULATIONS IN INDIA

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In the last two centuries, a large proportion of wildlife in India - about 66 species of mammals, 38 species of birds, 18 species of reptiles and amphibians have become endangered and listed in the IUCN Red Data Book. The lesser one horned rhino (*Rhinoceros unicornis*) and the Asiatic cheetah (*Acinonyx jubatus*) are already extinct. The Asiatic lion, snow leopard, wild ass, musk deer, brow-antlered deer, lion tailed macaque, fresh water crocodile and even the greater one horned rhino are all facing extinction.

Since 1970, several conservation measures like "Project Tiger", "Project Elephant" and "Project Rhino" have been initiated to conserve not only individual species but also the entire ecosystem which was essential for survival of these large herbivores and carnivores. Captive breeding has yielded good results. However, it is not the "game of numbers" of individual animal species which is important but the entire biological and genetic diversity which provides the necessary ecological adaptations for species survival. Also shifting and rehabilitation of endangered species to other ecologically similar habitats is essential because any habitat has a limited carrying capacity and it is risky to keep the sole surviving population of a species at one place as any catastrophic event could make them extinct.

IMPACT OF MODERN ANTHELMINTICS ON THE DUNG FAUNA

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The potential of excreted anthelmintic residues to adversely effect the growth and survival of non-target organisms, vital to the processes of dung degradation and nutrient cycling, was first recognised in the 1970s in relation to drugs such as phenothiazine and dichlorvos. The 1980s saw the introduction of the macrocyclic lactones (avermectins and milbemycins), broad-spectrum endectocides that are highly active at very low dosage rates. Egestion of the avermectins (abamectin and ivermectin) and milbemycins (moxidectin) occurs largely in faeces. Abamectin residues are more toxic than those of ivermectin, the effects of which vary with drug formulation and dosage route. Injectable and pour-on formulations of ivermectin lead to more protracted effects on dung arthropods than do oral formulations. Insects in the Orders Diptera and Coleoptera are most sensitive to avermectin residues when exposed as larvae, but reductions in adult survival and fecundity have also been reported. Avermectin residues also exert adverse effects on earthworms. With the milbemycins, high mortality has been reported in dipteran larvae reared in dung obtained from cattle treated with of a bolus formulation of moxidectin. However, in other studies, in which moxidectin was injected at recommended dosage rates, faecal residues of moxidectin caused no detectable effects on the development and survival of several species of Coleoptera and Diptera. These findings suggest that moxidectin will be less disruptive to the dung ecosystem than either abamectin or ivermectin. However, there is still a need for more data on the drug's environmental fate and its effects on other organisms involved in dung degradation (e.g. earthworms).

THE POPULATION ECOLOGY OF *ORYZA RUFIPOGON* Griff. ON THE SOUTH ALLIGATOR RIVER FLOODPLAIN, KAKADU NATIONAL PARK

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Oryza rufipogon (Wild rice) is an annual emergent grass which is abundant on the seasonally inundated floodplains of northern Australia. This species is a key component of the floodplain ecosystem, providing a major food resource for abundant species such as the Dusky Plains Rat and Magpie Goose. The floodplain environment is highly dynamic, both spatially and temporally.

This study has shown high rates of seedling emergence (600 m^{-2}), survivorship and seed production ($2,200 \text{ m}^{-2}$) for *O. rufipogon*. Stochastic seed predation events, at rates of up to 100% of exposed seed, are not expected to affect site population maintenance, due to high rates of seed production, some degree of seed bank persistence and microsites for avoidance of seed predation. Standing crop production varies greatly between seasons and sites. Greater standing crop production was observed during the 1992/1993 wet season than occurred during 1991/1992. This was due to the longer growing season, provided by early rain and gradual increases in water level.

This study documents the population dynamics of *O. rufipogon*, enabling the development of floodplain management strategies, with respect to this important species.

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GENERAL INFORMATION

ENQUIRIES AND MESSAGES: An enquiries desk will be staffed throughout the conference in the foyer of the Manning Clark Theatre Centre. A message board will also be located there. Contact numbers are: University House 06 249 5211, Burton and Garran Hall 06 267 4333 and CSIRO Division of Entomology 06 246 4001.

MEDICAL: A **chemist** is located in the southwest corner of the Union Court and is open from Monday to Friday (9am-5pm). An after hours pharmacy is located on Marcus Clarke Street (at the north eastern end of campus). The **student medical service** on 249 3598 is available for conference delegates. It is a bulk billing practice - Medicare card required or payment at the time of consultation. It is situated in the Sports Union Building facing North Road on campus. The nearest **24 hour hospital casualty** department is at Calvary Hospital, Haydon Drive (near Belconnen Way), Bruce.

UNION FACILITIES: Facilities available in the Union Court include banks, post office, pharmacy, bookshop, bakery, supermarket and several eateries.

BANKS: The following are available in the main square (Union Court) of the ANU campus:
Commonwealth Bank: Mon - Thurs 0930-1600, Fri 0930-1700. Autobank available 24 hours.

National Bank: Mon-Thurs 0930-1600, Fri 0930-1700. Flexiteller available 0600-0200.

Westpac: A branch is located on University Ave at the corner of Marcus Clarke St.

POST OFFICE: A Post Office is located at the rear of the newsagent on the ground floor of the Union Building. It is open 8am-6pm Monday to Thursday and 8am-5pm on Friday.

TELEPHONES: There are two public telephones in the foyer of the Manning Clark Complex. One is coin operated and one is card operated.

PARKING: Participants staying on campus are recommended to park at their accommodation and walk to the venue. A limited amount of visitor pay parking is available on campus. Participants may also use the dirt carpark at the southern end of the CSIRO Entomology building and then walk through the ANU.

TRANSPORT: There is a regular bus service from the University to Civic. Aerial Taxi Cabs can be booked by calling 285 9222.

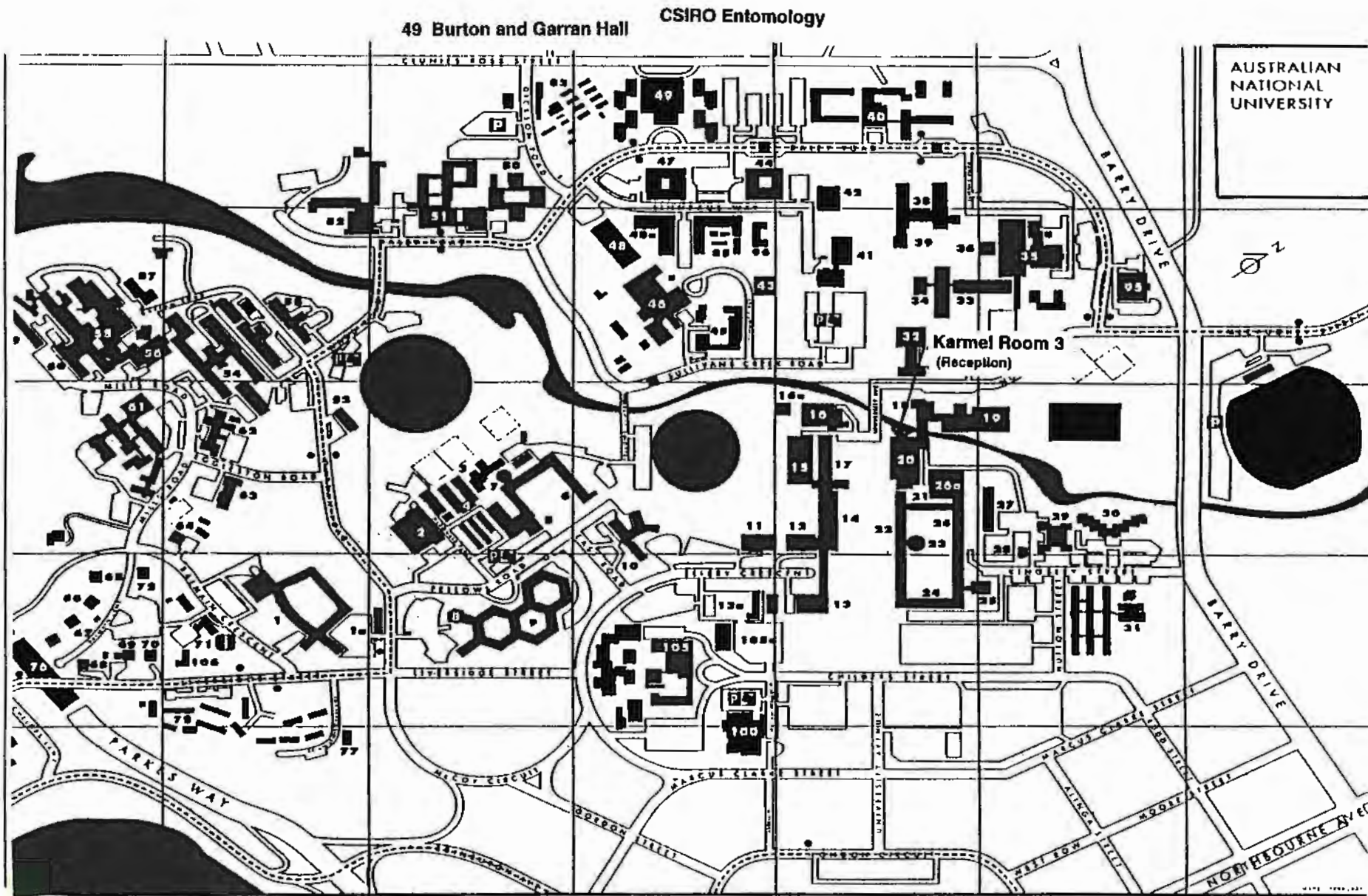
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|---------------------|--------|----------|--------|---------------|----------|
| To confirm flights: | Ansett | Domestic | 131231 | International | 216 6433 |
| | QANTAS | Domestic | 131313 | International | 250 8305 |

TOURIST FACILITIES: A tourist bureau is located in the Jolimont Centre, Northbourne Ave, Civic. The Botanic Gardens (exclusively native flora) are within walking distance on Clunies Ross St. The Gardens, shop, information centre and kiosk are open 7 days a week. Information brochures on Canberra tourist spots will be available at the information desk in the foyer.

NRMA: Located on Northbourne Ave, Braddon. For Road Service call 13 1111.

POLICE: Police Stations are located at the end of University Avenue on London Circuit (ph 256 7777) and City Walk, Civic. The free **police attendance** number is 1 1444. The **emergency number** for fire, police and ambulance is 000.

EMERGENCIES: In the event of a major emergency, assistance is available from the enquiries desk during conference hours or, after hours, from Paul Wellings (247 6480).



MAP OF UNIVERSITY CAMPUS

1 University House

17 Union Court
(Banks, chemist etc)

26a Manning Clark Centre

18 Health Services

To Civic Centre ↓

20 Union Building