Transport Corridor Management Conference

NOVEMBER 1999 • BRISBANE AND IPSWICH



PROCEEDINGS

Greening Australia™

Main Roads

NATURAL RESOURCES Queensland

QUEENSLAND GOVERNMENT Environmental Protection Agency

Ipswich City Council

Transport Corridor Management Conference

November 1999, Brisbane and Ipswich
Queensland, Australia

Conference Proceedings

Organised by Greening Australia Queensland (Inc.) as part of the activities of the Freeway Greening Project

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Main Roads

Natural Resources Queensland

Queensland Government Environmental Protection Agency

Ipswich City Council

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INTRODUCTION

In Queensland alone there are:

- 141,000km of local government roads;
- 34,000km of Department of Main Roads controlled roads;
- 72,000km in the stock route network of which 11,600km is active;
- 9,500km of rail lines;
- 176,468km of energy supply lines;
- 3,683km of pipelines; and
- In excess of 40,000km of Telstra optic fibre cables and an order of magnitude more of copper lines.

In the day to day management of these areas a significant aspect of the work undertaken is the management of vegetation. Every time a table drain is cut, every time a stockpile is generated, every time an area is slashed, every time vegetation is cleared for whatever purpose, by whatever means, vegetation is being managed. Sometimes what is normally considered a minor non-vegetation related work practice can result in long term vegetation maintenance issues. Hence, the impetus to conduct a conference on such a topic.

Welcome to the inaugural Transport Corridor Management Conference. As managers of transport corridors you will benefit from this conference in many ways. Presentations from our international and national speakers are aimed to:

- Identify reasons why vegetation should be considered in transport corridor management;
- Provide you with best practice examples of management systems; and
- Identify cost effective methods of vegetation management.

We trust also that you take the opportunity to network widely with your fellow participants, who are from diverse backgrounds and in many cases your key stakeholders in vegetation management.

ACKNOWLEDGMENTS

As with any other conference the Transport Corridor Management Conference did not come about through any small feat. Many people have contributed their time, resources and ideas to bring this conference to you. We would like to thank the following for their contributions, which in our opinion, have ensured the success of the conference:

- Our sponsors:
  - The Queensland Department of Main Roads;
  - The Department of Natural Resources; and
  - The Environmental Protection Agency.
- Our trade displayers:
  - Weedbug;
  - Macspread;
  - Tenkate Plant Hire;
  - Vemco;
  - Root Barrier;
  - Hortex;
  - WALTER Construction; and
  - Armsign.
- The organising committee:
  - Ms Sonia Culley, Conservation Parks & Sport Dept., Ipswich City Council;
  - Mr Peter Syson, Technology & Environment, Department of Main Roads;
  - Dr Michael Ryan, Technology & Environment, Department of Main Roads;
  - Mr David Wood, Senior Environmental Officer, Metropolitan District, Department of Main Roads;

- Mr Andrew Nguyen, Engineer, Metropolitan District, Department of Main Roads;
- Mr Paul Sattler, Biodiversity Planning, Environmental Protection Agency;
- Mr Michael Griffin, Biodiversity Planning, Environmental Protection Agency;
- Mr Rhys Allison, Stock Route Management, Department of Natural Resources; and
- Mr Wally Kearnan, Stock Route Management, Department of Natural Resources.

- Ipswich City Council;
- Thanks to Mike Olsen, Steve Fox, Rob Hooper, Peter Copping, and Trevor Armstrong for assisting on the field trip;
- The Master of Ceremonies at conference dinner, Mr Stephen Golding, Executive Director, South East Region of the Department of Main Roads;
- Our learned and often pestered speakers;
- The staff of Greening Australia Queensland (Inc.);
- Our session facilitators;
- Mr Andrew Straker, Victorian Roadside Conservation Advisory Committee, for providing advice and allowing the use of the conference promotional photograph;
- The conference organisers, Muller Mahony and Associates; and
- Of course, the participants.

Special thanks to the Honourable Stephen Bredhauer Minister for Transport and Minister for Main Roads for opening the conference and the Honourable Rod Welford, Minister for Environment and Heritage and Minister for Natural Resources for addressing the dinner.

This conference would not have been possible without the confidence of the Metropolitan District of the Department of Main Roads through their funding of Greening Australia Queensland (Inc.)'s Freeway Greening Project.



David Francis
Main Roads Extension Officer South
Greening Australia Queensland (Inc.)
(Conference Co-ordinator)

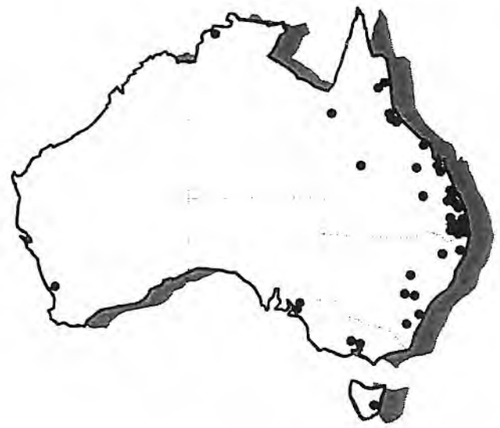


Howard Taylor
Main Roads Extension Officer North
Greening Australia Queensland (Inc.)
(Conference Co-ordinator)

WHO ATTENDED?

Over 250 people travelled from around the nation to attend the Transport Corridor Management Conference.

Participants from a diverse group of organisations and occupations were in attendance. State and Local governments, road authorities, rail authorities, service providers, consultants, engineers, environmental officers, agronomists, environmental practitioners and the rural fire service were all represented in our sponsors, speakers and participants.



ABOUT OUR SPEAKERS

Keynote Speaker
Bonnie Harper-Lore
Federal Highway Administration, USA



Bonnie is employed with the Federal Highway Administration (FHWA) which is an oversight and funding agency to all 50 States. Bonnie is one of the FHWA's natural environment team and, as a technical specialist, supports all States with technology transfer, environmental policy, and research funding.

Bonnie holds an MS from the University of Wisconsin, Madison.

Her experience includes 10 years of designing residential/corporate landscapes and has taught ecological landscape design and management for 9 years. Bonnie founded the first purple loosestrife coalition in the U. S. and passed legislation.

She coordinated roadside vegetation issues for the Minnesota State Department of Transport for four years and was hired to coordinate the national wildflower program for FHWA 6 years ago. Bonnie has developed this into a more holistic vegetation management program for roadsides.

She has been involved in the production of several publications, including, Editor for the quarterly newsletter, *Greener Roadsides*, for five years. Bonnie was the sole author of a handbook, *Roadside Use of Native Plants* and has written national guidelines for State wildflower programs and invasive weed programs.

Bonnie Harper has served on:

- the Federal Interagency Committee for Management of Noxious and Exotic Weeds
- the Plant Conservation Alliance (an interagency native plant conservation group)
- White House task forces (native plants, invasives, and wetlands)
- the IUCN North American native plant subcommittee
- the Transportation Research Board (TRB) maintenance committee

"I consider myself an advocate and/or bridge between engineers and vegetation specialists, as well as between the federal government and the public. It is a great job and I would do it for free! Timing is everything and we are at a point where bridging globally is possible. We need to be working with our "neighbours" to learn what works and what does not in our never-ending preservation and restoration of native vegetation opportunities. Better late than not at all!"

Dr Rod Fensham
Botanist



Dr Rod Fensham is an authority on the ecology and conservation management of vegetation in northern Australia, based on more than a decade of research in Queensland and the Northern Territory. He has published extensively on plant distributional patterns; conservation theory and practice; vegetation management; and the impacts of fire, grazing, tree clearing and other processes. In Queensland he has conducted research in dry rainforest and grasslands. He is currently working on projects monitoring structural change in vegetation using aerial photography, the ecology of a rare daisy and a Queensland-wide survey of artesian springs.

John O'Toole
Principal Engineer (Maintenance) Metropolitan District Department of Main Roads, Queensland



John has spent most of his working life involved in the design, construction and maintenance of roads and bridges.

Metropolitan District is responsible for the activities of the Department of Main Roads in Brisbane, Logan, Ipswich and Redcliffe Cities and Pine Rivers and Redland Shires and covers the largest urban concentration in Queensland, with about half of the State's population within the District boundaries.

As Principal Engineer (Maintenance), John is responsible for the delivery of a $40 million (approx.) per annum budget for the routine and programmed maintenance and rehabilitation of 2353 lane kilometres of road network.

The diversity of the South East corner of Queensland is demonstrated by the number of vehicles using sections of the District's road network; from 500 vehicles per day in rural communities west of Ipswich City to 130,000 vehicles per day for the South East Freeway.

John is a graduate of the Queensland Institute of Technology in Civil Engineering and his interests are family, travel and football.

Paul Smith
Associate, Dunhill Madden Butler, Solicitors



Paul Smith is currently an associate with Dunhill Madden Butler, Solicitors, Brisbane working exclusively in planning and environmental law. He holds a Bachelor of Architecture (UQ), Master of Urban and Regional Planning (UQ) and Bachelor of Law (QUT).

Paul has previously practiced as an architect and town planner in Queensland and Papua New Guinea and has held senior positions in the Department of Local Government and the Department of Housing, Local Government and Planning responsible for legislative reform. Paul was responsible for the development of the Integrated Planning Act and other planning and environment legislation impacting upon the Act.

David Lamont
Executive Officer, Roadside Conservation Committee, Western Australia



David Lamont is the Executive Officer of the Western Australian Roadside Conservation Committee (RCC), and has occupied this position since 1991. He has been extensively involved in liasing with community groups and local government on a variety of projects aimed at enhancing and sustaining remnant vegetation in linear reserves. Perhaps the most ambitious project to date, has been the community survey of roadsides for conservation values. Almost 50,000 km of roadsides in 30 shires have been surveyed to date.

Prior to working with the RCC, David spent many years working as a national park ranger in Western Australia and South Australia. He has also worked as a dairy farmer and market gardener.

David's tertiary qualifications include:

- Associate Diploma in Park Management, Riverina – Murray Institute of Higher Education
- Bachelor of Applied Science (Parks and Recreation), Charles Sturt University
- Masters Degree in Natural Resource Management, University of New England

His thesis was titled "The changing status of Rainbow Lorikeet, *Trichoglossus haematodus* (Linnaeus 1771)' in south-western Australia: its potential for range extension".
David is a passionate follower of the Rugby Union code, a keen horseman, photographer, traveller and naturalist. He was recently awarded the National Medal for Fire Service. In his 'spare time' David grows Australian native flowers for the interstate and overseas commercial markets.

John Lewis
Director of Engineering Services, Dumaresq Shire Council



John Lewis has spent most of the past 32 years in local government engineering in country New South Wales. Since graduating in Civil Engineering from the University of Technology, Sydney in 1975, he has worked at six non-metropolitan councils throughout the State and has been appointed Senior engineer at the last three. He is currently Director of Engineering Services at Dumaresq Shire Council, the rural bases council surrounding the city of Armidale on the northern tablelands of NSW. John commenced duties with Dumaresq Council in 1993 and his interest in roadside management began a year later.

In 1995 he was appointed as the Institute of Municipal Engineers' Association's representative on the NSW Roadside Environment Committee and is a past chairman of the committee. With the support of his Council and a successful National Landcare Project grant application, Dumaresq was one of the first councils in NSW to develop and implement a roadside management plan for all roads under the Council's care and control. Although a key element of the plan is simplicity, it continues to be successful in delivering positive results on the ground.

Sonia Culley
Conservation Policy/Research Officer, Conservation Parks and Sport Department, Ipswich City Council



Sonia Culley has 9 years experience in conservation planning and management. Sonia's current work with Ipswich City Council involves strategic research, policy and program development. Her three years with Ipswich City has seen her very involved with a variety of issues including private landholder support programs (eg. Land for Wildlife program), environmental weeds and sourcing external resources. Sonia previously spent six years working in various parts of Victoria, where her previous roles included landcare, salinity, pest plant and animal control and catchment management. Sonia has an Applied Science degree in Environmental Management and is currently finalising a Masters in Business Administration.

David Francis
Extension Officer, Greening Australia Queensland (Inc.)



David holds a Bachelor of Science with Honours from the University of Queensland in which he majored in Botany, Ecology and Zoology. He has since worked as a research assistant on aquaculture projects for the Department of Primary Industries and CSIRO. He started with Greening Australia Queensland as a volunteer and casual staff member on both bush regeneration and urban landscaping projects. David has worked as an Extension Officer to the Department of Main Roads on the Freeway Greening Project and as an environmental management consultant to local government and industry for the past five years.

In 1998 he jointly received the Queensland Arbor Day Award in the corporate tree planter division with the Department of Main Roads. He was a finalist for the 1999 Young Australian of the Year in the environmental division. David holds a strong interest in native vegetation and ecology and is considered by many of his professional peers as an expert on roadside vegetation and revegetation techniques.

Jencie McRobert
Senior Research Scientist, ARRB Transport Research Ltd



Jencie McRobert joined ARRB Transport Research after two years in environmental consultancy and seven years work experience in catchment management with the Department of Environment and Natural Resources, Victoria. Jencie has practical experience in vegetation and soil management; groundwater and surface water investigations, environmental policy development; and community consultation programs. Since joining ARRB TR, Jencie has developed expertise in the area of road drainage and biodiversity of waterways, resource use analysis techniques and related applications to sustainable transportation. Jencie holds a Bachelor of Science degree from the University of Melbourne and has post graduate qualifications in economics.

Particular areas of interest are:

- road drainage and biodiversity issues
- groundwater and salinity investigations
- land and water management, resource use and degradation
- community education and participation
- environmental economics
- environmental management plans

Dr Michael Ryan
Project Manager of the Environment Program, Technology and Environment Division, Queensland Department of Main Roads



Dr Michael Ryan recently joined the Department of Main Roads (DMR) as the Project Manager of the Environment Program within the Department's Technology and Environment Division. Prior to joining DMR, Michael worked at the University of Queensland in mine rehabilitation and pest management, and more recently for three years as an Ecological Consultant and Project Supervisor for an environmental consulting firm. Michael has 13 years experience as a fauna ecologist and has also completed project management courses.

Michael has a wide knowledge of environmental impact assessments and management practices to ameliorate identified impacts. Michael is a fauna ecologist specialising in the field identification of birds and mammals. In addition, he has been the Principal Author of more that 20 environmental assessments and environmental management plans. Michael is keen to help improve the Department's understanding and management of the potential impacts associated with managing the State-controlled road network.

Barry O'Connor
Legal Counsel, Department of Natural Resources



Barry O'Connor is currently appointed to the position of Legal Counsel in the Department of Natural Resources. He has also held senior legal and administrative position of Department of Natural Resources and its predecessors (including Director of Government Lands in the former Department of Lands). Barry holds a Bachelor of Law (L.L.B.) degree from the University of Queensland (1971) and a Master of Law from QUT (1998), specialising in environmental and administrative law. He has travelled extensively throughout Queensland over many years representing the State in a diverse range of land and valuation cases.

Sean Bellairs
Senior Research Officer, Centre for Mined Land Rehabilitation, University of Queensland



Sean Bellairs is a Senior Research Officer with the Centre for Mined Land Rehabilitation at the University of Queensland. He majored in Botany at the University of Western Australia and then carried out a PhD investigating seed sources and establishment ecology of native species used to rehabilitate a species diverse minerals sands mine near Eneabba, Western Australia. For this research he won the 1990 Australian Mining Industry Council Student Medal for excellence in environmental research. After a Post doctoral position with CSIRO he joined the CMLR in 1994 where his research focus is on seed biology of Australian native plants and vegetation establishment processes on mined lands. He has edited two National Workshops on Native Seed Biology for Revegetation and published papers on seed biology in national and international journals. Currently he is involved with research into seed germination, seed dormancy, establishment ecology and native vegetation development on disturbed lands with mining companies throughout Australia as well as Queensland Main Roads and Greening Australia.

Mark Lewty
Program Leader Silviculture, Queensland Forestry Research Institute, Department of Natural Resources



Mark Lewty holds a Bachelor of Science in Forestry (1st class Honours) from Australian National University (1979) and a Doctor of Philosophy, University of Queensland (1989).
His field of expertise is the management of commercial forest research and development, plantation establishment research, nurseries research, weed control systems, plant physiology and hardwood plantation silviculture.

His professional experience includes:

- Program Leader Silviculture, Queensland Forestry Research Institute
- Technical adviser to the R&D Program for RGM Forestry Services
- General Manager R&D, for RGM Forestry Services, Sumatra, Indonesia
- Officer in Charge of Plantation Silviculture Speciality; responsible for the plantation silviculture research program at the Queensland Forest Research Institute
- PhD Studies - "Response to soil flooding of two *Pinus* species and their hybrid"
- Research Forester; responsible for weed control research. Directed research programs in herbicide screening, competition studies, cover crops and weed control systems
- Field Forester; plantation (Toolara and Imbil) and hardwood forest (Monto) activities

His involvement in technology transfer, commercialisation and extension include:

- Implementation of a container hoop pine system based on the findings of nursery R&D work.
- Transfer of findings from process studies on the physiological responses to establishment of *Pinus* seedlings and cuttings into operational practice.
- Developed nursery regimes for pines and native tree species.
- Demonstrated to field managers the importance of applying appropriate silviculture for successful plantation establishment.
- Developed, directed and implemented R&D Programs for large-scale commercial plantings of eucalypt, acacia and plywood species.

Mark Coffey
Manager of Business Development, Greening Australia Victoria



Mark was qualified initially in recreational turf, horticulture and arboriculture whilst working in amenity and landscape horticultural industries. He studied through both the Industrial Training Commission and the (former) Burnley Horticultural College, Melbourne. In 1996 Mark commenced business management studies at Swinburn University Graduating in 1999.

Mark managed the grounds of Government House Melbourne, The University of Melbourne and as a joint proprietor of Landmark Horticultural Services – a landscape and horticultural consulting business, designed and built landscape projects throughout Victoria. He is a founder member of Greenlink Box Hill – a community volunteer group restoring creeklands in Melbourne's inner eastern suburbs since 1987. Mark joined Greening Australia Victoria in 1991 as a contractor for direct seeding operations in regional Victoria then joining full time in 1992 as a technical officer. Mark has been involved in developing land restoration, weed management and plant propagation techniques and has extensive experience in the management of regional seed collection and seedbanks and direct seeding operations including data management.

Currently Mark is the Manager of Business Development where his role is principally developing programs, services and sponsorships with corporations and business focussing on land restoration and conservation. Marks other interests are in farm production, particularly beef cattle breeding. He is a member of the jazz ensemble Pavlov's Cats, playing double bass, an interest, which poses little threat to professional musicians.

Max Gilbert
Gilbert Consulting Pty Ltd



Max Gilbert, a qualified Civil Engineer with post-graduate management qualifications, commenced his career with the Victorian State Road Authority. Max moved into Local Government where he spent most of his engineering career balancing road infrastructure requirements with the need to protect the natural roadside vegetation. At the former Shire of Gisborne he developed and implemented one of the first comprehensive Roadside Management Plans. Max has been an active member of the Victorian Roadsides Conservation Advisory Committee for twelve years and is the current Chairman. Max has spoken at conferences and run workshops on the practical application of Roadside Management. He currently operates his own consultancy business.

Cuong Tran
Griffith University–Gold Coast

No photo available

Cuong is currently a PhD Candidate in the School of Environmental and Applied Science, Griffith University–Gold Coast. The title of his research is "Determination of the Flammability of Plants in South-East Queensland: Identifying Fire Retardant Species for Use in Green Firebreaks". His professional interests include forest fire research and fire ecology.

His work history has includes:

- Research Assistant for the Queensland Department of Environment & Heritage and Griffith University investigating the identification of ecological sustainable fire regimes for the south-east Queensland region
- Research Officer for the Tasmania Parks & Wildlife Service–Fire Management Section (Department of Primary Industries, Water and Environment), Forestry Tasmania and Tasmania Fire Service investigating fire behaviour, measurements of wildfires and prescribed fires in Tasmania and assessment of the accuracy of fire danger prediction models determination of wind speeds under different heathland canopies
- Tutor/Laboratory Demonstrator at the School of Environmental and Applied Sciences Griffith University–Gold Coast in undergraduate Subjects

He was awarded first prize in the Griffith University Ecology Symposium Presentations in 1998.

Michael Frankcombe
Regional Environmental Officer, Department of Main Roads



Michael's qualifications include a Bachelor of Environmental Science majoring in Land Resources and Management and is a Certified Professional in Erosion and Sediment Control (CPESC). His expertise lie in soil erosion and sediment control, tropical mine and construction sites, environmental management and environmental auditing. Michael's professional affiliations are as the Director of the International Erosion Control Association (Australasia), Chairperson of the CPESC Committee, The Environment Institute of Australia and The Association of Professional Engineers, Scientists and Managers.

He is currently employed with the Department of Main Roads as a Regional Environmental Officer who is responsible for the environmental management of road planning, construction and maintenance in Far North Queensland as well as supervision and management of district environmental staff and consultants. Specific activities include: the preparation of environmental management plans; environmental auditing; environmental design; risk management; staff training; and the provision of technical advice to Executive Management, Departmental personnel, contractors, local councils, other Government Department's and relevant stakeholders. Previous positions held by Michael include Environmental Systems Manager for RZM Pty Ltd and Senior Environmental Scientist for Gutteridge Haskins and Davey Pty Ltd.

Michael Norvill
Regional Technical Officer, Department of Land and Water Conservation NSW
Mick's work history has included:

- Family sheep and cattle property, Hunter Valley NSW.
- Twelve months New Zealand, various rural occupations.
- Soil Conservation Service NSW, dozer operator, construction of conservation earthworks, dams, contour banks, waterways, access roads and fire trails.
- Soil Conservation Service, Field Supervisor, Earthworks construction, including design and survey, supervision and book keeping.
- Soil Conservation Service, Technical Officer, Dam Storage Foreshore Management. Project planning, budgeting and supervision of 6,500 ha.
- Soil Conservation Service, Regional Field Service Manager, Design and implementation of earthworks, supervision of construction, coordination and deployment of construction teams. Conduct training in Conservation Earthworks, dam construction and design, contour bank construction and design, erosion and sediment control, roads and access track design and construction. Development of 4WD training course and Conservation Earthworks courses both of which involved curriculum and competency development.
- Department of Land and Water Conservation. Regional Technical Officer, vegetation management and compliance, (erosion control in clearing and logging operations) design and implementation of erosion control and land management works in the Hunter Valley NSW.



Areas of expertise focus around training and advice on design, construction and erosion control for access tracks, fire trails, logging operations and moderate to low usage gravel roads.

Formal training in the above has been conducted for both the private and public sector in NSW, South Australia and the Northern Territory. Further areas of expertise include conducting: Four Wheel Drive and Driver Awareness training for the Department;

Part time teacher, NSW Technical and Further Education; and Conservation Earthworks Training course.

Tim Scanlon
Consultant to the North Coast Weed Advisory Committee
Tim Scanlon is currently preparing a "camphor laurel, bitou bush and other environmental weeds" management strategy for the NSW North Coast weed advisory committee. He produced the Nymboida Shire roadside environment plan of management and the Bellingen Shire roadside management plan. These roadside plans feature maps of weed infestations and areas susceptible to future weed invasion, as well as management strategies to address all issues important to the roadsides. He has represented the NSW Roadside Environment Committee at several roadside workshops and conferences.



Tim has completed a Bachelor of Science (Honours) degree at the University of Newcastle and has a broad depth of experience including engineering, strategic planning and environmental department experience in local government. He has worked for catchment management and coastline management committees, NSW National Parks and Wildlife Service, private companies and has also produced numerous environmental consultancy reports. Tim is currently based at Coffs Harbour on the NSW mid-north coast.

Trevor Armstrong
Agronomist, Alan Fletcher Research Station, Department of Natural Resources
Trevor Armstrong holds a Bachelor of Agricultural Science and a Bachelor of Economics and has completed Postgraduate training in weed control. He is currently working for the Alan Fletcher Research Station with the Department of Natural Resources and holds the position of Agronomist. He has been employed researching problem non-crop weeds and their control since 1975.



Trevor's key expertise lie in all forms of integrated vegetation management, particularly control of woody weeds and environmental weeds. Trevor has assisted in the development of curriculum for training others through TAFE and other educational institutions overseas. Trevor has received the Weed Society of Queensland Award for weed management and assisting in the organisation of six Queensland Weeds Symposiums and other worthwhile events.

Trevor's has held an interest since childhood in managing land for multiple uses, including grazing for duel purpose cattle production.

Dr Mike Olsen
Lecturer, School of Australian Environmental Sciences, Griffith University
Dr. Mike Olsen is finishing his academic career as a lecturer at Griffith University in the School of Australian Environmental Sciences at the end of this year. He has more than twenty-five years experience in landscape assessment, particularly with regard to the native flora and fauna of Queensland. He completed his Honours (1983) and doctoral studies (1990) in the Botany Department of the University of Queensland with which he maintains a professional association. His commissions have included surveys and analyses of vegetation and other biotic resources at scales ranging from individual site environmental impact assessments to Shire wide and regional vegetation and natural landscape projects. His experience covers such diverse land management prerogatives as on-site effluent disposal via agroforestry schemata, mixed species high-value cabinet timber plantations for individual landowners to specialised assessments and planning initiatives and considerations regarding local and regional noteworthy flora and fauna. These programs have been extended to similar tasks in the nearby south east Asian and south west Pacific regions. He is one of the principals of a consultancy firm (Landscape Assessment, Management and Rehabilitation Pty Ltd (LAMR) – mikeo@lamr.bu.aust.com) specialising in vegetation-based studies and assessments including the provision of expert evidence to a variety of Australian courts.



Rhys Allison
Policy Officer, Stock Route Management, Department of Natural Resources
Rhys is involved in developing and administering policy for the effective management of the State's Stock Route Network for the primary benefit of travelling and agisted stock, protecting its value for conservation, tourism, cultural heritage and recreation consistent with the public needs of transport, power and communications and other resource interests.



John Courtney
PROBE
John Courtney has worked for in excess of twenty years in the development of tourism across north Australia, Papua New Guinea and the Pacific. He was for many years CEO of the Gulf Local Authorities Development Association, GLADA, and therefore manager of the Gulf Savannah tourist region. He currently is a partner in the tourism design, planning and management firm, PROBE.
Presently he is working as part of a team undertaking a three year implementation of an AUSAID funded project designed to enhance tourism within the Pacific nation, the Kingdom of Tonga. John's role in this project includes the design for tourism trails, interpretive signage and the establishment of the Tongan national guide system.



He is not new to any of these activities. In the past he and his team have developed tourism strategies for the PNG Provincial governments of New Ireland and Moreobe, created and implemented the Savannah Guide system across northern Australia, created and designed the Matilda Highway as a concept and developed an ecotourism plan for UNESCO's Man and the Biosphere project in South Australia. He is a member of the Wet Tropics Community Consultative Committee, Chairman of the North Australia Chapter of the Pacific Asia Travel Association and founding member of the Alliance for Sustainable Tourism. He initiated and contributed to the development of the Main Roads best practice manual roads in the Wet Tropics.

John Anderson
Queensland Transport
John is currently studying towards his PhD in Communication Philosophies. He has an Associate Diploma in Civil Engineering; a Bachelor of Arts with a Double Major in Journalism and Journalism Practice. John is an active Federal Executive Member of the Australian Council of Trade Unions.



John's work history includes:

- Regional Manager for the Cultural Heritage Program in the south west Queensland Region for the Queensland Environmental Protection Agency
- Senior Policy Officer on work and labour market programs in the Employment and Training Initiatives Unit of the Queensland Department of Training and Industrial Relations
- Civil Engineering Designer with the Queensland Department of Main Roads

He has represented Indigenous perspectives at every level including keynote addresses to international forums in:

- Yokohama, Japan (1997)
- Ottawa, Canada (1998) and
- The Second World Indigenous Peoples Conference in Toowoomba (1998).

His most recent overseas experience was at the invitation of the United States Information Service during August 1999.

John has held positions as State President of the Association of Apex Clubs of Queensland and National Chairman of the Apex Family Protection Trust, which was developed to protect children against all forms of abuse.

Mark Casswell
Vegetation Management Officer, Ergon Energy (Wide Bay)
Mark holds an Associate Diploma of Applied Science (Horticulture) and a Bachelor of Applied Science (Environmental Horticulture).

For the past two years Mark has been employed as the Vegetation Management Officer, Ergon Energy (Wide Bay). In his role Mark undertakes contract administration and supervision for regrowth control and urban tree management. He is required to assist, audit, promote, train and research vegetation and environmental issues to benefit functional units on behalf of the environmental section.



In previous employment Mark has undertaken:
- advanced tree transplanting
- various landcare activities
- horticultural activities including garden design and maintenance
- chemical regrowth control
- nursery work
- plant operation
- mine and cadastral surveying
- timber bridge reconstruction

Philip Quelch
Senior Engineer, Access Delivery, Commercial and Consumer Business Unit, Telstra
Philip Quelch graduated from James Cook University of North Queensland with a Bachelor of Engineering (Electrical) in 1986. Since then he has held a number of positions within Telstra Corporation Ltd (previously Telecom Australia).
A significant portion of this time was in the area of "Power Co-ordination" which involves the management of hazard and interference from electricity networks.
He is currently a Senior Engineer in the Access Delivery group of Telstra's Commercial and Consumer Business Unit. His duties include managing compliance and regulatory issues of Telstra's construction activities, liaison with external authorities, and project management of major construction projects.
He is a member of Standards Australia committee ET/7/1 "Earth Potential Rise".



Vanessa Craigie
Grassland Coordinator, Flora & Fauna Statewide Programs Branch, Department of Natural Resources & Environment, Victoria
Vanessa Craigie is the Grassland Coordinator with the Threatened Species and Communities Section of the Department of Natural Resources and Environment, and has been employed with the Department under its various names and guises since 1986. She has worked on management plans and strategies for remnant grassy ecosystems, has been the executive officer for the Grassy Ecosystem Reference Group and last year convened "Down to Grass Roots", a conference on grassy ecosystem research and management. Prior to 1992 she worked on the early development and implementation of the Victorian *Flora and Fauna Guarantee Act* 1988, and was Scientific Officer for the FFG Scientific Advisory Committee.



Vanessa has a BSc Honours in botany and zoology from Monash University, majoring in marine intertidal ecology. Despite this her attention has focussed closely on native grasslands and grassy woodland ecosystems for the last eight years. She regularly runs spring walks and talks in grasslands and is committed to the day when Australians appreciate native grasslands as much as rainforests.

Mark Watson
Principal Environmental Consultant and Director, ECOS Consulting (Aust) Pty Ltd
Mark holds a Bachelor of Applied Science (Natural Resource Management), University of Adelaide (Roseworthy). He is a member of the Environment Institute of Australia and the Environmental Affairs Committee, APIA.

Mark has worked in the field of environmental management since 1984. He held positions within both Government and industry prior to joining a specialist environmental consulting firm in 1994. Mark has extensive experience as an environmental scientist, planner, researcher and manager. He has expertise in the oil and gas, pipeline and construction industries and has a broad skills base in environmental impact assessment, project management, environmental auditing, natural resource and cultural heritage management and community consultation.



Mark's special fields of competence include:
- Major Project Environmental Impact Assessment
- Environmental Management, Onshore Pipelines & Petroleum Industry
- Natural Resource Management, Crown Lands
- Experience in Environmental Management Systems, Guidelines, Procedures and Environmental Auditing

Nicole Moore, Environmental Planner, Manningham City Council, Victoria and
Les Moore, LA and NJ Moore Pty Ltd
Nicole started out in academia lecturing in ecology and biogeography following her PhD studies into the ecology of rainforest fauna. After several years working as Townsville City Council's first environmental planner she moved to state government. Before becoming the Manager of the Wildlife section in the Department of Environment and Heritage in Cairns, Nicole set up the first environmental training courses for tourist operators in the Wet Tropics. Four years as a specialist environmental consultant followed before Nicole moved to Melbourne and a job as an Environmental Planner with one of the most progressive councils in Melbourne. Nicole's major interests are in demystifying science and motivating others to become more personally responsible for implementing environmental change.



Les was a researcher with CSIRO Wildlife and Ecology for 29 years undertaking field programs in wildlife ecology and conservation throughout Australia. Afterwards he worked as the Senior Ecologist with Queensland's largest specialist environmental consultancy company before setting up his own consultancy practice. Les has worked in the scientific research field all his professional life and is recognised as a tropical fauna expert with extensive field expertise, knowledge and publications in the areas of cassowaries, rainforest birds and small mammals.

Geoff Edwards
A/Principal Adviser, Resource Management, Department of Natural Resources
*Geoff Edwards is Acting Principal Adviser Resource Management with the Department of Natural Resources, a policy formulation role across the natural resources of land, water, forests and vegetation. In previous appointments he managed Melbourne's metropolitan parks system and was Superintendent of Parks, Gardens and Sports in Port Moresby. He has been a local government councillor and Shire President. In Victoria he was a co-sponsor of the pivotal 1975 conference on roadside management and pro tem chairman of the Roadsides Conservation Committee which arose from that forum. This committee operated for more than 20 years as an informal, non-statutory forum for consultation and drove Victoria's pioneering work in the management of linear reserves. Geoff is qualified in biological science and public administration. He is currently studying part-time for a PhD. under Assoc. Professor John Wanna and Professor Pat Weller in the School of Politics and Public Policy at Griffith University. His project aims to define the meaning of "public interest" in public affairs.



Andrew Straker
Roadside Conservation Program Leader, Roadsides Conservation Advisory Committee, Victoria

CV not available.



PAPERS

OPENING ADDRESS

The Honourable Stephen Bredhauer
Minister for Transport and Minister for Main Roads

INTRODUCTION

Conferences such as this are important and valuable for the creation of "healthy" transport corridors for the future, which both integrate with the surrounding environment and preserve biological diversity.

There are many tangible and intangible benefits from undertaking best practice vegetation management, which is the focus for this Transport Corridor Management Conference over the next three days.

AIMS OF THE CONFERENCE

The main objective of the conference is to promote discussion on four areas. These include:

- the benefits of effective vegetation management in transport corridors;
- the techniques that reduce maintenance costs and improve aesthetics by retaining native vegetation;
- the legal obligations with regard to vegetation management; and
- best practice in species selection, erosion and sediment control, weed management and fire retardants.

From the variety of speakers addressing this conference, it appears the quality of debate and discussion will be high.

The Role of Main Roads within the Transport Portfolio

The Transport portfolio of Queensland, and in particular Main Roads as steward of Queensland's State-controlled road system, has an important role to play in encouraging discussion and development of work on vegetation issues along our transport corridors.

Some of our transport corridors contain stands of significant remnant vegetation which has remained protected from the impacts of agricultural practices and other development. Examples found along the State-controlled roadsides include:

- Childs Scrub - located at Nudgee, alongside the Gateway Motorway, which contains a significant remnant of dry rainforest from the Brisbane region;
- Gateway Motorway - a recent finding of the shrub *Keraudrenia* sp. was very recently identified near the Boondall Wetlands. Only three small populations of this species have been identified;
- Bowenville Junction - on the Darling Downs. This contains a significant area of remnant native grasslands;
- Ebbw Vale - along the Cunningham Highway, where the largest known population of a native olive *Notelaea* sp. in the world has been located. Along this section of highway there are 14 of the 20 plants of this species recorded in the world; and
- Emerald - In Central Region, around Emerald, endangered brigalow scrub is contained in 2/3 of the region's road reserve.

There are other examples around the State and knowing how to effectively manage these resources, to protect the existing vegetation and surrounding natural environment, offers many benefits to the community, the environment and our organisations.

That we have delegates here today from organisations across the nation, and a level of international interest, recognises the growing importance of managing vegetation in transport corridors to meet the needs of the community and the environment.

The flow-on economic benefits which stem from addressing community and environmental issues cannot be undervalued.

VALUING THE ENVIRONMENT

Valuing the Environment is one of the Beattie Government's seven priorities and an area which Main Roads and Queensland Transport, take seriously.

Within Main Roads sustainable environmental management is one of our highest corporate priorities.

An example is the Pacific Motorway project where 250,000 trees have been planted to date with a further 750,000 to be planted by the end of the project.

Main Roads is currently researching a number of environmental areas including lung fish habitat improvements, canopy connectors for tree dwelling fauna, underpasses for animal movement and dry climate batter stabilisation.

The department's Environmental Manuals, which promote excellence in road management, have received widespread recognition within Queensland and are generating interest from organisations in other States.

In particular the Roads in the Wet Tropics Manual has received international recognition and is being promoted and supported by the Tropical Rainforest Ecology and Management arm of James Cook University's Cooperative Research Centre.

The Road Landscape Manual received national recognition when it won the Australian Institute of Landscape Architects, National Research and Development Award last October. The manual provides guidance and instruction for the assessment, design and management of the State-controlled road network within the broader landscapes of Queensland.

The other manuals cover Cultural Heritage, Environmental Legislation and Erosion and Sedimentation and Road Traffic Noise.

This financial year implementation of an Environmental Management System was undertaken in all Main Roads' regions across the State to integrate environmental management practices into normal work procedures.

ROAD CORRIDOR ENVIRONMENTAL ASSESSMENT PROJECT

A need has been recognised to go continuously improve our management practices and Main Roads is currently working on a Road Corridor Environmental Assessment project. The aim is to tie together a number of environmental databases and ensure valuable environmental resources, including vegetation, are considered in early planning decisions for the road network.

The Road Corridor Environmental Assessment project will be discussed further in today's program by Dr Michael Ryan of Main Roads' Technology and Environment Division.

Early identification of environmental assets assists in effective planning which ultimately offers economic benefits in the longer term.

AWARD FOR ENVIRONMENTAL AUDITS OF WORKSITES

Main Roads' commitment to environmental management was recognised in July when the department was awarded a Case EARTH Award by the Civil Contractors Federation for environmental initiatives implemented in 28 of our depots and workshops across Southern Queensland. (Main Roads also won this award in 1998 for the best practice Environmental Manuals).

Extensive work was undertaken to upgrade and rehabilitate departmental depots, quarries and other work sites to meet environmental compliance standards and address potential problems including waste disposal, land contamination and storm water run-off.

Through implementing better systems and re-engineering our work environment, this project is creating a better and safer environment for our staff and the wider community, with long term financial and management benefits.

MAIN ROADS INVOLVEMENT WITH THE CONFERENCE

Over the last seven years Main Roads and Greening Australia have been working together to revegetate our roadways through projects such as the Freeway Greening Project in Metropolitan District and other similar projects around the State.

Today Main Roads is proud to be a Gold Sponsor of this conference, which has been organised by Greening Australia, and I invite you all to take a look at our trade display booth during your attendance.

At the booth you will find copies of our best practice Environmental Management Manuals including our internationally recognised Roads in the Wet Tropics Manual and nationally awarded Road Landscape Manual.

I encourage you to have a look at these and discuss them further with our officers at the stand.

CONCLUSION

The aim of this conference is to encourage discussion on vegetation issues and to share work to date in this field which is being undertaken by State and Local Government and those in the transport and infrastructure fields.

KEYNOTE ADDRESS - A HOLISTIC APPROACH TO VEGETATION MANAGEMENT IN TRANSPORT CORRIDORS

Bonnie Harper-Lore
Federal Highway Administration USA

AUSTRALIA...Crossing the Borders

We have some 12 million acres of highway rights-of-way in the United States. None are managed by the Federal Government. Maintenance is the responsibility of the 50 State Departments of Transportation (DOT). Some of them rely on County Governments to maintain the roadsides; others rely on private contractors, but most on their own forces. And every State has a different policy, different budget priority, and a different climate (political and physical) under which it operates. All States traditionally prefer to use a few seed mixes on all projects. We are asking the DOTs to customise their seed mixes project-by-project; use local ecotype seed as much as available; use as much diversity as they can afford; disturb as little of the site as possible and; use preservation of vegetation whenever possible. I need precedents of successful restoration and preservation to help them make changes. I need your help.

Information sharing and partnering among States has not been common. So each learns its own lessons and tends to hold on to "the way we've always done it" in response. However, what has worked in the past does not always coincide with the environmentally correct thing to do as we enter the 21st century. We have learned a lot since the first roads were built in the 20th century:

- the 1930s roadside development as our "nation's front yards";
- the 1950s addition of herbicide sprays to the maintenance tool box;
- the 1970s energy crunch, when fuel was unavailable for mow-spray operations; and
- the 1990s directives to use native plants as much as practicable.

The United States has lost a large percentage of its grasslands, wetlands, and woodlands. Once largely lost, our natural heritage became more important to our decision-making. We looked for opportunities to restore this heritage and found such an opportunity on highway rights-of-way. We also found some remnants of our native plant communities worth protecting. As we did so, we learned that some States were still unwittingly planting known-invasive species like Russian olive, black locust, purple loosestrife, oxeye daisy, honeysuckles, Japanese barberry, reed canary grass, and English ivy. Some but not all of these species have been put on State noxious weed lists. But again not all States operate in the same way. Twelve states have no noxious weed list and therefore have no legal push to prevent or control invasive species. And why is this important to native plant preservation and restoration efforts? Without weed control, restorations will fail, and preserved areas will be degraded.

To further complicate the prevention and control of invasive species, if a plant is pretty, there is no immediate public will to stop planting it, i.e. purple loosestrife, dames rocket, and Queen Anne's lace. I am convinced that the tax-paying public thinks all green plants are good. The lack of public awareness about the impacts of invasive species is huge. Internal and upper management awareness within transportation is troublesome. Without this awareness, many States do not get the financial support necessary for control. But there is hope! The following are examples of State Departments of Transportation who are making environmentally correct decisions, one at a time.

- Minnesota reduced mowing legislation in 1985. Wisconsin and Michigan followed suit;
- Florida requires weed-free sod on all construction projects. Florida's legislature just required 1% of construction budgets for landscaping = $8million;
- Wyoming is one of a handful of States that specifies weed-free mulches;
- Montana's legislature is considering the requirement of weed-free gravels in construction;
- Massachusetts is exploring the notion of a weed-free-soils requirement;
- Iowa's legislature set aside a Roadside Trust to fund integrated management of roadsides;
- California is locating roadside remnants, signing them, and managing them uniquely;

- Illinios is planting native grasses on roadsides at a rate of 1000 acres/yr;
- Oregon has inventoried their roadsides and marked all endangered species locations;
- Washington has studied and defined a system of three right-of-way maintenance zones; and
- Utah is inventorying vegetation and with the help of GIS will manage a State-wide plan.

Recently, we the Federal Highway Administration, sent guidance to all States regarding the President's Executive Order on invasive species. We will no longer allow federal funds to be spent on the planting of "known invasive species". We encourage the use of federal funds to strengthen roadside vegetation programs. Since they largely fall within maintenance programs, and the FHWA does not fund maintenance; this is news-making. This issue which will drive States to do State-wide inventory and planning, as well as look at this issue during the entire pre-design NEPA (National Environmental Policy Act) process. Utah was the first State to call an interoffice and interdisciplinary team to define a proactive response. They are likely to require control of more than the minimum weed list, the washing of all construction equipment moving on to or off a project, weed-free mulches, soil, and seed, and greatly increased training.

Since plant and animal species do not respect political boundaries, those of us in the business of vegetation management must also cross borders to form partnerships, reduce political barriers, and share the resources and technical information necessary to prevent and control invasive species, plus restore and preserve the remaining native pieces of landscape for our own quality of life and that of our childrens' children. After all, we are all connected.

NATURE CONSERVATION VALUES IN QUEENSLAND ROADS

Dr Rod Fensham
Botanist, Queensland Herbarium

ABSTRACT

Roadsides are a key component of nature conservation in Queensland. For some endangered ecosystems, such as grassland threatened by cultivation, they provide the most extensive and viable remnants. In these fertile landscapes they provide habitat for numerous rare plants. It is not only the physical setting of roadsides in these situations that provides the necessary habitat. Many of these species appear to be reliant on the types of disturbance phenomena to which roadsides have been historically exposed. Frequent fire and occasional, intense, but never continuous, stock grazing may provide the appropriate niches for some of these species. The absence of disturbance altogether, although disfavouring exotics, tends to result in the dominance of only a few native grasses at the expense of inter-tussock herbs. The evidence for these suppositions is largely anecdotal and there is a clear need for survey and research directed towards management of roadsides. This is particularly true given that the threat of mechanical disturbance, arising from road maintenance and development, seems to be cataclysmic for their natural integrity. Nature refuges need to be developed that provide the appropriate protection for important sites and without better knowledge this management should maintain the historical status quo.

***Key words**: grasslands, roadsides, rare plants*

Roadsides are a key component of nature conservation in Queensland. Some of the best-documented examples are the stock routes in the Darling Downs and central Queensland that provide key habitat for remnant grassland (Fensham 1998; 1999a). In the eastern Darling Downs the conversion of grassland to crops has reduced the grassland habitat to <1% of the original area and the stock routes provided some of the largest remnants. *Solanum papaverifolium* is only known from this habitat, although it is extremely rare. In the grassy woodlands of the Darling Downs there are a whole host of rare plants including the native thistle (*Stemmacantha australis*), another daisy (*Picris evae*), the austral toadflax (*Thesium australis*), the anchor plant (*Discaria pubescens*) and a grass *Homophilis belsoni.*

The Belyando cobbler's peg (*Trioncinia retroflexa*) was only recently rediscovered on a roadside near Clermont in central Queensland (Fensham 1999b). For these species it is not only the physical setting of roadsides that provides the necessary habitat. The disturbance phenomena to which roadsides have been historically exposed appears to be critical for their survival. Frequent fire, and occasional, intense, but never continuous, stock grazing may provide the appropriate niches for some of these species. The absence of disturbance altogether, although disfavouring exotics, tends to result in the dominance of only a few native grasses at the expense of inter-tussock herbs.

A retired stockman testified to the historical disturbance regime at the Clermont site. The stock route was used as holding paddock prior to transport from adjacent stock yards. The trampling and grazing of large herds of cattle would have had a major impact, but only for short periods of time and only during the months April to September. The idiosyncratic management history of the site would seem to provide the specific ecological requirements of the Belyando cobbler's peg. The dominance of native perennial grasses is reduced by intense grazing over short periods during the winter months. The Belyando cobbler's peg only grows flowers and fruits after good rain and is thus typically dormant in winter. Grazing has only rarely occurred on the site during the wet season when the relatively short-lived plants are reproducing.

The number one threat to roadsides is posed by mechanical disturbance. In the Darling Downs a number of disasters have occurred in the last five years. In 1995 virtually all of the rail reserves were graded for the first time in their history. In 1996 a 4000 x 50m wide swathe was graded through one of the last surviving stock routes to divert traffic, while road maintenance was conducted. These situations could undoubtedly have been avoided and alternative options developed with effective communication and consultation with government agencies. Mechanical disturbance can result in severe management problems such as those in the Peak Downs Shire where roadsides have been needlessly graded, resulting in the proliferation of Johnson grass (*Sorghum halepense*), which has the potential to develop fuel loads akin to sugar cane crops. In this case not only are very important conservation refuges lost, but a severe management problem is created. Johnson grass creates massive fuel loads causing an

exceedingly difficult fire management problem. By comparison, controlled burning of native grassland is relatively straightforward and is still pursued by other shires in the area.

Protection measures for important roadside remnants are needed at a number of levels. For very high priority areas, nature refuge agreements need to be developed. This is a legally binding agreement that is bound to title and would stipulate against such management practices as mechanical disturbance. In general and without better knowledge, management of remnant vegetation on roadsides should maintain the historical *status quo*. Thus in most cases the continuation of grazing and burning is judicious. There are numerous examples from around Australia where formal and informal agreements on the management of transport corridors are breached with cataclysmic consequences. Major damage has occurred for example during the annual holiday of a conscientious shire engineer. Signage along important roadsides is required and is well established in Western Australia (Hussey 1991) and has been employed to prohibit vegetation clearance on roadsides near Tara in order to protect the endangered shrub *Acacia lauta*. In order to avoid vandalism it may be appropriate that the signs are only symbolic. A yellow triangle for example could become clearly understood by road workers to signify that advice needs to be sought on allowable practices in the area. In other situations there is ample opportunity for interpreting the natural values of roadsides to the public. A sign has been developed for the remnant grassland of the Darling Downs and will be erected on the Warrego Highway between Oakey and Dalby. It reads:

SIGNIFICANT ENVIRONMENTAL AREA

"This area is one of the largest remnants of native grassland on the Darling Downs. This naturally treeless landscape has now been reduced to less than 1% of its former area. The dominant grass is Queensland bluegrass (Dichanthium sericeum) occurring here on some of Australia's most fertile agricultural soils. A diversity of other grasses and herbs are prolific after rain.

Before doing any work in this area please ring 4639 0777 and quote DMR3/18B/SEA1."

There is much more work required before we have developed a system that adequately protects the nature conservation values of our roadsides. However, in most cases protection does not detract from the primary purpose of road corridors, but does have the potential to enhance the value of roads and the experience of those who travel on them. Highly significant roadsides need to be developed as Nature Refuges to ensure that all parties have a legal commitment to appropriate management.

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ENGINEER'S PERSPECTIVE ON VEGETATION MANAGEMENT IN TRANSPORT CORRIDORS

John O'Toole
Manager - Maintenance Delivery Department of Main Roads - Metropolitan

ABSTRACT

This paper puts in perspective the management of vegetation and landscaping in the overall maintenance task for a road network. It highlights the need for good landscape design incorporating safety criteria.

The author also discusses initiatives developed to increase the funds available to enhance the aesthetics of a road corridor while reducing the recurrent management costs.

INTRODUCTION

Engineers have a morai and legislative responsibility to protect the public health and safety of the community. Therefore engineers working in the construction, maintenance and operation of a road network are focussed on the safety of all road users whether they are motorists, cyclists or pedestrians as well as our colleagues, the roadworkers.

Just as there are standards such as design speed to determine criteria for the design of a new section of roadway, road maintenance has criteria which are essentially safety related to ensure the network is maintained to a safe and useable standard.

Some of these maintenance criteria are:

- Intervention levels (IL). These criteria define when a particular defect needs to be repaired.
- Response times. This is the time in which the maintenance contractors must have effected the repairs. The time reflects the risk associated with a particular defect. For example, the loss of power to a set of traffic signals could result in serious accidents if the repair was not effected within an hour of notification.
- Restoration standards. These standards determine the quality of the finished repairs.

The Maintenance Unit of Metropolitan District is responsible for vegetation management once the construction and/or landscaping projects are completed. This paper describes how vegetation management fits in the maintenance task, maintenance strategies to enhance the road corridor and management of the landscaped asset.

STRATEGY DRIVEN MAINTENANCE OR THE "BIG PICTURE"

In Metropolitan District a systematic approach to the management of maintenance is undertaken.

This approach involves:

- Identification of maintenance in advance:
  - The network is inspected regularly to identify and record defects. This list of defects is known as the defect backlog. The intervention level (IL) is the criteria used to determine whether a defect is to be logged.
- Planning and prioritising of the maintenance recorded on the backlog. This ensures operations efficiencies are achieved. The identified defects are prioritised according to whether they are:
  - Safety.
  - Preventative maintenance.
  - Usability related.
- A number of safety related defects are assigned response times. This means the contractor is required to undertake the repairs within a stated time limit eg. pavement pothole repairs within 24 hours.
- Undertake the maintenance. The repairs are to be undertaken to the agreed restoration standards and the maintenance contractor's quality system.

- Recording and reporting of completed maintenance:
  - These reports are used for payment and district and corporate analysis such as network deterioration rates.

Vegetation issues such as grass height or trees/shrubs blocking sight lines are not logged as the mowing of the grass or trimming of trees is completed by the time the defect is logged. However, the situation is monitored regularly both during daylight and at night by an Inspector who is assigned this responsibility.

This management strategy ensures all safety issues are addressed and we have been working with our maintenance contractors to improve the efficiency and effectiveness of the road network maintenance. A number of innovative methods, new technologies and productivity improvements have been trialed and if successful have been implemented.

Some examples of the fine tuning to maintenance management that have been implemented are:

- Road Maintenance Performance Contract with preferred suppliers.
- Open market maintenance contracts.
- Undertaking maintenance at night.
- Functional maintenance work units such as vegetation management, pavements, structures traffic and quick response safety teams.
- Purpose built plant and equipment.
- Management of vegetation using chemical treatment technology.

Improvements to the delivery of the preventative maintenance and aesthetic maintenance components have also been investigated with strategies implemented to:

- Reduce the cost of litter collection by the use of people who have to undertake community service orders.
- Apply improved products and machinery for crack sealing of road surfaces.
- Reduce the incidence of graffiti on public infrastructure.
- Introduce agreements with Local Government to undertake vegetation management on the behalf of the Department of Main Roads (economies of scale).

These financial gains within the constrained maintenance budget can then be utilised to enhance the aesthetic appearance of the road network.

VEGETATION MANAGEMENT

It has been estimated that the annual cost to maintain parks, reserves and roadside grasses by Local Government and State Authorities in south east Queensland is about $60 million per annum. This is a large recurrent cost and Metropolitan District has in place a strategy to reduce this drain on the maintenance budget and divert savings to enhance roadside landscaping.

There are a number of policies, guidelines or research projects in place to improve our management of the roadside environment. Some of these are:

- Road Landscaping Manual (Statewide).
- Vegetation Management Policy (Metropolitan District).
- Vegetation Management Species Selection Policy (Metropolitan District) which includes Preferred Landscaping Species list and a generic list of Environmental Weeds.
- Native Grass Species and Provenances Most Suitable for Planting on Road Verges Research - a collaborative project between The University of Queensland, Greening Australia and the Queensland Department of Primary Industries and funded by the Queensland Department of Main Roads.
- Direct seeding of road batters.
- Report on effectiveness of weed control barriers for landscaping.
- Recycling of vegetation pruning and clippings as mulch.

The project which has the greatest potential for savings is the chemical treatment of grasses/weed using glyphosate and a wick wiping technology. Glyphosate, which is a non-selective herbicide, is used selectively via this technology. The concept is to eliminate the tall growing grass and weed species by the height of application and promote the growth of low growing species, such as couch by a reduction in competition and increased light penetration.

The cost of a treatment is about equivalent to the cost of mowing and a program of treatments and mows over a three year period can usually convert an area to predominantly low growing species with a significant reduction in the recurrent management costs (up to 50%). A maintenance program of one or two treatments per annum is normal to reduce the reinfestation of unwanted grass species.

A possible outcome of this work is twofold:

- The budget savings could fund additional landscaping projects on the road network.
- Resources usually fully committed on vegetation management could be utilised on safety issues or landscaping projects.

Successes

- Our partnership with Greening Australia (Queensland) has been an important influence on improvements to roadside corridor vegetation management in Metropolitan District.
- 1998 Queensland Arbor Day Award - Corporate Tree Planter Award presented to Graham Shardlow, Metropolitan District.
- Individual Projects :
  - South East Freeway Greening.
  - Ipswich Motorway.
  - Centenary Highway.
  - Old Northern Road, Albany Creek.

Disappointments

The disappointing aspect of the landscaping in Metropolitan District until recent years has been the poor design by landscape architects. As a road engineer, my primary focus has to be road safety and this has not been appreciated by the designers.

Landscape design within a road reserve cannot be done in plan view. The designer has to consider the:

- Horizontal and vertical geometry.
- Intersection sight lines and distances.
- Stopping distances.
- Pedestrian movements.
- Special requirements for cyclists.
- Roadside hazards and clear zones.
- Visibility issues regarding road signage.
- Above all, the mature dimensions of the plants.

They should also realise that the construction and maintenance professionals who will implement the landscaping projects generally do not have a botanical background.

Current Initiatives

An exciting initiative which has been recently agreed between the Brisbane City Council and Metropolitan District is the Green Routes Program. This is a partnership between the two authorities to green the major road corridors leading into the capital city.

Two jointly funded projects which are currently underway are:

- Beaudesert Road, Acacia Ridge.
- Gympie Road between Chermside and Carseldine.

It is hoped to extend this Program with other Local Governments which neighbour Brisbane City.

Another aspect of landscaping design which we would like to explore is "landscape themes" for various routes. For example, a route to a particular destination may have species planted which flower in a particular colour at different times of the year. This would reinforce the destination route signing as well as having an aesthetic appeal for the road user.

At the entrances to local towns, we would like to reinforce the native plants common to that area, the Local Government floral emblem, etc by planting these species exclusively.

CONCLUSION

Landscaping is an important component of the assets provided in road corridors. It has to be well designed and managed to ensure it is "user friendly" to the community using and residents/businesses abutting transport corridors.

Above all vegetation must enhance the safe use of the corridor by complimenting the safety features built into the network as well as softening the impact of major transport routes.

The author gratefully acknowledges the support provided by Metropolitan District, Department of Main Roads and permission to prepare this paper.

The views expressed are those of the author and not necessarily that of the Department of Main Roads, Queensland.

MANAGING VEGETATION IN TRANSPORT CORRIDORS ENVIRONMENTAL LEGAL ISSUES

Paul Smith
Dunhill Madden Butler Solicitors

ABSTRACT

Before 1788 the natural environment of the continent had been more or less stable for thousands of years. Within only a few generations we, in Australia, have managed to eradicate more than half the world's mammal species and destroy many native species of plants and animals. Currently, some 800 species of plants and over 100 species of animals are considered endangered or vulnerable in Australia.

A range of environmental laws has been introduced in Queensland by both the Commonwealth and State Governments aimed at reversing this trend. The focus has shifted from protecting individual property rights to balancing those rights with the rights of the community as a whole and future generations, to have such things as clean air and a sustainable natural environment.

The principal source of this new wave of environmental laws may be found in international conventions and treaties which set international agreed standards for conservation, pollution control and the like. While Australia may be a party to particular conventions and treaties, generally speaking, they do not form part of Australian law so as to affect legal rights or obligations unless they have been validly incorporated in our municipal law by legislation.[1]

There was a flood of environmental legislation introduced in the 1970s and 1980s[2] which intended to do just that. For example environmental controls were beginning to appear in the *Land Act*, the *Environmental Protection Act,* the *Local Government (Planning and Environment) Act,* the *Water Resources Act* and others.

The approach taken at the time was ad hoc and uncoordinated. Essentially the responsibility for administrating environmental laws was given to the State department responsible for administering a particular government function. For example the Department of Mines and Energy was given the responsibility for managing the environmental effects of mining activities. Many other State departments resisted any environmental controls at all over their own activities. Essentially they saw environmental management as contrary to the objectives of National Competition Policy and simply as a nuisance that diverted valuable resources away from their core business.

The late 1990s has seen a move away from diverse and uncoordinated legislation towards integrated environmental controls. For example, the Commonwealth introduced the *Environmental Protection and Bio-diversity Conservation Act* in 1999 to replace and repeal a number of existing Commonwealth Acts including the *Environmental Protection (Impact of Proposals) Act 1974,* the *Endangered Species Protection Act 1992* and the *National Parks and Wildlife Protection Act 1975*. The new *Environmental Protection and Bio-diversity Conservation Act* will come into force on 16 July 2000.

Queensland introduced the *Integrated Planning Act 1997* in 1998 which will progressively incorporate all development control provisions of various State Acts, including the *Environmental Protection Act 1994*.

The *Environmental Protection Act 1994* has been amended to consolidate environmental controls previously contained in the *Contaminated Land Act,* and other environmental legislation.

Further, an Environmental Protection Agency (EPA) has been established in Queensland to provide a single body to be responsible for the enforcement of environmental controls. State departments and local governments have also reluctantly given in to public pressure for them to be bound by their own environmental laws.

I believe this is an indication that both the Commonwealth and the State are taking their international obligation to protect the environment for future generations more seriously than they have in the past.

The question I will discuss in this paper is how, if at all, this new wave of environmental laws affects managers of the State's roads and stock routes.

I will briefly discuss:

1. *who is responsible for the management and control of our roads and stock routes*
2. *what decisions those managers make that impact on the removal or conservation of vegetation and*
3. *what environmental laws impact on those decisions.*

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1 Refer, for example, to the convention on biological diversity drawn up at the Earth Summit in 1992.

2 Refer *Environmental Protection (impact of proposals) Act 1974* (CTH); *Environmental Offences and Penalties Act 1989* (NSW); *Environmental Planning and Assessment Act 1979* (NSW); *Environmental Protection Act 1973* (TAS); *Environmental Effects Act 1978* (VIC);.

THE COMMONWEALTH

The general rule is that the Commonwealth Constitution grants legislative competence to the Commonwealth with respect to a number of specific areas. All other areas are the responsibility of the States.

There is no specific reference to the Commonwealth being responsible for the environment in the Constitution. Following the general rule, managing the environment is therefore the responsibility of the States. This is not to say, however, that the Commonwealth cannot legislate in respect of matters of environmental concern. The Commonwealth may, for example, introduce legislative controls over Commonwealth land, Federal territories, coastal waters, continental waters and matters bearing upon the Commonwealth's external affairs and defence responsibilities.

There will be occasions when consideration will need to be given to Commonwealth legislation. However, by far the most relevant legislation affecting vegetation management is that of the State. I will therefore leave further consideration of the Commonwealth's role in environmental management to another day and make no further reference to the Commonwealth in this paper.

ROADS AND STOCK ROUTES

Roads and stock routes will generally be unallocated State land dedicated as a road in accordance with the relevant provisions of the *Land Act 1994* or its predecessor. While roads are commonly referred to as "road reserves", with minor exceptions, it has not been the general practice in Queensland to reserve land for road purposes.

Under s.93 of the *Land Act 1994*, a road is defined to include:

> *"a street, esplanade, reserve for esplanade, highway, pathway, thoroughfare, track or stock route".*

A road is defined in s.94 of the *Land Act 1994* as:

> *"an area of land whether surveyed or unsurveyed -*
> 1. *dedicated, notified or declared to be a road for public use; or*
> 2. *taken under an Act, for the purpose of a road for public use."*

A road includes a bridge, causeway, culvert or other works in, on over or under a road and any part of a road.[3]

"Stock route" is defined as meaning:

> *"a road or route ordinarily used for travelling stock".*

A road may be a State controlled road, a local government controlled road or a stock route.[4]

In addition to the *Land Act 1994*, the powers of local government in respect of local government controlled roads are generally provided for within the *Local Government Act 1993*. Local government's responsibility for stock routes is contained in the *Rural Lands Protection Act 1985*.

The powers of the State in respect of State controlled roads are generally provided for within the *Transport Infrastructure Act 1994*.[5]

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3 The pastorage rights for travelling stock along stock routes is contained within s.432 of the *Land Act 1994*.

4 Also the responsibility of local government

5 Also refer *Transport Infrastructure (Roads) Act* 1991.

LOCAL GOVERNMENT CONTROLLED ROADS

The *Local Government Act 1993* includes a definition of road which is similar to that provided for in the *Land Act 1994*. It also includes "an area that is open to or used by the public and is developed for, or has as one of its main uses, the driving or riding of motor vehicles".

A road may therefore include an area of private or public land that has not been dedicated or reserved for a road.

In accordance with s.901 of the *Local Government Act 1993* a local government has control of all roads in its area and may take all necessary steps to construct, maintain and improve the roads and to regulate the use of roads by local law.

Section 901(2) provides that the control of roads includes the capacity to take all necessary steps to, among other things, construct, maintain and improve roads.

Further, a local government may make local laws generally on any matter the State can make laws about. Local governments may make local laws within its territorial unit and any additional territorial unit put under its control.[6]

Local governments may therefore make local laws to regulate the removal of vegetation on local government controlled roads and stock routes.

STATE CONTROLLED ROADS

The management and control of State controlled roads is given to the Department of Main Roads under the *Transport Infrastructure Act 1994*.

An objective of the Act is, among other things, to establish a regime under which a system of roads of national and State significance can be effectively planned and effectively managed.

Section 23 provides that the Minister may, by gazette notice, declare a road or route or part of a road or route to be a State controlled road.

Chapter 5, commencing at s.21, provides a framework under which the construction, maintenance or operation of a State controlled road can be done by the Chief Executive or by a local government or someone else under agreement with the Chief Executive.

Section 26 provides that the Chief Executive may exercise, for a State controlled road in the area of the local government, all the powers the local government may exercise.

Section 47 provides that the Chief Executive may construct, maintain or operate or conduct ancillary works and encroachments on a State controlled road.

"Ancillary works and encroachments" are defined to include, among other things, clearing, trimming, slashing, landscaping, planting and burning off and removal of trees.

Section 46 provides that if a person causes damage to roadworks or ancillary works and encroachments that person is liable to pay to the Chief Executive the cost of repair, replacement or reconstruction. If a Court finds a person guilty of an offence against this Act, the Court may require the person to pay an amount towards the cost of repairing the damage.

Section 47(6) provides that a thing is not done contrary to this section if it is permitted under the *Land Act 1994*, the *Traffic Act 1949* or an Act about local government.

The effect of these provisions is that State controlled roads come under the control of the Department of Main Roads whose principal responsibility is to establish a system of roads of

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6 Refer Chapter 2 *Local Government Act 1993*

national and State significance. The Department has the power to clear, slash and burn off trees and other vegetation in the performance of that role.

STOCK ROUTE MANAGEMENT

The stock route network comprising some 1.5 million hectares of land, consisting of approximately 72,000 kilometres of stock routes and a large number of reserves, has been set aside primarily to enable stock to travel.

This is still a valid purpose although most stock is now transported by road or rail.

The network is also important because it contains remnant timber stands and water used by both native fauna and stock.

In some cases water facilities have fallen into disrepair, trees have been destroyed or removed and rock and earth quarried.

There are a number of Acts affecting the management of stock routes, principally the *Land Act 1994* and the *Rural Lands Protection Act 1985.*

Section 57(1) of the *Rural Lands Protection Act 1985* provides:

> *"A local government shall, as a function of local government control, improve and maintain stock routes and reserves for travelling stock within its area".*

There is no specific reference in the *Rural Lands Protection Act* or the *Local Government Act* for local governments to give regard to environmental protection and conservation when exercising control over stock routes.

As with local government roads, local government may make local laws to have the effect of regulating tree clearing and the like on stock routes.

SERVICE PROVIDERS

Generally service providers including telecommunication providers, electricity authorities and gas providers are empowered under their respective legislation to slash, burn and remove vegetation and to carry out other works on roads to carry out their statutory functions.[7] However, in most cases, notice to the relevant road authorities (Main Roads or local government) must first be given and, in the case of the *Electricity Act 1994* approval obtained.[8]

MAJOR INFRASTRUCTURE PROVIDERS

Persons who propose to construct a pipeline or power line may also destroy vegetation on roads if authorised by the licensee or approval issues under the *Petroleum Act 1923* or the *Electricity Act 1994.*

Proposals for major infrastructure projects will, however, require a comprehensive assessment of the environmental effects of the project.

This will involve the preparation of an Impact Assessment Study under the *State Development and Public Works Organisation Act 1974* or alternatively form part of the development assessment system under the *Integrated Planning Act 1997.*

Generally the environmental assessment of projects of this nature will consider the full range of environmental issues and a consideration of these projects is beyond the scope of this paper.

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7 For example, s.102-5 *Electricity Act 1994 (Qld)*

8 Consent must not be unreasonably withheld - s.102-5 *Electricity Act 1994.*

TREE MANAGEMENT ON ROADS AND STOCK ROUTES

Tree management on roads and stock routes, is partly governed by Part 6 of the *Land Act 1994*, the objective of which is to include maintenance of biodiversity and environmental values and preventing degradation.[9]

Permits may be issued by the Chief Executive, Department of Natural Resources, who must take into account the presence of environmentally sensitive areas, as well as any social and economic benefits associated with the clearing before issuing a licence.[10]

No permits are required for routine management except in critical areas[11] or for routine transport corridor management and safety purposes.[12]

The *Water Resources Act 1989* also prohibits the destruction of vegetation in watercourses and lakes without a permit.[13]

The *Forestry Act 1959* also requires a permit to remove timber which is of commercial value.[14]

THE BIG PICTURE

As noted in the introduction to this paper, beginning in the early 1970s, legislatures in Queensland have progressively introduced environmental legislation first in an uncoordinated ad hoc manner and, more recently, in a more coordinated way with amendments to the *Integrated Planning Act 1997* and the *Environmental Protection Act 1994*.

Increasingly we find in legislation statements describing the environmental purpose or objective of the Act.

For example, s.1.2.1 of the *Integrated Planning Act 1997* provides:

> *"The purpose of this Act is to seek to achieve ecological sustainability by:*
>
> .....

Section 1.2.2(1) provides:

> *"If, under this Act, a function or power is conferred on an entity, the entity must:*
>
> *(a) perform the function or exercise the power in a way that advances the Act's purpose"*

Section 1.2.3(1) provides:

> *"Advancing the Act's purpose includes:*
>
> *(a) ensuring decision-making processes -*
>
> *I. take account of short and long term environmental effects of development at local, regional, State and wider levels; and*
> *II. apply the precautionary principle;*
> *III. seek to provide for equity between present and future generations."*

The *Environmental Protection Act 1994* also contains an objective clause.

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9 S.252 *Land Act 1994*

10 S.255, 262 *Land Act 1994*

11 S.253 *Land Act 1994*

12 S.257 *Land Act 1994*

13 S.70-76 *Water Resources Act 1989*

14 S.45 *Forestry Act 1959.*

Section 3 of the EPA provides:

> *"The object of this Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends ("ecologically sustainable development")."*

Section 2 of the EPA further provides that if a function or a power is confirmed on a person under this *Act*, the person must perform the function or exercise that power in the way that best achieves the purpose of the *Act.*

Section 14A of the *Acts Interpretation Act 1954* provides:

> "*(1) In the interpretation of a provision of an Act, the interpretation that will best achieve the purpose of the Act is to be preferred to any other interpretation.*
>
> *(2) Subsection (1) applies whether or not the purpose is expressly stated in the Act."*

Environmental lawyers have praised this approach. When the protection of environmental values appeared to conflict with the traditional protection of individual property rights, reference may be made to the legislative purpose to support a particular argument.

No doubt in prosecuting an offence against the *Integrated Planning Act 1997* or the *Environmental Protection Act 1994* for, for example, the destruction of an important wetland, it will be necessary to cite the objective of the Act to convince the Magistrate that it is a serious offence warranting a significant penalty.

Whether such clauses go further to provide a statutory obligation on decision-makers is another question and one which has not yet been tested in the courts.

However objective clauses of this nature are not well suited to determination by the courts because they may mean different things to different people particularly when they are written in general parenthood terms.

It is therefore likely that when such clauses are considered by the courts, they will be forcefully relied upon by all parties to the dispute to support their particular position.[15]

ENVIRONMENTAL PROTECTION ACT

Activities that are likely to cause environmental harm are regulated in 2 ways under the *Environmental Protection Act 1994* (EPA). Firstly the EPA provides that a person must obtain a licence or an approval before commencing a range of Environmentally Relevant Activities prescribed by regulation. An Environmentally Relevant Activity, is either a level 1 or a level 2 activity depending on the risk of environmental harm.[16] A level 1 Environmentally Relevant Activity requires an annual licence and a level 2 activity requires a one-off approval.

The Act also provides that any activity is unlawful where it causes serious environmental harm, material environmental harm or an environmental nuisance[17] unless it is authorised under an Environmental Protection Policy, an Environmental Management Program, an Environmental Protection Audit, an Environmental Authority or an emergency direction.[18]

[15] Refer R Molesworth AM, QC, The Integration of Environmental Imperatives into decision making, National Environmental Law Association Inc 1996 Conference.
[16] Refer s.38 (2) *Environmental Protection Act* 1994.
[17] Refer s.120, 121, 123 *Environmental Protection Act* 1994
[18] Refer to s.119(1) *Environmental Protection Act* 1994

The construction of roads and the necessary vegetation clearing is not an Environmentally Relevant Activity. Therefore the only issue for consideration under the EPA is whether such activities cause unlawful environmental harm.

Environmental harm is defined as:

> *"Is any adverse effect, or potential adverse effect (whether temporary or permanent, for what ever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance."*[19]

"Environment" and "environmental value" are both defined.[20] "Environment" includes among other things, all natural and physical resources. "Environmental value" includes amongst other things a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety.

Section 36 provides a general environmental duty on all persons not to carry out an activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practical measures to prevent or minimise the harm.

A breach of the general environmental duty does not, of itself, give rise to a civil right or remedy[21]

However in accordance with s.119(2) it is a defence to a charge of unlawfully causing environmental harm to prove that the defendant complied with the general environmental duty either by complying with the relevant code of practice (if any) or in some other way.

Section 219 provides that the Minister may, by gazette notice, approve codes of practice stating ways of achieving compliance with the general environmental duty for any activity that causes, or is likely to cause, environmental harm.

In the past the codes of practice referred to in S.219 have been prepared by various industry groups and approved by the Minister. However to my knowledge there are no codes of practice that have been approved for the construction of roads or associated clearing of vegetation.

It is noted that s.37 provides the duty of any person to notify the EPA when environmental harm has been caused. In other words if managers of roads and stock routes cause environmental harm during their normal construction program they must notify the EPA of that harm.

In summary the EPA imposes an obligation on managers of roads and stock routes not to cause environmental harm which may result from destroying vegetation. It is arguable that environmental harm may, for example, be caused if a particular stand of remnant vegetation plays an important role in soil conservation or preserving the State's biodiversity.

However it is a defence to a prosecution of an offence for causing environmental harm if the person has complied with that person's general environmental duty. Evidence of complying with a code of practice is a defence against the prosecution. Evidence that a reasonable procedure was followed to identify environmentally sensitive areas, and to mitigate the adverse affects on those areas before works were commenced may also provide a defence against prosecution.

[19] Refer to s. 14 *Environmental Protection Act* 1994
[20] Refer to s.8 & 9 *Environmental Protection Act* 1994
[21] Refer s.21(3) *Environmental Protection Act* 1994

NATURE CONSERVATION ACT

The object of this *Nature Conservation Act 1992* is the conservation of nature by an integrated and comprehensive conservation strategy for the whole of Queensland that involves, among other things the protection of the biological diversity of native wildlife and its habitat.[22]

The Governor in Council may prescribe specific wildlife (including both plants and animals) as endangered, vulnerable, rare etc.

A person must not take a protected plant, other than under

(a) a conservation plan applicable to the plant or
(b) a licence, permit or other authority issued or given under a regulation
(c) an exemption under a regulation.

It is a defence to a charge of taking a protected plant to prove that

(a) the taking happened in the course of a lawful activity that was not directed towards the taking and
(b) the taking could not have been reasonably avoided.[23]

It is possible that protected plants and animals will be found on roads and stock routes and the question will arise, if a manager was to rely on the defence provided for in the Act, as to what steps were taken to "reasonably avoid" taking a protected plants without the approval required under the Act.

CONCLUSION

There is a range of environmental laws that impose a general obligation on managers of roads and stock routes to manage those areas so as not to cause environmental harm. The principal legislation is the *Environmental Protection Act*, the *Nature Conservation Act* and the *Land Act*, all of which require managers to take into account environmental values when making certain decisions.

However, some distinction is drawn between decisions associated with routine construction and management of the State's road infrastructure and decisions made to remove vegetation where such removal is not directly associated with the road infrastructure. For example there is no specific legislative requirement in the *Transport Infrastructure Act*, the *Local Government Act* or elsewhere for regard to be given to environmental values by road construction authorities when deciding where and how to construct a road.

An activity involving the building or roads of the clearing of vegetation is not an activity that requires a licence or an approval under the *Environmental Protection Act*. However the question may still arise as to whether such activities may cause unlawful environmental harm and therefore be an offence against the *Environmental Protection Act*. There may also be an offence committed against the *Nature Conservation Act* if protected species of plants and animals are removed.

I believe that in practice these questions are only of academic importance because there are limited third party rights of enforcement in the *Environmental Protection Act* or the *Nature Conservation Act* and it is unlikely that one state agency would prosecute another agency if that other agency is properly carrying out their essential community obligations.

This is not to say that managers should not take environmental matters into account, nor is it to say that the Courts will not give weight to the broad environmental objectives and other

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22 Refer sections 5 and 6 *Nature Conservation Act 1992*
23 Refer section 89 *Nature Conservation Act 1992*

provisions of the relevant Acts should a dedicated officer of the EPA or an environmental group seek to halt the construction of a project on the basis that it would cause environmental harm.

It is my view that while there may be some difficultly both in understanding and enforcing the environmental obligations contained in the *Environmental Protection Act*, the *Integrated Planning Act*, the *State Development and Public Works Organisation Act*, the *Nature Conservation Act* and other Acts, the safe approach is for managers to assume that there is a general environmental duty to ensure that activities undertaken on roads and stock routes do not cause environmental harm.

The only practical way to satisfy this general environmental duty is to carry out an environmental audit to determine if there are any particular environmental values under threat before carrying out work and to have in place a reasonable process to consider environmental issues as a normal part of the routine decision making process.

Guidelines or Codes should be prepared to assist managers to meet their environmental duty.

Acknowledgment is given to Dr Gerry Bates' "Environmental Law and Road Reserves", the Australian Road Research Board and Doug Fisher's "Environmental Law - Text and Materials", the Law Book Company Limited.

ROADSIDE FLORA, WHAT'S IT WORTH?

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ABSTRACT

Wildflowers and Western Australia are synonymous. Few areas of the globe can boast a flora as diverse or with such high levels of endemism. Approximately 10,000 species are known from the south west botanical province. Only the Cape Province of South Africa and a few oceanic islands have a higher level of endemism than that of the flora of the south west of Western Australia.

As a consequence, intra/interstate and international visitors flock to Western Australia to view the spectacular flora. Tourism surveys indicate that in 1995 > 500,000 visitors viewed wildflowers whilst in WA. The paucity of quantitative data constrains the accuracy of estimates regarding the economic value of the native flora to tourism. However conservative extrapolation of available data suggests that wildflower tourism has major economic implications for local and regional economies.

Past surveys, albeit as inconclusive and limited as they are, indicate that 18% of all visitors to Western Australia, cite wildflower sightseeing as a reason for their stay. Furthermore indications are that these visitors had a daily expenditure of $88.33 per adult. Thus the retention and sustainable management of roadside flora whilst desirable for its own intrinsic value can also have positive financial implications for local communities.

PREAMBLE

In Australia, more than 870,000 kilometres of roads, that's more than 21 times around Earth at the equator, have been established since European settlement. Approximately 20 per cent (192,492 km) of this vast network is found in Western Australia. Road managers responsible for managing the greater proportion of the Western Australian road network are: Main Roads WA (17, 326 km); Local Government Authorities (145,511 km); and the Department of Conservation and Land Management (CALM) (30, 155 km) (Lamont 1998).

In the past, road builders paid scant heed to anything but the formed surface, and roadside verges were simply the pieces of land left over after the road was made. But with the recognition of the value of remnant vegetation, this has created widespread problems as competing values struggle to either remove the vegetation or remove it. More recently, roadside verges have come to be recognised as valuable wildlife corridors and habitat.

In the early 1960s, the then Premier and 'father of roadside conservation' in WA, David Brand, initiated a policy of creating wide road reserves, wider even than needed for road establishment alone. In some instances these wide reserves have become gazetted areas of the conservation estate. Brand suggested a minimum width of 200 metres, and that the extra area be dedicated to the preservation of indigenous flora. (Lamont and Blyth 1996)

Often, roadsides provide the last refuge for species of plants that have become extinct in other locations. The mass clearing of native vegetation has also resulted in habitat fragmentation with small, discontinuous and isolated pockets and patches of natural vegetation. Along with river and stream reserves, roadsides are a vital link between these pockets and patches, and it is imperative they don't become the missing one (link). This is particularly true in agricultural areas, where up to 98 per cent of the land has been cleared in many areas.

Currently, 321 plant species are declared rare under the Wildlife Conservation Act 1950-1979. Of these, more than 100 are known to be from roadside populations. In fact, roadside plants represent more than 80 per cent of the known populations of 40 of the 'Declared Rare' species and three of these are known only to exist in roadside populations (Govt Gazette 1998).

Whilst the first function of a road reserve has always been to act as a transport corridor, alternative values are also present and should always be considered. Roadsides often contain a significant proportion of the overall biodiversity in an area. They act as wildlife conduits and are valuable for conservation *per se*, landcare, culture, history, agriculture, recreation and tourism. Clearly, road verges hold enormous potential. Unfortunately, this potential is all too often neglected (Roadside Verge Conservation Committee 1983).

WILDFLOWER DRIVES

In many areas roadsides support a good representation of the flora as existed prior to European settlement and some local governments and communities have realised that this can be utilised as a priceless tourist resource. The Western Australian Roadside Conservation Committee (RCC) provides an array of services to assist local communities and local government maintain these linear remnants. This includes the development of wildflower tourist drives and accompanying brochures of the local roadside flora.
This assists local government and community groups to maximise the benefits of roadside flora and encourages sustainable management of roadside flora.



Figure 1. Wildflower Drives in the Shire of Morawa is typical of a local wildflower drive brochure produced by the Roadside Conservation Committee

To date about 20 wildflower tourist drive brochures have been prepared by the RCC. These are prepared at no cost to the local tourist committee and feature a map which illustrates a series of drives that enable visitors to access areas of the district that are not generally well known but often contain the more spectacular areas of roadside flora.

The brochure also provides the visitor with a brief description of the flora present within the district and is illustrated with high quality line drawings of salient flora

FLORA ROADS

Another initiative of the RCC is to provide a method of designating and creating a register of significant sections of roads that have special conservation and or tourism value. These are known as Flora Roads and identified with advisory signs. The salient feature of Flora Roads is the high standard of aesthetic and conservation value of the flora found growing therein and as such provides areas of importance to wildflower tourism.



Figure 2. Flora roads have special conservation and tourist value

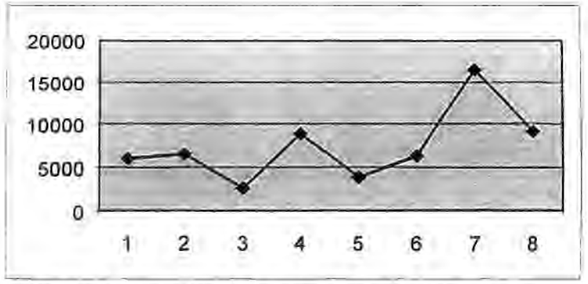
ROADSIDE CONSERVATION VALUE SURVEY

An important tool for identifying roadsides with high conservation and thus tourism values is the RCC's Roadside Conservation Value Survey. This enables persons with little suvey or botanical knowledge to assess roadside vegetation and thus provide a rating system for it. This data is also used to produce GIS maps of the roadside conservation values that can be used for a wide variety of planning and maintenance projects within the road reserve (Hussey 1991).

WILDFLOWER TOURISM

Visitors flock to WA in the thousands to see its unique and spectacular wildflowers. In a survey conducted during the early 1990s of tourists staying in commercial accommodation in WA, it was found that 18 per cent gave wildflower sightseeing as a reason for their stay. Because roadside reserves are often the only exposure that travellers have to the world-renowned flora of WA, roadside vegetation is important to our wildflower tourist industry. While it is impossible to put a price on the 'wildflower experience', the survey did find that visitors had an estimated daily expenditure of $88.33 per adult (WA Tourism Commission 1990). Although accurate data is not available, trends suggest that this figure can only have increased in recent years. Consequently there are sound economic incentives at local and regional levels for managing roadsides in a sustainable manner. Just as obviously, mismanagement of roadsides will quickly erode this potential cash flow.

Total expenditure by all visitors to Western Australia in 1998 amounted to $2.1 billion; as such it is an important economic factor in federal, state and local economies. The figures above are illustrative of the level of spending within Western Australian by overseas tourists. A proportion of which is therefore available to local economies, if the tourist can be attracted to regional areas. Wildflower tourism is often the drawcard needed to entice visitors to visit rural areas away from the popular tourist icons. Many local communities have recognised this and stage wildflower festivals to attract tourists to their districts. More than 20 such festivals or wildflower shows are held in Western Australia during late winter and spring time.



Graph 1. International visitors viewing wildflowers
Legend
Country of origin and amount of expenditure in $M
1. New Zealand ($72), **2.** Japan ($69), **3.** Malaysia ($70), **4.** Singapore ($112)
5. Indonesia ($112), **6.** USA ($41), **7.** UK ($133), **8.** Germany ($46).

Coach companies from both intra and interstate run tours that feature viewing of wildflowers when in season. The price and length of these tours varies considerably but on an average range from $75 for a single day tour to $238 for two days to around $1,000 for an eight day trip. A considerable amount of this is retained in local communities for accommodation, fuel, meals and sundries such as film and souvenirs. Generally speaking, people taking coach trips in Western Australia are from the eastern states, middle aged and with ample financial resources. However by far the greatest number of tourist trips taken to view wildflowers is by either private or hire motor vehicle. The great Australian dream of driving around the continent accounts for many wildflower tourists who ensure that their trip down the west coast coincides with the wildflower season. This can often last from July/August/September in the northern agricultural districts to October/November on the south coast.



Figure 3. Advertising brochure for Wattle Week at Dalwallinu

The incentive for road managers, particularly local government road managers is amply demonstrated, and if for no other reason than financial incentive, roadside vegetation provides a spectacular drawcard to entice visitors into the hinterland of the Wildflower State.

Because WA's roadside reserves are often the nearest our environment has to pristine conditions, these tracts of land are much more than a vital link to the past; they are a source of hope for the future.

Wildflower Tourism in the Shire of Morawa, a Case Study

The Shire of Morawa is typical of the recognition of the value of tourism to the local community. Morawa is located 362 km north of Perth, covers an area of 3,528 sq km and is located in the northern agricultural region of Western Australia. The main agricultural activities are sheep, cereal and legumes. Although rainfall is mainly restricted to the winter months, the region is renowned for its spectacular display of wildflowers in August and September.

Five species of declared rare flora and more than 600 species of native flora are known from the Shire of Morawa. This area is part of the renowned Wildflower Way, which consists of the surrounding shires of Perenjori, Mingenew, Mullewa, Dalwallinu and Morawa. These shires have recognised the value of wildflowers to the local economies and have well developed tourist centres that provide visitors with local advice on tourism in general, but with particular emphasis on wildflowers when in season. Often they have specific events such as Wattle Week at Dalwallinu or the Wildflower Expo at Mingenew.

In the early 1990s members of the Morawa community being aware of the gradual degradation of their road verges, sought assistance from the RCC to protect their roadside flora. As a consequence the RCC was contacted for assistance and subsequently assisted the local community to conduct a roadside conservation value survey of the shire. On completion, GIS maps were produced that depicted prevailing conservation values on the roadsides. A direct result of this map was the production of a wildflower tour guide that would enable visitors to access the most spectacular areas of roadside flora. See figure 1.

A former president of the Morawa Shire, Mr Joe North, who also served as a local government member of the RCC, and his wife Lyn, who manages the tourist information centre, have taken prominent roles in the protection of roadside flora in their shire. The tourist centre at Morawa is staffed on a voluntary basis from May to November. This is due to the fact that the very hot summers with temperatures in the 40s bring tourism to all but cease. Perusal of the number of enquires in relation to the time of year, at the Morawa Tourist Centre, clearly illustrates the nexus between the wildflower season and influx of visitors to the district. See table 1.

The Morawa tourist centre itself generates some income for local community projects through the sale of souvenir items such as wildflower books, sew on badges, pens and fridge magnets etc. This seasonal influx of visitors to the town is also beneficial to local businesses with general food items, butcher, drapery, mechanical repairs, post office, news agent, chemist items, fuel and accommodation all being purchased on a steady basis by the tourist visitor . If the estimate of travellers spending $88 per adult, per day is correct it can be reasonably suggested that visitor spending at Morawa, based on tourist centre figures, would be in excess of $285,120.

Table 1. Visitor enquiry in the Shire of Morawa.

Month	1998	1999
	No of enquires	No of enquires
May	76	83
June	82	37
July	162	169
August	798	946
September	1658	1431
October	364	270
November	100	4 (incomplete)

SUMMARY

The nebulous nature of available data regarding wildflower tourism makes it difficult to provide an exact $ value of wildflower tourism. However it is clearly illustrated that wildflower tourism is able to provide a much needed financial cushion for rural towns. Far too often the hackneyed cry of shire engineers and supervisors is that they would love to keep the roadside vegetation but it is just 'cost prohibitive' to do so. This mentality needs a rethink as it has been shown that roadside vegetation is an asset with both financial and intrinsic values. This is becoming increasingly obvious as the loss of native vegetation results in the degrading effects of salinity, sand drifts, erosion and weediness with flow on increased incidence of fire.

Whilst many regeneration and revegetation projects have had some success they are expensive (approximately $2,000 per hectare). It is all but impossible to replace roadside remnants to a pristine state once they are lost. It is therefore incumbent on us to ensure both singularly and collectively that roadside vegetation is retained and prospers because roadside vegetation is the vital link of our landscapes ecosystem and attendant fauna. We are stealing from future generations if we allow roadside vegetation to be lost through ignorance and empathy by all that work in the roadside environment.

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MANAGING ROADSIDE VEGETATION WITH FINANCIAL BENEFITS

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ABSTRACT

It has been said that it is cheaper and easier to protect existing trees, shrubs and groundcovers in road reserves than it is to replace them. Replanting trees, revegetating disturbed areas and correcting needless erosion years later can be expensive. This statement poses the questions: "could effective roadside management actually save more than it costs?"

In this paper local government engineer, John Lewis, looks at his Council's experiences with roadside management and the economic and environmental results.

In 1994, Dumaresq Shire council, located on the Northern Tablelands of NSW, was successful in obtaining a National Landcare Project grant, which provided the resources to develop a roadside management plan.

Included in this paper are the reasons for the Council's initial involvement and an outline of the basic structure of the plan and its development. The plan is not a single document but rather a collection of elements including assessment sheets and management prescriptions for specific sites, maps, signs, a handbook and field staff training.

Two brief case studies are presented as examples of the economic savings that can be achieved by adopting improved roadside management practices in both road construction and maintenance works.

INTRODUCTION

There are approximately 181,000km of public roads in NSW. When the area of these roads is added to that of the network of travelling stocks routes, the combined area is about the same as the total area of National Parks across the State. In NSW, local government is responsible for the care, control and management of about 89% of the total length of public roads, with the Roads and Traffic Authority responsible for most of the balance. The Roads and Traffic Authority has adopted a Roadside Environment Policy which states in part that the Authority 'will work to improve the management and enhancement of the roadside environment'. Local government, as a body, has no such policy. Of the approximate $600 million spent on roads annually in NSW, only a minuscule amount is allocated by local Councils for roadside management.

THE DUMARESQ SHIRE COUNCIL EXPERIENCE

Dumaresq Shire is located on the Northern Tablelands of NSW and surrounds the provincial city of Armidale. It covers a diverse area of 4,200 square kms, from west of the Great Dividing Range to the coastal plain along the Macleay River in the east. The Council is responsible for just under 1,000 kms of public roads, including 82 kms of Waterfall Way, a state road linking the tablelands to the mid north coast.

In 1994, Dumaresq Shire Council began thinking about roadside management after recognising the importance of roadsides and the need to conserve and protect native vegetation within the reserves.

The reasons for Council's involvement can be summarised as follows:

- recognition of past poor practices of local government as an industry and that road construction and maintenance works have a lasting impact on roadsides.
- increasing community awareness.
- the threat of impending state legislation.

In late 1994, the Council was successful in obtaining a grant through the National Landcare Program which provided the means to develop a roadside management plan. Two project officers were appointed under a job sharing arrangement firstly to undertake the task of assessing roadsides within the Shire.

The attributes within the road network reserves were mapped and 'special' sites were identified in 3 categories:

- R (Rare) plant species considered to be rare or threatened and listed in the ROTAP publication by Briggs and Leigh.
- S (Significant) contains species which may be at the edge of their geographical range, uncommon in the area or have some other significance eg cultural, historical.
- H (HCV) high conservation value sites which are wide sections of road reserve and contain remanent vegetation in near natural condition.

Dumaresq Shire contains many rare plants, significant occurrences and a diverse range of community types. The highest conservation value sites are generally found in the eastern parts of the shire and are associated with the dry open forest areas of the gorge country and adjacent National Parks. Waterfall Way has a patchwork of high conservation value reserves with a number of significant occurrences and ROTAP locations. It has been estimated that there exists a greater diversity of plants and more species along Waterfall Way than exist in all of England. The Roadside Management Plan was developed following completion of the assessment and planning stages with input from the community, local Landcare representatives and works staff. The final plan did not consist of a single discreet document which may be condemned to collect dust on an office shelf, but rather a series of outcomes which included:

- a set of maps which identified the R, S and H category locations.
- management recommendations for each of the above sites.
- an operations handbook for use by roadworkers in the field.
- a set of guidelines and policies under which roadsides will be managed. Includes issues such as firewood collection, stock grazing and revegetation after roadworks.
- signage of 'special' locations ie R, S & H sites.
- works staff training.

For Council's 'core' business, road construction and maintenance, the management plan has two tiers:

Tier 1 (applies Shire wide)
Work is carried out in accordance with the Codes of Practice for both construction and maintenance which are contained in the Roadside Handbook.

Tier 2 (applies to special sites)
Where works impact on a R, S or H category sites, the specific management plan for that site may impose additional conditions for works at that location.

Of all the outcomes of the plan, perhaps the training of field staff deserves special mention. Training was effective, well received by the staff and has led to changes in work practices. It has gone a long way to change the traditional attitude that the job was all important and the roadsides were of little consequence.

FINANCIAL IMPLICATIONS

With regard to the financial cost of implementing roadside management measures, the Victorian experience suggested that increased costs in the range of 1.5% to 2.0% of the cost of construction works could be expected.

For maintenance works, the increased costs were thought to be somewhat less than 1.5%, depending however on the practices adopted. For example, the Victorian Roadside Handbook recommends that excess drain material be directed onto the road pavement, collected and disposed of 'in an area that will not cause a weed problem. Of course, this method would add considerably to the cost of patrol maintenance grading and has not been adopted at Dumaresq Council.
The following two brief case studies are presented as examples of the economic effects of adopting improved roadside management practices in both road construction and maintenance works.

CASE STUDY NO 1:

A review of the cost associated with Dumaresq Council's operations has revealed that on at least two recent construction projects, the cost of the roadside management measures adopted resulted in a marginal decrease when compared to the expected costs of traditional methods.

The savings occurred chiefly in two areas: by adopting a 'minimum disturbance' approach, less plant time was involved in stripping topsoil prior to the earthworks stage, and by planning timber removal from the site ie chipping as much on site as possible, savings resulted from less loader hire and truck haulage costs were reduced. These savings more than offset the cost of chipping.

Other benefits which are difficult to measure and were not factored into the costs were fewer or no complaints from the public and a much reduced chance of the need to return to the site in future to repair problems caused by erosion, weed invasion or high salt levels. These costs could well have been substantial.

CASE STUDY NO 2:

Council is currently investigating alternatives to slashing of road shoulders and verges to control growth. Field trials of wick wiping taller grasses are being undertaken in cooperation with our neighbour to the north, Guyra Shire Council.

This technology is an Australian invention which provides alternate and selective application of herbicide onto targeted weeds using a rotating wick wiping applicator attached behind a tractor. Guyra Council has provided costings which indicate that while there is an initial cost increase in year 1, grass maintenance costs are expected to decrease by over 20% by year 3 and then be maintained in future years. Savings are due to a reduction of more than 60% in the amount of slashing by tractor and mower and a large decrease in the overall amount of herbicide being used to control weeds.

CONCLUSION

Roadsides represent a significant community resource which needs to be managed effectively. Currently in NSW, insufficient funding and effort is provided by local government to improve the management of roadsides and to preserve and protect the natural environment on road reserves. Dumaresq Shire Council has implemented a modest roadside management plan which has been successful in delivering on-ground results through increased awareness of the value of remnant roadside vegetation and a resulting change in work practices.

The Victorian experience which has suggested an increase in work costs of 1.5% to 2.0% could be expected to meet the costs of implementing roadside management practices. However, Dumaresq Shire, after initially meeting the costs of preparing and implementing a plan, have shown a decrease in the direct cost of some recent construction and maintenance works. Given the environmental and economic advantages, Dumaresq Council believes that roadside management is worth it.

IPSWICH CITY COUNCIL PLANNING FOR VEGETATION

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ABSTRACT

Ipswich City Council recognises that conservation values occur on a variety of land tenures - private land and crown land, including roadside reserves. To support the ongoing management and protection of these conservation values a variety of mechanisms have been developed and implemented over the last four years. For the private landholder these include technical advice, the Land for Wildlife program, financial and in-kind incentives on different aspects of remnant vegetation management. Remnant vegetation on private land provides important linkages to vegetation within road corridors.

Previous roadside vegetation assessments have identified areas within Ipswich City Council that are of high conservation value. To ensure these areas are adequately protected and appropriately managed Council has developed a Roadside Vegetation Management Strategy. This strategy established the framework to address the various issues involved in roadside vegetation management throughout the municipality and identifies management strategies to resolve any future conflicts.

The strategy is supported by extensive flora and fauna survey work that has been undertaken across the council and ICC's Nature Conservation Strategy that provides strategic direction and priorities. Management strategies in place include an Environmental Weed Control rebate which provides a subsidy for the control of environmental weeds on roadsides and roadside signs or markers that are utilised to identify significant areas to roadside operators.

INTRODUCTION

Ipswich City Council (ICC) recognises that many of the city's natural assets are located on both crown land and freehold land. Regardless of land tenure there is a general community expectation that governments at all levels will work to protect and enhance the natural environment.

ICC has been actively providing a range of support initiatives to assist private landholders managing remnant vegetation, along with the ongoing management of a growing conservation estate of parks, reserves and local roads.

BACKGROUND

Ipswich City Council

Ipswich City Council is the fourth largest local government in Queensland, covering an area of 1,778 square kilometres. The present population is 135,000 with a considerable level of growth anticipated over the next few years. The population is predicted to swell to 250,000 by 2011.

Ipswich City is located 40 kilometres west of the city of Brisbane. The city consists of a large urban area in the north east surrounded by vegetated ranges to the north, west and south east and the majority of the Bremer River catchment. These surround a large rural area that incorporates primarily cattle grazing with irrigated cropping and some dairy farming.

Ipswich's Natural Resources

The city incorporates a variety of vegetation types including:

- Wet and dry rainforests
- Wet and dry eucalypt forest
- Freshwater wetlands
- Brigalow scrub
- Tea tree forest
- Mountain heathland

ICC has records of over 900 plant species and over 400 species of fauna. Two major river systems flow through the city, the Bremer River and Brisbane River. Remnant vegetation covers 37% of the city (43,733 ha). It is estimated that less than 10% of council managed roads contain areas with high conservation roadside vegetation.

Council's vision for the city strongly commits the Council to conservation as an integral part of its future development. The city's conservation values in terms of flora and fauna species, as well as regional ecosystems, are highly significant. These natural areas are not generally in good condition, the result of clearing, grazing, weed infestation and fire frequencies. These pressures combined with erosion and soil loss provide strong support for a strategic and planned approach to the on-going management of vegetation on council land.

Community Expectations for Conservation

Ongoing community consultation is an important component of ICC's conservation program. The 'package' of nature conservation initiatives made available within ICC has been developed in close consultation with the community.

The Conservation Parks and Sport Department of Ipswich City Council has an Environment Consultative Committee made up of members of various stakeholder groups and community members. It is this committee that advises the department in the development and implementation of its various programs.

Prior to the introduction of the Enviroplan in 1997, consultation was conducted through three separate survey instruments (telephone, written & interviews). This approach aimed to capture a true cross section of the community and provide a wide range of information on community views about conservation and land management issues.

This consultation package identified major conservation issues identified by residents throughout the city as:

1. Water quality and pollution of waterways
2. Bushland loss/loss of species/habitat destruction
3. Provision of wildlife corridors; management of conservation areas
4. Soil erosion/streambank erosion
5. Weed invasion
6. Soil salinity
7. Grazing and farm management

The top five issues listed are directly applicable to roadside vegetation management.

ROADSIDE VEGETATION

Ipswich City Council, like many other councils, is responsible for most road reserves in the council area and must make decisions in consultation with other authorities on appropriate management for each road and adjoining roadside.

Road reserves are established to provide legal access and a route from one place to another, but have since evolved to cover a whole range of other activities. Service corridors for gas, electricity, drainage, sewage and communications are usually located on roadsides. Roadsides also play an important role in minimising the risk and impact of fires, along with the provision of recreational and tourism values.

Roadsides are now highly valued for their remnant vegetation, particularly in situations where most of the native vegetation on adjacent private land has been cleared. In some situations the roadside provides a critical link or wildlife corridor between two separate areas of bushland.

Remnant vegetation has become an important environmental asset. Protecting and enhancing this asset while maintaining the other functions of roadsides can prove quite a challenge.

ROADSIDE VEGETATION MANAGEMENT STRATEGY

Ipswich City Council has developed a Roadside Vegetation Management Strategy to address issues impacting roadside vegetation management throughout the local government area and to identify management strategies to resolve any areas of conflict.

This is the first roadside strategy of its kind in Queensland local government. Extensive work has been undertaken in other states of Australia that provided a good basis for the development of this strategy. However interpretation of the different state legislation proved to be a time consuming challenge.

The strategy primarily covers Ipswich City Council controlled rural roads. Queensland's Main Roads, as the responsible authority for most State highways and freeways, has its own management programs that extend beyond local government boundaries.

Goals of Strategy

- To protect, conserve and enhance biodiversity values in vegetation located on roadsides in the Ipswich City Council within the confines of ensuring the safe function of the road
- To promote a corporate and community culture that recognises the importance of indigenous vegetation located on roadsides within Ipswich City Council
- To ensure the safe function of the road and protection of the road formation

Objectives of the Strategy

- To protect areas of indigenous vegetation; rare, threatened and significant flora and fauna; and cultural or heritage assets
- To enhance and maintain indigenous vegetation communities; fauna habitats and corridors; and visual amenity and landscape qualities and character
- To minimise conflicts in the management of roadsides and the protection of roadside values
- To inform Council staff, Government agencies, landowners and road workers of the strategy and encourage their participation and commitment to its implementation

The strategy is primarily directed toward assisting ICC as the primary land manager, along with other organisations, whose actions may have impacts on roadside vegetation, to minimise and prevent environmental damage within the road reserve. Such organisations generally include state government and private service utility providers and road construction and maintenance bodies.

The Roadside Vegetation Management Strategy also provides a mechanism for conservation groups and the community to become more actively and responsibly involved in the conservation of vegetation and other assets, such as cultural and heritage items, within the road reserve.

The Ipswich City Council Roadside Vegetation Management Plan is divided into two main sections:

Part A - Introduction and Background Information

Provides information on goals and objectives of the strategy, its formulation context, definitions and terminology used within the strategy and legislation affecting roadside uses and users.

Part B - Issues and Management Strategies

Consists of the management issues each with several underlying sub-issues. Details of each of the sub-issues are explained along with a number of specific management strategies.

The development of the Roadside Vegetation Management Strategy provided an array of challenges for council to manage and address. The large number of stakeholders involved has lead to the view that roadside vegetation is 'somebody else's responsibility' in a lot of circumstances. Also the large number of obligations and delegations associated with the different state and federal legislation was quite a hurdle to overcome in the strategy's early development.

The development of the strategy has been motivated and driven by council's conservation program, however the benefits of roadside vegetation management impact a number of other sections of Council and the community.

The strategy has been 'in the pipe line' for quite a few years. It initially started in the Moreton Shire in the early 1990's and developed further over recent years. However it was a project that often tended to 'drop off the priority list'. This may well be a reflection of the lack of recognition of the importance our significant roadside vegetation has within the community and government as a whole.

Many of the benefits of managing roadside vegetation are intangible and therefore difficult to quantify. However they are slowly being recognised within the region as industry and government strives to achieve environmental best practice in all that we do. Ipswich City Council's Roadside Vegetation Strategy provides the direction for council to implement roadside vegetation management.

Roadside Signage

The Roadside Vegetation Management Strategy identified the need for clear markers identifying areas of high conservation value.

Local naturalists and detailed field survey works have identified rare and threatened plants on roadsides for a number of years in particular parts of the council area. Earlier conservation assessment work has also been undertaken. However without an appropriate signage system, identification and assessment work on its own does not enable high conservation areas to be adequately protected and appropriately managed.

Appropriate signage is currently being finalised for use in accordance with the Roadside Vegetation Management Strategy throughout the city. This has built on the work developed by the state and will be implemented within Ipswich City in consultation with appropriate stakeholders to ensure issues such as signage location are not in conflict with overall road management.

Only high conservation value sites will be marked identifying them as requiring different management to roadside operators, eg. not slashed. This involves only a small number of sites across council.

The ongoing management responsibility of the identified high conservation areas is an issue that local governments need to resolve internally to ensure clear delineation of responsibility.

Implementation

With the large majority of the planning and identification of significant vegetation on roadsides well underway, the challenge for ICC now is the implementation of the Roadside Vegetation Management Strategy and the on-ground protection and management of significant roadside vegetation.

A large number of branches and departments from various sections within local government are involved in roadside management, not to mention a number of outside organisations and agencies. The on-going involvement and consultation with all stakeholders is critical to the successful management of valuable roadside vegetation.

It is planned that the Roadside Vegetation Management Strategy will lead into an implementation phase that will:

- Develop and implement action plans - identifying priorities, responsibilities and time lines
- Develop and implement appropriate operational standards
- Examine training requirements of staff and develop appropriate training programs

STRATEGIC PLANNING INITIATIVES

Roadside vegetation management is not being addressed in isolation. Council has a history of active pursuit of protection and rehabilitation goals for the city's flora and fauna communities. Council has developed a range of initiatives to protect and manage remnant vegetation city-wide. Some of these include:

- Vegetation mapping and ecological assessment work provides council with a significant information base about the natural areas of the city
- Nature Conservation Strategy – this defines and identifies key areas where conservation values are secured. More importantly in terms of management responsibilities, the strategy identifies gaps or key areas for strategic management for both securement and rehabilitation programs to be targeted
- Flora and Fauna Database – this is utilised both for internal use and external advice to landholders. It contains a comprehensive record of species occurrence throughout the city. This database and council's GIS system will be critical components utilised in recording and monitoring significant roadside vegetation
- Planning Scheme Provisions through appropriate zoning enables conservation and environmental values to be protected. These values are also incorporated into the development application process and strategic planning documents
- Environmental Weeds are nearly always an issue with managing remnant vegetation. This has been recognised by Council through the development of an Environmental Weeds Policy that identifies an environmental weeds register or list. Environmental weeds also feature as a critical component of Council's Pest Management Plan. Within this plan environmental weeds have been prioritised for each of the vegetation communities within the city based on a cost benefit analysis

MANAGEMENT INITIATIVES

A variety of management initiatives are being implemented throughout Ipswich City Council to cater for the different situations and land tenures. On ground management of significant roadside vegetation is a reasonably new role for ICC and will be supported utilising the range of initiatives outlined below.

Enviroplan

Established in 1996, the Ipswich Enviroplan is a program of environmental initiatives to facilitate the management and appropriate usage of natural resources in Ipswich City, and securement of areas in public or private ownership. Enviroplan funds are raised through the Enviroplan levy ($28 per year per rateable property) that raises approximately $1.25 million per annum.

Management and awareness raising through on-ground activities, education and promotion are an important component of this program. Direct support to landholders includes:

- Environmental Weed Control rebate
- Revegetation Assistance – free plant program
- Voluntary Conservation Agreements – rate rebate, in-kind management support
- Education - seminars, fact sheets, brochures

Conservation Partnerships

Successful partnerships have developed with a number of regional, state and federal organisations. These have many indirect benefits for roadside vegetation protection and management. Some of these partnerships include:

- Land for Wildlife program – a SE Qld program supported by the Natural Heritage Trust
- Local tertiary institutions - work experience & industrial placement projects with third year students
- Healthy Waterways - Mihi Creek, northern side of town reach of Bremer River
- Ipswich Rivers Improvement Trust - weed control and replanting
- Bremer Catchment Association – Streambank restoration grants and catchment eduction and awareness activities
- Society for Growing Australian Plants – environmental weeds poster and fact sheet
- Ipswich Envirocare – Work for the Dole projects in bushland and riparian areas

These partnerships demonstrate the level of resource support that is available in the community and potentially some of these support programs could have a role with roadside vegetation management.

The Bushland Care Program enables the community to become involved in the management and rehabilitation of bushland areas. This program provides vital community ownership and support to the Council's growing conservation estate. ICC currently has 10 groups actively involved in this program. There is scope for this program to have a roadside vegetation management focus in the future.

The Environmental Weed Control Rebate aims to assist landholders in the control of environmental weeds. A 50% rebate for the cost of environmental weed control, up to $400 per rate assessment per financial year, is available. Approved works on private land includes the purchase of herbicide, contract labour to poison, fell and chip environmental weeds. This rebate extends to 100% rebate for the control of environmental weeds on roadsides.

CONCLUSION

Extensive community benefits flow on from the range of conservation initiatives for nature conservation available from ICC. For example, increased biodiversity through the protection of rare and threatened species and decreased levels of land degradation will help ensure that remnant vegetation is protected for future generations.

The management and protection of significant vegetation areas on roadsides will ensure a greener quality lifestyle for the Ipswich community as a result of cooperative planning, assessment/identification and management.

The Ipswich community has acknowledged that there is public benefit in the active management of remnant vegetation on both crown land and freehold land. The community's involvement through the various support programs is critical to ensuring the protection of these areas of vegetation.

The benefits of roadside vegetation are wide ranging, from conservation to increased levels of coordination. Time, money and resources can be saved through the application of roadside vegetation management principles. Whether this is through decreased maintenance costs with weeds and erosion or safety issues, such as reduced headlight glare and dust suppression.

As we enter the twenty-first century there is general consensus by the broader community that preserving vegetation has significant benefits for all sectors of the community. If we then look at roadside vegetation with high conservation values as an environmental asset, it is then critical that these values be protected wherever possible through appropriate road design, construction and maintenance. In today's society there is a moral, but also professional expectation, within our community that these environmental assets be protected and managed for future generations.

The Roadside Vegetation Management Strategy and the roadside signs, along with the other planning and management activities outlined, are helping to work towards the on going protection of one of Ipswich's important environmental assets, significant roadside vegetation.

FREEWAY GREENING PROJECT - A CASE EXAMPLE OF VEGETATION MANAGEMENT IN ROAD CORRIDORS

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ABSTRACT

Greening Australia Queensland (Inc.) has been working under contract with the Department of Main Roads (DMR) since 1992 on the Freeway Greening Project in the Metropolitan District with the aim of assisting the department with the management of roadside vegetation.

To approach the issue of roadside vegetation, Freeway Greening Officers must:
1. Work with the DMR to identify and address their needs;
2. Work with the broader community to cater for their needs; and
3. Work to achieve the best practice environmental outcome.

Problems that have been addressed by this three way partnership include:
- Reduction in the maintenance requirements of the DMR;
- Conservation of rare and threatened species (sometimes the last population of a species occurs in a road reserve);
- Improvement of the aesthetics of roadways;
- Improvement of the corporate image of the DMR; and
- Addressing other technical matters such as weed control; suitable species selection; fauna issues and rehabilitation of degraded areas.

This paper will address how this is achieved and the financial, social and environmental benefits of the work.

Key words: *Extension, Vegetation, Community, Trial*

THE FREEWAY GREENING PROJECT

The Freeway Greening Project commenced as a small project, which primarily focussed on tree planting with the community to provide effective visual screens for the south east Freeway. Since the project's beginning the services that Greening Australia Queensland (Inc.) has provided to the Metropolitan District has continually expanded. Some of these activities are outlined in the following. To date, over 25,000 trees have been planted by at least 2,500 members of the community.

COMMUNITY BASED PLANTING

The core focus of the Freeway Greening Project is to undertake community-based tree planting activities adjacent to roadways. Planting are primarily requested by the local community or by the DMR in either high profile or problematic areas (eg. areas that are hard to maintain).

To ensure planting projects are successful the following are undertaken:
- **Consultation**
  Although some plantings are requested by individuals the broader local community is always consulted. This is done through door knocking, letter-boxing and public meetings.
- **Design**
  A design is prepared for ratification by the Metropolitan District, which is based on local community input, DMR requirements and the local environment (ie. climate, soils and vegetation). This includes safety audits for community participation.
- **Implementation**
  After site preparation by RTCS staff (normally including herbiciding, deep ripping and mulching) the planting is undertaken involving local residents and often a local community group (such as a school, scout group or service club). Many participants receive a slide presentation on environmental issues either before or after the planting and all participants receive a certificate of appreciation.

- **Maintenance**
  Often local residents participate in the maintenance of a planting. This is always supported by an on-going maintenance program by Freeway Greening staff, which included herbiciding, watering, replacement planting and rubbish removal.

  - Benefits
  Many planting areas are in areas requiring regular mowing. This can cost $0.14 - $0.41 per square metre annually for slashing or up to $6.00 per metre squared for brush cutting. A typical tree planting costs $2.50 per metre square to prepare (commercial rate to herbicide, deep rip and mulch to 100mm deep on an ideal site) and $0.96 to supply a tree and fertiliser. If this tree is then planted by the community the total cost is only around $4.00 per tree. Species selected are low maintenance, are long lived and will shade out at least 1m squared – ie. once established the area will not require any maintenance costs – therefore in a brush cut area the tree has paid for itself in a little over a year.

Other benefits not accounted for in this calculation are:
- The media benefits (approximately one in three plantings are reported in a local newspaper);
- Additionally, the trees act as "scrubbers" of both air-borne particles and gaseous pollutants improving the health of residents in the immediate area; and
- Other environmental and aesthetic benefits.

COMMUNITY BASED VEGETATION MANAGEMENT

Community Based Nursery Work

Community nurseries have grown plants specifically for the Freeway Greening Project in the past. Freeway Greening staff visit schools and provide training sessions on propagation.

- Benefits
  In the year following March 1997 over 80% of the trees planted were donated by the community and community nurseries (ie. over $3,400 worth of stock).

Bush regeneration - Community Service Orders

Freeway Greening staff engage the services of the young offender community service order program coordinated by the Department of Families Youth and Community Care. Through this program a youth worker works with young offenders to undertake varying tasks in the field. The primary focus of their work has been the regeneration of a 1ha-bushland remnant under control of the DMR.

- Benefits
  To date it is estimated that the young offenders have undertaken over 1000 person hours of hands-on work – this can be equated to $15,000 of labour.

Trainee Projects

A number of expired DMR depot sites are currently being revegetated through the Freeway Greening Project with low cost revegetation methods. One of these sites is an expired quarry at Coleyville. A revegetation plan was prepared taking into consideration the heritage values of the site. To implement the project, Greening Australia Queensland (Inc.) lodged a successful application for a Green Corps team. The Green Corps team consist of ten trainees and a supervisor working for a total of 14 weeks on a selected nature conservation project.

- Benefits
  A total of 770 working days will be provided at no cost as a part of the implementation of the Coleyville project. This can be equated to $92,400 worth of labour that results in the conservation of a historical site, enhancement of an environmentally significant area and training for ten young people in a rural area.

ADVICE ON VEGETATION MANAGEMENT

Vegetation Management

Freeway Greening staff respond to varying vegetation management inquiries from Metropolitan staff. Amongst many inquiries, these have included weed identification and control techniques and the identification of significant native vegetation.

Landscape Design

A number of landscape designs have been prepared for areas that are inaccessible to members of the community, such as median strips. For example, a 3.5km median of the Centenary Highway south of the Brisbane River was designed through the project.

Vegetation Consultancy Service

Through the Business Unit at Greening Australia Queensland (Inc.) and the Freeway Greening Project documents have been prepared for both the North Coast Hinterland and Metropolitan Districts detailing preferred species for landscaping along road corridors. In conjunction with the Queensland Herbarium, maps were prepared detailing the various vegetation communities occurring within each district. Associated with each vegetation community were lists of species that were endemic to those vegetation communities and commercially available.

- Benefits
  The ability to select correct species to be planted on a site improves plant establishment rates. By accurately identifying weed species, treatments can be prescribed that specifically addresses the problem, reducing the need for excessive maintenance visits.

Trial Work

The general perception of native plants is that they are short lived and look poor after a brief period of time. Unfortunately this perception is based only on a select few native plants that have been commercially available – largely these natives originate from across the nation. In south east Queensland alone there are over 3,600 species of plant (this is equivalent to the diversity of flora in either Victoria or South Australia (Stanley & Ross, 1983)). It is estimated that less than 10% of the species native to south east Queensland are available from nurseries (based on figures provided by a leading local native supplier (*pers comm.* Mr Wayne Webb)). Of this, only a few are commonly utilised in landscapes.

Hence, there are enormous opportunities to identify local native species, which are suitable specifically for use in roadways. One of the focuses of the Freeway Greening Project is trialing local native vegetation and establishment techniques, which are not commercially available.

Any plant selected must be appropriate for their specific use. For example, plants that are to be utilised in the lead up to intersections or traffic signs should be of a low stature. Whatever the situation, the selected plant species must be of "industrial strength", that is, they must:
- Be fast growing and long lived;
- Exclude undesirable species;
- Be aesthetically pleasing; and
- Be hardy and require little maintenance.

The Freeway Greening Project has explored the capabilities of several plants native to south east Queensland some examples include:

Myoporum montanum

A smaller trial identified this species as a suitable median strip planting – that is, it was dense, long lived, attractive and has highly flexible stems in case of car impact. This plant would make a suitable native replacement for the exotic Oleander. Over 1,140 of these plants were commercially grown and were subsequently planted in an 800m stretch of the Gateway Motorway.

- Benefits
  The planting is passed by 62,000 vehicles per day - signage associated with the planting demonstrates that the DMR are committed to improving their landscaping of roads with native species. Additionally, Main Roads often set the example for the community, people plant the species they are familiar with in their own yards – Freeway Greening Officers receive many inquiries from the community regarding species planted along roads. If successful, the species will be a suitable species to reduce/eliminate headlight glare across carriage-ways.

Native Grasses

In recognition that native grasses are of a smaller stature than exotic grasses (such as Rhodes or Guinea grass) and are slower growing, a small trial of native grasses was undertaken to determine the effect of mowing and overall height when not mown. The positive results of this trial have now resulted in a joint trial between the Centre for Mine Site Rehabilitation at the University of Queensland and the Department of Primary Industries to determine which genetic varieties are best suited for mass establishment along roadsides.

- Benefits
  If successful, the native species can be utilised in areas that normally require regular mowing – thus reducing maintenance costs.

"Frangibility" of Vegetation

It is recognised that roadside objects result in significant road accidents. Vegetation can contribute to this, however if the vegetation was "frangible", that is, can break on contact, it would be more suitable for use in roadways. Unfortunately there is no measure of frangibility and "best guess" is often employed to determine frangibility. Often this is done poorly with species such as *Elaeoopcarpus grandis* blue quandong, which can reach an ultimate trunk diameter of 2m (Boland *et al,* 1985) being recommended as suitable (*pers comm.* Mr Robin Stone). Recently an application was lodged with the Road Accident and Road Safety Research Grant Scheme for a project to determine suitable frangible vegetation for use in roadways. The aim of this exercise is to determine frangibility through stress gauging native species of varying ages, computer modelling and ultimately full scale crash testing.

- Benefits
  An accurate assessment of roadside vegetation in high-risk areas can be made prior to removal. Compensatory plantings can be installed of frangible species or new landscapes can be planned to include appropriately frangible species in high-risk areas.

Nature Conservation

It is a well-documented fact that roadsides often contain vegetation of conservation significance (Breckwoldt, 1990). This is a result of the roadside "capturing" pockets of vegetation during construction, whilst the surrounding land is urbanised or developed for agriculture. Examples of nature conservation projects in the Metro District include:

***Notelaea* sp. Site**

In a half-hectare remnant adjacent to the Cunningham Highway, occur five species of significance – two of which are listed as vulnerable under the Nature Conservation Act. The most significant species is *Notelaea* sp. – only 20 specimens occur in the world, 13 of which occur on this site with five occurring immediately adjacent on Claypave land. A successful application for $4,000 from the Threatened Species Network and the World Wide Fund for Nature was tendered to fund regeneration work on the site. Additionally, Claypave have donated $10,000 to eradicate weeds on the site and propagate the species.

Discovery of Rare *Keraudrenia* sp.

During a site inspection adjacent to the Gateway Motorway a plant was identified that Freeway Greening staff suspected may be significant. A sample was forwarded to the Queensland Herbarium who subsequently noted it was only the third ever collection of the species.

Fauna And Roads

In 1997, a workshop was organised through the Freeway Greening Project and the Downfall Creek Bushland Centre, to investigate ways of improving culvert design or retrofitting existing culverts to facilitate fauna movement under roadways. This successful workshop involved engineers from the DMR and local councils, fauna experts, hydrologists and culvert manufacturers and resulted in the production of a booklet of recommendations. To pursue this further we are working with the University of Queensland Zoology Department to establish trial sites and with a hydrologist to develop standard culvert drawings which incorporate the workshop recommendations.

- Benefits
  The Department of Main Roads in the Metro District have the opportunity to accurately address conservation issues in roadways and take measures to address these. More often or not in a cost-effective manner.

SEED COLLECTION

Where sites are to be revegetated the use of locally collected seed for the production of plant stock or direct seeding for a revegetation project can improve the success of tree establishment. Unfortunately it is often difficult to obtain local seed for projects.

The Department of Main Roads are presented with a unique opportunity to collect large volumes of local seed from sites, which will be cleared for future roads years in advance. This seed can then be drawn on at the time of construction to propagate new plants for revegetation purposes. This is currently being done by the NSW Road Transport Authority (RTA) prior to the construction of the M5 East in Sydney (*pers comm.* Mr Ian Bourke) primarily for the purpose of quality assurance.

Freeway Greening staff and volunteers have collected over 50 kilograms of local provenance seed for revegetation projects in both a commercial and volunteer capacity.

- Benefits
  Local seed can improve the success of a revegetation capacity. Additionally, this seed can improve the likelihood of a regeneration project resembling the plant community that once occurred on a site. If this seed were applied through direct seeding methods it may cost as little as $0.85 per square metre to result in an established tree (this cost is based on a hectare and includes site slashing, two herbicide applications, deep ripping, application of seed and maintenance for a year).

CONCLUSION

The Freeway Greening Project has achieved the following outcomes:

- Improved the community perception of the Department of Main Road's role in vegetation management through implementing on-ground change and liaising between the community and the Department of Main Roads; and
- Reduced maintenance costs in target areas, improved aesthetics of roadsides, active conservation work and cost reductions through access to environmental grants and programs.

The Freeway Greening is a model project. A vegetation extension officer working in closely with the Department of Main Roads or a local authority has the opportunity to understand their problems and requirements. The vegetation extension officer (through their own knowledge base or through their networks) can then address these problems in a pragmatic way that Department of Main Roads or local authority understands.

An additional benefit of the model is that the community do not perceive the vegetation extension officer to be associated with the Department of Main Road or local authority and are therefore more likely to listen to this person. Because the vegetation extension officer has an intimate understanding of the Department of Main Road's or local authority's issues and understands what solutions are possible, they are in the perfect position to relate information to the community.

The Freeway Greening model is applicable to other districts of the Queensland Department of Main Roads and/or local authorities.

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OPERATIONAL ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT

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ABSTRACT

Ecologically Sustainable Development (ESD) is about the integration of social, environmental and economic factors into decision making processes and the balance of outcomes resulting from the decisions made. The principles of ESD apply to all levels of decision making – policy development, program implementation and at the project level. This paper provides an example of how ESD principles and objectives can be operationalised when applied to the management of road shoulders.

ARRB Transport Research has recently completed a project for Transport SA involving an ESD assessment of options for the management of road shoulders. The project has accomplished some progress in moving ESD assessment toward the operational end of decision making. Specifically the project developed an assessment tool to evaluate the performance of different road shoulder management techniques from an ESD perspective. The management options chosen by an expert panel for the evaluation were sealed shoulder, grassed shoulder, unsealed shoulder (wet maintenance), unsealed shoulder (dry maintenance) grassed shoulder (sprayed) and natural soil (graded). The approach involved the collection of both qualitative and quantitative data from many sources, holding a workshop with a range of Transport SA staff and then analysis of results. Finally the ESD assessment recommended a ranking of these management options.

***Key words**: Ecologically Sustainable Development, ESD, decision making, assessment, road shoulder management*

INTRODUCTION

Environmental decision making is characterised by uncertainty and trade-offs between criteria which often cannot easily be compared and are sometimes conflicting. The 1992 National Strategy for Ecologically Sustainable Development (NSESD) provides a framework for considering social, economic and environmental factors in the decision making process (CoA 1992). Although the NSESD contains a statement of the goal, core objectives and guiding principles[24], very little guidance is provided on how these principles can be implemented in practice.

In part, the lack of evaluation and decision tools is one reason for the slow progress with ESD implementation. This paper discusses a decision support tool for ESD that has been applied to road shoulder management options.

The decision tool presented in this paper is based on the multi criteria analysis (MCA) family of tools. The process adopts the use of a multi-disciplinary team (which includes both expert and non-expert opinion) to allow for qualitative and quantitative information to be incorporated into the decision process. A participatory and co-decision making process explicitly takes into account the views of different stakeholders and interest groups. It also acknowledges that the decision process is not value free. The notion of 'value' is important to environmental decision making. For example, determining what we measure, how we measure, and the implicit value assumptions within the techniques we use, all influence the decision process.

The tool described in this paper uses a criteria weighting procedure[25]. to describe the relative importance between selected criteria. A ranking system is then adopted which decides on the relative performance of the management options against each weighted criteria. Finally the tool uses a simple decision strategy to achieve a final ranking of road shoulder management options in terms of which option best meets ESD objectives and principles.

[24] The NSESD principles include the conservation of biodiversity, maintenance of ecological processes, promotion of intra-generational and inter-generational equity, and a precautionary approach to decision making.
[25] The capability to define criteria weights has been described by the Resource Assessment Commission (RAC, 1992, p.21) as "the most valuable aspect on multi-criteria analysis because it allows different views and their impact on the ranking of alternatives to be expressed explicitly".

ESDTHINK: A TOOL FOR ECOLOGICALLY SUSTAINABLE DEVELOPMENT

ARRB Transport Research developed a prototype decision support system (called ESDthink) in response to a project sponsored by Transport SA aimed at improving awareness, knowledge and use of ESD techniques in the South Australian transport sector. ESDthink is not a decision *making* tool, rather it is a decision *support* tool intended to inform and shape decisions and actions.

The six steps of ESDthink are familiar steps (see Figure 1).

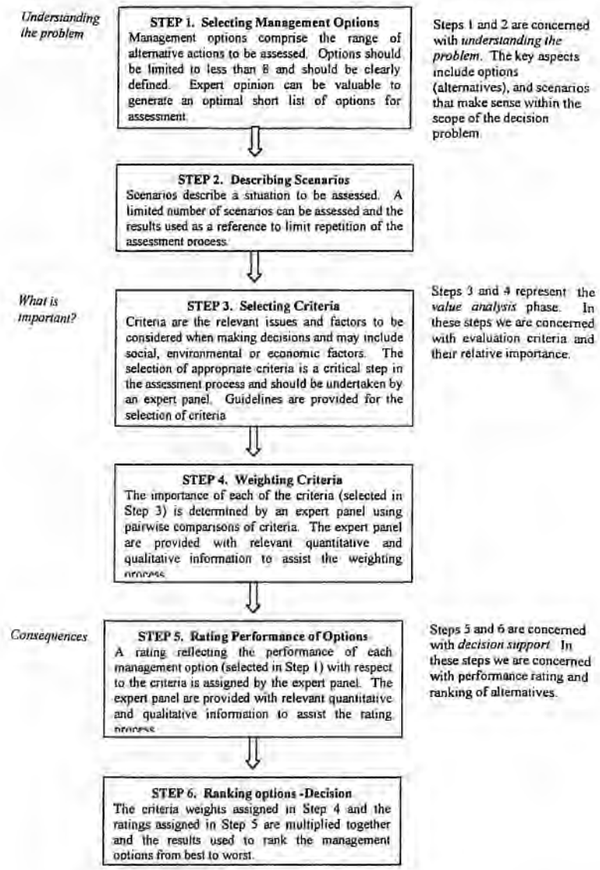


Figure 1. Six Steps of ESDthink

The steps cover gathering relevant information, identifying alternatives, determining what is important so we can make choices between the alternatives and examining the likely consequences. The procedure recognises the need to combine *quantitative information* and *qualitative knowledge*. Although ESDthink is described using six steps, it is important to note that the *process should be tailored* depending on the nature of the problem, stakeholders and the organisation's level of interest and knowledge, as well as the availability of resources and time. The process should also involve some trial and error or repetition to ensure that there is feedback between the various stages of the process. In this way, possible options or choices are not prematurely closed.

Application of Step 1. Selection of Management Options

Step 1 is common to existing approaches to decision making. Identifying options or alternatives involves understanding the problem. It involves information collection and idea generation. This step is very important. A diversity of stakeholders and specialists within associated disciplines may be used to ensure that all options are considered (especially unconventional options).

In some cases there may be a long list of possible options. It is often useful for an expert panel to review the identified options and select a *short list* (say seven or fewer) based on their experience and skill that are consistent with the decision constraints (eg. economic viability, technical feasibility, political sensitivity, social acceptability and environmental sustainability). The short list of options should be clearly described including relevant information relating to their scope and extent. Box 1 (over page) lists a selected set of options for road shoulder management. Plate 1 provides an illustration of grassed shoulders on a low volume road in the Barossa tourist region.



Plate 1. Grassed shoulders on a low volume road in the Barossa tourist region.

Box 1. Road Shoulder Management Options

Management options were developed from consultations with roads engineers and maintenance personnel within TSA. Both the construction phase and the maintenance phase of the management option are considered in the assessment. The selected management options represent a simplification of often complex combinations of management activities into 6 categories. The road shoulder management options considered were:

Unsealed (dry maintenance). This is the most common road shoulder management method in South Australia, with most regions indicating that more than 80% of shoulders are maintained in this way. The construction phase, known as gravel sheeting, usually involves the import, spreading and compaction of quarry waste. If dry maintenance is used the shoulder will generally last for 10 years before resheeting is required. Dry maintenance, or 'patrol grading' involves the grading up of the shoulder to level with the seal and the elimination of ruts and weeds. Dry maintenance generally involves a single grader and driver. The frequency of maintenance is dependent on many factors, including traffic volumes, vehicle mix, seal width, road slope and curvature and climate.

Unsealed (wet maintenance) This option is very similar to the *unsealed dry maintenance* option except that maintenance activities include the addition of water to bring the shoulder material up to the optimal moisture content for compaction, and the use of rollers to compact the material following grading. These additional steps require extra resources (plant, personnel, time, money) however the maintenance frequency is approximately halved and the life of the shoulder may be increased by up to 50%. This option is more common close to urban centres where water is easily accessed, and is uncommon in remote areas.

Sealed Shoulders are generally only sealed on high volume roads or in locations where there is high shoulder wear (eg. access points to commercial properties and adjacent to turning lanes). Sealing involves the spraying of emulsion and the spreading of stone chips onto the unsealed shoulder. A multi wheel roller is used to complete the operation. The shoulder can be expected to last at least 20 years assuming periodic maintenance (filling of potholes, etc) is carried out. Sealed shoulders are expensive to construct, however they provide optimal safety and wear well.

Vegetation (mown) Vegetated shoulders are generally unsealed shoulders (ie. sheeted gravel construction) that have been allowed to grow grass for aesthetic or other reasons. Maintenance involves mowing using a tractor and slasher and brushcutting around roadside furniture. Grass shoulders offer aesthetic and environmental advantages (eg. water quality), however they provide poor skid and wear resistance (especially when wet) and therefore rate poorly from a safety perspective.

Vegetation (sprayed) The use of herbicides on vegetated shoulders for weed control is often used as an alternative to brushcutting around roadside furniture and in cases where the biology of a particular weed warrants its use. Spraying is rarely a broad- scale option, and is usually carried out in combination with slashing or grading. As with the *vegetation mown* option, the *vegetated sprayed* shoulders are generally unsealed shoulders (ie. sheeted gravel construction) that have been allowed to grow grass for aesthetic or other reasons. The use of herbicides is an environmental issue in terms of the persistence of residual herbicides in runoff water (and subsequently in water reservoirs) and also in terms of the contamination of livestock grazing along unfenced roadsides.

Natural materials In remote areas, or on roads with very low volumes, the natural soil may be graded to form the road shoulder.

These soils will vary in composition and while they provide a low cost option, they will require considerable maintenance, especially following rain.

Application of Step 2. Describing Scenarios

Scenarios are used to take into account the particular circumstances that will influence the decision process. For example, a road maintenance process that produces dust may be very important in an urban setting, yet in a rural environment this parameter may not be so important.

Scenarios can be used to simplify the diversity of real conditions into a limited number of 'cases' for assessment. To keep the analysis time and effort manageable, it is important to have a small number of scenarios (say four or less). Box 2 provides a description of four scenarios used in the road shoulder management study.

Box 2 Describing Scenarios

There exist many thousands of possible scenarios for road shoulder management because the importance of relevant criteria (environmental, economic, social) changes from road to road, and even from one section of a road to another. There is no single best option in ESD terms, rather, each situation presents a unique combination of issues that will result in a different ranking of options. The following 4 scenarios were described to highlight some of the differences in criteria importance in different locations. They represent a range of environments and road conditions within South Australia.

Scenario 1. Major Highway (eg. Stuart, Eyre, or Lincoln Hwy).

This road is a Major Highway. Traffic volumes are high. Surrounding landuse is agriculture. The road reserve is fenced and stock cannot access the road shoulder. The road is not in a drinking water catchment. Remote location means the transportation of road building and maintenance materials is costly.

Scenario 2. Minor road in Tourist Region eg. (eg. Barrossa Valley)

This road is connecting tourist attractions. Traffic volumes are moderate to low. The surrounding landuse is intensive agriculture and the landscapes are considered attractive. The road is not in a drinking water catchment. The road reserve is fenced. Weed dispersal is considered a problem in this area.

Scenario 3. Road in water catchment (eg. Adelaide Hills)

A medium capacity road in a drinking water catchment. Water quality issues are a concern. Traffic volumes are moderate. Surrounding landuse is native forest and hobby farms.

Scenario 4. Road on the urban fringe (eg. Main North Road)

Major freeway into an urban area. High traffic volumes. Both air and water pollution are important issues. Road is a gateway to the city so aesthetics may be important. Road reserve is fenced.

Application of Step 3. Selecting Criteria

The selection of an appropriate *number* and *type* of criteria is a critical step in ESDthink. Too many criteria will make the comparative performance assessment by the panel very time consuming; too few criteria may not provide adequate coverage of (and distinction between) important issues. As a rule you should aim for around six to 10 criteria.

The selection of criteria must also recognise the potential for 'double counting' and biasing. In general, one should aim to include criteria from economic, environmental and social themes in numbers consistent with the importance of these themes to the activity being assessed. Table 1. shows the criteria used in the road shoulder management study.

Table 1. ESD criteria for road shoulder management

ESD Criteria	Elements	Description
Water	*Herbicides* *Sediment* *Runoff quality* *Runoff Volume*	Water contamination with residual herbicides Water pollution with sediment from roadsides Water pollution with road runoff pollutants from road Increased runoff volumes from impermeable shoulders
Land	*Herbicides-land* *Aesthetics*	Contamination of land with herbicides Landscape values and tourism issues
Biodiversity	*Weeds*	Spread of weeds from shoulders
Air	*Air emissions* *Dust*	Air quality impacts from the use of machinery Air quality impacts from the generation of dust
Resources	*Energy* *Materials*	Energy consumption (including embodied energy); including greenhouse gas emissions Consumption of renewable and non renewable resources
Function	*Performance* *Cost* *Safety*	Engineering performance of shoulder (shoulder wear) Economic impacts Road user safety

Application of Step 4. Weighting Criteria

Pairwise comparison is a common technique used in environmental assessment processes which can be used as a basis for deriving weights. In the prototype version, a simple approach is used to obtain weights from a pairwise comparison matrix. This approach assumes that the pairwise comparisons are consistent (which, in practice, is unlikely due to the different viewpoints of the people involved in the comparisons). If resources are available, background information including qualitative and quantitative data, should be compiled to assist the expert panel with the weighting procedure.

Experience has shown that an effective approach is to structure the 'expert panel' into teams of two people (with similar areas of expertise where possible). The team members act as 'sounding boards' for initial ideas as the weighting process is undertaken.

It is important that the weighting is applied to likely effects (and not the criteria themselves). These 'effects' can be described as changes in indicator values which may use ordinal (descriptive) or cardinal (quantitative) scales.

The criteria weights can be derived from this comparison matrix. Figure 2 provides examples of the criteria weights derived by different panel members for the Major Highway scenario, in the road shoulder study.

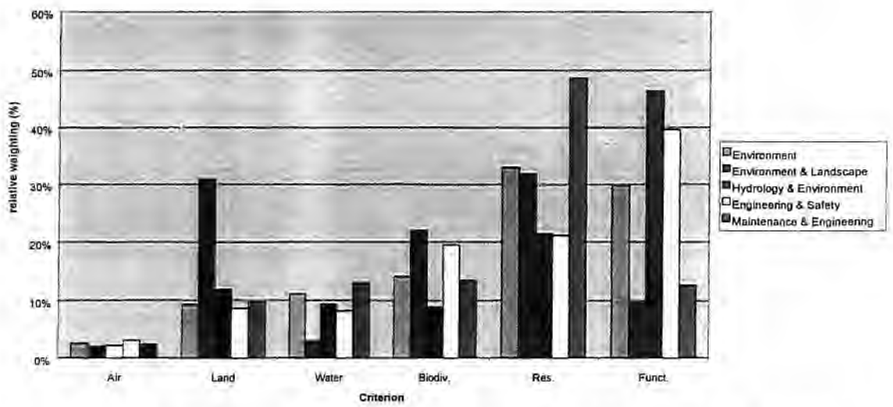


Figure 2. Weighting of Criteria for Scenario 1 (Major Highway) by different expert groups

Figure 2 illustrates the variation in importance of different criteria depending on the experience and background of panel members. For example, the engineering and maintenance people rated the resource use criterion most highly while those with expertise and interest in safety rated the road function more highly. Also, those with a knowledge of landscape values gave the land criterion (including aesthetics) greater importance than other panel groups. All groups rated air quality as low importance for a major rural highway, as expected. This demonstrates the importance of representative panel selection to ensure the potential for bias toward one issue of importance over another is minimised.

Application of Step 5. Rating Performance of Options

This step is used to assess the performance of each management *option* relative to the changes in selected indicators for each *criterion*. The results are represented in a performance matrix. The performance matrix uses a simple ordinal rating scheme to represent the panel members' views. The values listed below are used to rate the performance of each management option:

Option **performs very poorly (VP)** (option has a **very large impact** on this criterion).
Option **performs poorly (P)** (option has a **large impact** on this criterion).
Option **performs OK** (option has a **moderate impact** on this criterion).
Option **performs well (G)** (option has a **small impact** on this criterion).
Option **performs very well (VG)** (option has a **very small impact** on this criterion).

An example of the performance rating of each road shoulder management option for scenario 1 is shown below. Sealed shoulders rate 'very well' (VG) with respect to their performance in minimising impacts on water quality and aquatic ecosystems but their performance is 'poor' (P) with respect to usage of resources such as new materials and energy. Sealed shoulders are likely to be beneficial in reducing erosion and sedimentation while their use will be resource intensive in terms of initial sealing inputs and the need for periodic reconstruction.

Expert Team 1.	Scenario 1 – Major Highway					
Rating	wet	dry	seal	mow	spray	nat.
Air	OK	OK	OK	OK	OK	OK
Land	OK	OK	VG	VG	VP	VP
Water	OK	OK	VG	VG	OK	P
Biodiversity	G	OK	VG	G	OK	VP
Resources	OK	OK	P	VG	VG	VG
Function	VG	G	G	P	P	VP

Legend: VP (Very Poor) 0.1, P (Poor) 0.3, OK – 0.5, G (Good) 0.7, VG (Very Good) 0.9

Application of Step 6. Decision Support

ESDthink allows for different decision strategies to be used. However, in the prototype software, a simple linear aggregation technique is used. In this technique, the criteria weights assigned in Step 4 and the ratings assigned in Step 5 are multiplied together and the results then used to rank the management options from best to worst.

It is important to note that the aggregation method used is not intended to replace negotiation between people involved in the decision making process. The approach recommended in this report is a decision *support* tool. It is not a decision *making* tool.

An example ranking of road shoulder management options (for scenario 1) is shown below. The ESD assessment indicated that sealed shoulders perform the best while natural materials are the least attractive option.

Option	**wet**	**dry**	**seal**	**mow**	**spray**	**natural**
Rank	**3**	**5**	**1**	**2**	**4**	**6**

The two highest performing road shoulder management options (sealed and unsealed/grassed/mown) are presently used the least in SA. The high ranking of these options (which, in general, perform well in environmental terms) reflect the focus on environmental criteria used in the assessment process in this example.

Further practitioner workshops are currently being held to investigate different criteria sets and the applicability of this approach to other scenarios within Transport SA. It is anticipated that guidelines for road shoulder management will be prepared following further application of this approach.

CONCLUSIONS

This paper has described an approach to ESD assessment and presented an application relating to road shoulder management. The result highlights the importance of criteria selection on the assessment process and the potential for bias if a balanced set of criteria are not chosen. The process demonstrates the success of a simple tool which can help overcome the difficulties of blending both qualitative and quantitative data into the decision process.

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THE ROAD CORRIDOR ENVIRONMENTAL ASSESSMENT PROJECT

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ABSTRACT

The Department of Main Roads initiated a project in late 1998 that aimed to identify environmental assets within the state-controlled road reserve. The Department is presently finalising the desktop and field survey methodologies so that a consistent approach to data collection and storage can be achieved. The information to be collected has grown from the identification of significant flora and fauna habitats, communities and species, to include the identification of areas that require priority input from maintenance crews (eg. in the instance of severe erosion) and major threats to identified environmental assets. The primary benefit of this project will be the provision of environmental data to aid the concept planning phases of road construction. In particular, the data will enable planning for future road corridors to take account of, and avoid where possible, environmental assets within the road reserve.

***Key words**: environmental impact assessment, strategic planning.*

INTRODUCTION

Main Roads is committed to the protection of the environment by observing the Government's policy of ecologically sustainable development (ESD). One mechanism established by Main Roads to promote ESD is the development and distribution of best practice environmental management manuals. The Technology and Environment Division within the Department of Main Roads is responsible for the production of these manuals. One such manual documents the assessment and reporting procedures relevant to each phase of a road project (the Road Project Environmental Management Processes Manual 1997). The manual outlines the sequential phases of a road project and discusses the accompanying environmental management documentation. Table 1 provides a summary of each phase in a road project together with the accompanying environmental management documentation.

Table 1: Summary of road project phases and accompanying environmental documents

Road Project Phase	Environmental Document
Network Planning	-
Concept Planning	Review of Environmental Factors (Concept)
Preliminary Design	Review of Environmental Factors (Planning) or Impact Assessment Study Environmental Management Plan (Planning)
Detailed Design	Environmental Design Report
Construction	Interim Environmental Management Plan (Construction) Environmental Management Plan (Construction)
Maintenance	Environmental Management Plan (Maintenance)

As outlined in the table above, there is presently no formal Main Roads environmental management documentation that aligns with the initial network planning phase of a road project. To address this issue, Main Roads has initiated the Road Corridor Environmental Assessment project. This project will lead to the identification and documentation of the environmental values within the state-controlled road network (approximately 33,500 km). Once collected, this information will allow the consideration of environmental values to be included in the early planning decisions for the road network.

PROJECT OBJECTIVES

The objectives of the Road Corridor Environmental Assessment project are listed below and each relates to the state-controlled road reserve.

- To identify environmentally significant areas (eg. vegetation types/communities, sites of cultural heritage significance, etc)
- To identify areas that are known and/or likely to support scheduled and/or otherwise significant flora and fauna species
- To identify areas requiring priority input/attention from maintenance crews
- To collect the desired information in a manner that enables ready input into a useable and readily accessible digital format
- To identify threats to significant areas

PROJECT METHODOLOGY

The methodology for the project is divided into three phases. These are as follows:

- Collation of existing information
- Field surveys
- Reporting and entry into digital database system

A brief discussion of each phase is provided below.

Collation of existing information

Main Roads has negotiated the purchase of whole of the State databases from the Environmental Protection Agency, Queensland Herbarium, Queensland Museum and Department of Natural Resources. These are being combined with existing Main Roads datasets to enable internal access to the following information:

- State-controlled road network with the road reserve boundary
- Digital Cadastral Data Base (DCDB)
- Land tenure
- Named rivers and creeks
- Herbrecs data on scheduled flora species
- Queensland Museum data on scheduled fauna species
- Bioregional ecosystems as per the EPA classifications
- Soils
- Topographic contours
- Forest Reserves
- National Parks

These digital datasets will be available for the use of all Main Roads staff through the development of a user-friendly Intranet web page.

Field surveys

The outcome of the above stage will be the production of field maps that contain relevant data layers. These maps, in combination with field survey sheets developed by Main Roads, will aid field staff in the identification, collection and verification of environmentally significant areas. It is envisaged that qualified fauna ecologists and field botanists will conduct field surveys. To aid our districts in the selection of such professionals, the Technology and Environment Division is preparing a list of preferred professionals for each District (this list is being developed in collaboration with staff from the Environmental Protection Agency, Queensland Herbarium and Queensland Museum).

Field staff will be encouraged to collect additional information prior to undertaking the field surveys. Sources of information include the following:

- Naturesearch database (now WildNet) – fauna
- Birds Australia Atlas - birds
- Queensland Ornithologists Society - birds
- Queensland Frog Society - frogs
- Council databases – flora and fauna
- Local community groups – flora and fauna
- Local wildlife carers – fauna
- Local naturalists – flora and fauna
- Aerial photographs – for habitat connectivity
- Published reports – flora and fauna
- Previous DMR assessments – flora, fauna, cultural heritage, erosion prone areas, etc.

Reporting and entry into digital database system

The development of our Intranet web page has been undertaken in such a manner that enables the inclusion of collected information as per our field survey sheets, but also enables the addition of further datasets that may be identified as being of relevance during the field surveys. By doing so, Main Roads will be able to display digitally, the location and attributes associated with all environmentally significant areas within the state-controlled road network.

ECONOMIC BENEFITS

The environmental benefits of such a project are varied and numerous. However, economic benefits will also result. Such benefits include:

- Reduced cost for subsequent environmental assessments as key elements will have already been identified and therefore target specific assessments for ecological attributes only would be required
- The potential for costly time delays for road projects on environmental grounds would be significantly reduced as a result of considering environmental values in the early planning stage
- Relevant environmental information will be available and easily accessible to all Main Roads staff, thus avoiding the timely and costly collation of information

CONCLUSIONS

Main Roads has initiated the Road Corridor Environmental Assessment project so that existing areas of environmental significance within our road reserves may be identified and recorded. This information will assist the development of an ecologically sensitive road network through the consideration of environmental values in the network planning stage of future road projects. By doing so, Main Roads is promoting continual improvement in our environmental performance in addition to contributing to ecologically sustainable development.

DEPARTMENT OF NATURAL RESOURCES - ROLE IN TRANSPORT CORRIDOR VEGETATION

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ABSTRACT

There are approximately 1.85 million hectares of land dedicated to roads in Queensland, the majority of which are vegetated (or at least partly). Legislation and policies administered by the Department of Natural Resources have an important bearing on control of such vegetation on roads. Three statutes are most relevant. The *Land Act 1994* vests the ownership of all roads in Queensland in the State and its "trespass" and tree clearing provisions cover interference with a range of resources on such roads. The *Forestry Act 1959* (currently under review) governs the sale and destruction of defined "forest products" not only on State Forests, but also on roads. The *Water Resources Act 1989* (also under review) controls destruction of riverine vegetation in the path of a proposed road.

LAND ACT 1994

The *Land Act 1994* came into operation on 1 July 1995 following an extensive inquiry and Report on Crown land administration in 1992 (the Wolfe Report). It is the general legislation that covers all non-freehold land in Queensland – Crown leasehold, Reserves, unallocated state land (formerly Vacant Crown land) and roads. Like many modern Acts, it contains an "objects" section (s.4), which outlines key principles that must be considered in the Act's administration. Of the seven principles listed, the one most relevant to the present topic would be "protection" – protection of environmentally and culturally valuable and sensitive areas and features. "Evaluation" and "community consultation" also impinge on management of road vegetation.

All roads dedicated and opened for public use vest in the State (s.94). This vesting relates to the ownership of the land area of road (ie boundary to boundary to the "vertical" limits above and below). The Department of Natural Resources (DNR) is the agency of the State presently responsible. Main Roads (DMR) and local authorities have specific management responsibilities for roads under their control.

The *Land Act* (Part 6) also contains comprehensive provisions relating to tree management. While this Part has attracted recent publicity because of its more stringent tree control on Crown leases, it also relates to trees on roads. Again, principles (but more specific than in the objects clause) are stated (s.250) to govern the operation of the Part. Those relevant to roads include:

- to prevent degradation of the land;
- to maintain biodiversity;
- to maintain environmental and amenity value of the landscape;
- to maintain scientific, recreation and tourism values of the land; and
- to ensure public safety.

A person is prohibited from clearing a tree other than under a Tree Clearing Permit (TCP) or contravening a condition of a Permit (s.255). The maximum penalty is 400 penalty units. Upon conviction, the Court may also order (a) payment for any remedial work or rehabilitation necessary because of the offence and (b) payment of the value of every tree cleared or destroyed, which is the price ordinarily obtainable for the sale of the tree.

A tree clearing permit is not needed if a person is permitted under another Act (eg *Forestry Act*) to clear trees (s.257). There is no restriction on who may apply for a TCP on roads. An application must be on the approved form and lodged in a DNR office in the relevant district. The chief executive (or their district delegate) may ask the applicant for:

(a) a tree management plan; or
(b) a map clearly delineating the area to be cleared.

While a tree management plan would be more likely to be requested for, say, clearing on a Crown lease, it could also be demanded if a significant area of road was sought to be cleared by an adjoining owner. It would need to identify such aspects as major vegetation types, environmentally sensitive areas, stands of commercial timber, the way the trees are to be cleared and any planned revegetation or rehabilitation.

In deciding whether to issue a TCP, the chief executive must consider a range of quite specific issues (these can be generally thought of as refinements of the wider principles considered above). Additional areas most relevant to trees on roads are:

- protection of the water catchment;
- fire management;
- existence of commercial timber;
- value for bee-keeping purposes of the trees proposed to be cleared;
- heritage or cultural value of the trees; and
- information contained in any management plan.

The TCP may be issued with or without conditions or may be refused. The Permit must state the purpose for which the trees are to be cleared and the way in which clearing is to occur.

Cancellation of the TCP may be effected by DNR if:

- it was obtained on the basis of false or misleading material in the application;
- the person has contravened a condition of the permit;
- clearing has been carried out in a way likely to be harmful to the land or adjoining land; and
- there has been substantial change in circumstances since the Permit issue and the Permit would no longer issue.

FORESTRY ACT

The current *Forestry Act 1959* is some 40 years old and, while it has been periodically amended, it lacks certain of the more enlightened principles permeating the *Land Act* considered above. A major revision is likely once the Regional Forest Agreement with the Commonwealth is settled. The cardinal management principles of State Forest management under the Act are only twofold – reservation of areas for timber production and protecting the watershed. The possibility of applying areas to recreational and grazing use is also recognised.

The Act (s.45) clearly provides that all forest products on lands dedicated for public purposes (including all roads except State controlled roads under the *Transport Infrastructure Act 1994*) are the absolute property of the Crown.

Interference with any forest products on any road (except State controlled roads) is prohibited under s.54 except:

- under the authority of another Act, eg the *Land Act*; or
- under authority of a permit, licence etc under the *Forestry Act*.

However, the section makes it plain that the provisions of the *Transport Infrastructure Act 1994* take precedence.

Licences to get forest products on roads may be granted but only for a limited range of purposes, eg to get timber for fuel (s.55). However, s.70 grants a wider power to the corporation (ie the Primary Industries Corporation, the successor to the Conservator of Forests, and acting through DNR Resource Management) to issue permits for the destruction of trees on roads.

During this process, DNR Resource Management refers the application to DPI Forestry if commercial timber is likely to be involved. This is to ascertain any effects on commercial timber supplies and the logistics of salvage if the application is approved.

It should also be mentioned that the Corporation is given a wider power (s.46) to sell forest products that are the property of the Crown. This includes commercial timber on roads. Powers of access etc are granted under the Act or "sales permit".

In contrast to the statutory criteria for permit approval under the *Land Act* previously considered, there are no statutory equivalents under the *Forestry Act*. This obviously connotes a wider discretion in considering an application under the latter Act. However, as a matter of policy, a range of factors are considered which parallel (if less comprehensively) the *Land Act* criteria.

The matters currently considered in respect to permit applications under the *Forestry Act 1959* include: the State's commitment to the National Strategy for Ecologically Sustainable Development (NSESD), the National Forest Policy Statement (NFPS) and the National Greenhouse Response Strategy (NGRS) which deal with:

- sustainable resource use and development;
- evaluation of land capability based on economic, environmental, cultural and social values and opportunities;
- retention of land for community purposes; and
- protection of environmentally and culturally valuable and sensitive areas.

Forest officers, appointed under the *Forestry Act* or "authorised persons" appointed under the *Land Act*, are responsible for investigation of all suspected unauthorised clearing, removal or interference with roadside vegetation (including non-commercial vegetation) on Local Authority Roads and Reserves.

A recent indication of the serious concern Parliament has for improper destruction or interference with timber is the substantial increase (from May 1999) in penalties for offences. A first offence for illegal destruction now attracts a maximum of 1000-penalty units ($75 000) with an increase to 3000 units for a subsequent offence (s.54).

LOCAL GOVERNMENT ACT 1993

The *Local Government Act 1993* (s.901) vests in a local government control of all roads (excluding State-controlled roads) in its area. Control includes capacity to take all necessary steps for construction, maintenance and improvement of roads. Such a power enables a local authority to clear vegetation on local roads without further permit provided such clearing is reasonably necessary for road construction (or management). Further, cleared timber can be subsequently used in works incidental to the road. What is not permissible without permit is a local authority selling or purporting to transfer rights in the cleared timber to another party eg the road construction contractor.

TRANSPORT INFRASTRUCTURE ACT

Main Roads (DMR) are given all the powers of a local authority in respect of State-controlled roads in the local authority area. In addition, as discussed earlier, and unlike local government, timber is under the control of DMR. It is an offence for a person to damage, remove or interfere with naturally occurring materials (eg timber) on State roads (s.43).

The only apparent restriction on control of vegetation in DMR activities relates to destruction of vegetation in a watercourse (s.70 of the *Water Resources Act*). A permit is required from DNR. This is despite s.35 of *Transport Infrastructure Act* which gives DMR, in carrying out works, power to divert a watercourse provided consideration is given to the physical integrity and flow characteristics of the watercourse. DMR, in recent consultation with DNR, is content that the permit arrangement is a satisfactory practice – whether the permit is granted to DMR or it's contractors.

CONCLUSION

The regulatory regime outlined above is supported by an extensive DNR network of technical and administrative staff throughout the State. While targeted community education and advice is the preferred means of regulation, prosecution is a necessary alternative for the (unfortunately) incidences incident of unauthorised interference.

DIRECT SEEDING AS A TOOL FOR NATIVE VEGETATION ESTABLISHMENT

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ABSTRACT

Re-establishing native plants on roadsides and other disturbed lands from seed has often proven difficult. Seed availability can be a problem and when sufficient seed is available establishment is often poor. This is because seed biology of native species is complex in comparison to crop species and lack of understanding can lead to no germination what so ever of perfectly good seed. This paper provides a summary of the results of many studies into the seed germination, dormancy and seed biology of native species which have mainly been carried out by the mining industry. The effectiveness of this research is illustrated by the most advanced mining companies now routinely being able to establish hundreds of species over ten's of hectares of disturbed land.

Collection of native seeds must be carried out by experienced seed collectors to ensure the seed lot is of maximum viability. Seed lots should have their viability tested to avoid wasting resources. Unlike crop seeds most native seeds won't germinate when they are warm and moist. Rather they require other environmental stimuli. Research has found some species may respond to heat, scarification, smoke, leaching, aging or require particular seasonal temperature or light conditions. Management of the site and treatment of weed seed banks is also important for effective establishment.

Treating native seeds appropriately can dramatically increase establishment, while inappropriate treatment can lead to no germination. Effective revegetation requires appropriately treated seeds and managed sites!

Key words: *direct seeding, germination, seed viability, seed quality, native plants*

INTRODUCTION

Broadcasting seeds of native species rather than planting seedlings from tubestock is widely used in large-scale revegetation projects. It has several advantages, for most species it is cheaper, plants establish in the appropriate niches for the species and it can result in a more natural looking landscape. Seeds of most species can also be stored with minimal maintenance. Use of seeds also allows the introduction of greater genetic diversity and therefore greater genetic flexibility to deal with changes in the environment. For large projects seeds are generally the most practical means of establishing a diverse range of native plants in quantity.

However sowing seeds of native species is not as straight forward as sowing crop seeds. If quality and the seed biology of the species is not considered results can be disappointing and thousands of dollars wasted. In this paper the success of direct seeding is considered in terms of seed quality, seed germination and seedling establishment (Table 1). Much of the research I have been associated with has involved direct seeding of disturbed mined lands to revegetate them with a self-sustaining native plant assemblage.

SEED QUALITY

Seed viability is concerned with whether the seed has the potential to germinate given suitable moisture, temperature, oxygen and dormancy breaking treatments. The embryo needs to be metabolically active. The seeds to be sown must be of high viability, if they are of low quality then success will be poor irrespective of other treatments or procedures applied. We need viable seed before we consider any of the other factors influencing seed germination and establishment. Seed quality is affected by factors intrinsic to the plant producing the seeds and by extrinsic factors that act on the plant and the seeds.

Table 1. Factors to be considered for efficient and successful direct seeding of native vegetation.

Species Selection

- High seed viability and germination
- Species/variety adapted to soil and climate
- Species assemblage will achieve end land use

Seed Quality

- Seeds should be collected by reputable suppliers from many plants that have received adequate rainfall during seed filling
- Seed lot should not contain fungi or insects
- Seeds should be stored in dry cool conditions except for species requiring after-ripening which should be stored in dry room temperature conditions

Seed Germination and Dormancy

- Seeds may need to be treated to get optimum germination
- Seeds need to be sown correctly for germination to occur, some species need to be buried, others sown on the soil surface

Sowing and Management

- Control weeds prior to sowing
- Sow in the season(s) when weather conditions will promote establishment
- Remove weeds when sowing and manage weeds after sowing if necessary

Factors intrinsic to the plant include genetic factors and biological factors. If the seeds are collected from small isolated populations of the plants then the impact of fertilising the seeds with pollen of closely related plants can result in depression of seed quality and of the fitness of the resulting plants. The seeds may abort resulting in few seeds produced or seeds may develop that are not viable, or have inferior vigour.

Another factor intrinsic to the plant is the provision of moisture and nutrients during the growing season prior to seed production and temperature and moisture conditions during filling of the seeds. Provision of moisture and nutrients during the growing season allows the plant to build up reserves of carbohydrate which can be translocated into the seeds. During seed filling temperature and moisture availability can have a major role influencing the development of the seeds. Drought conditions during the end of seed filling can result in small seeds of reduced vigour and less food reserves to cope with competition. When collecting seeds it is important to obtain the seeds from plants which have received reasonable levels of rainfall. This has been found to be critical for some species, spinifex grasses (*Plectrachne* and *Triodia* species) for example tend only to produce seeds of reasonable quality in populations that have received good rainfall during seed production (Jim Tyler personal communication).

Some Australian native species have naturally low levels of viable seeds. Dixon and Meney (1994) showed that for some species of *Calytrix* and *Stirlingia* the viable seeds were distributed amongst inviable seeds at a ratio of 1:100. They propose that the inviable seeds act as decoys for seed predators such as ants. Because so few of the seeds contain a food source, seed eating insects will seek seeds of other species rather than *Calytrix* and *Stirlingia*. Considerably larger amounts of seeds of such species would need to be collected to provide reasonable levels of viable seeds but often these species produce many seeds which are reasonably easy to collect.

Factors external to the plant which affect seed quality include disease, insect predation, harvesting techniques and post-harvest conditions. Little is known of the affect of disease of seeds on Australian native plants. Websdane *et al.* (1994) found smut fungi to occur in seeds of some Australian native plants and collection of diseased seeds can spread the disease to other healthy seeds when mixed in the same lot. Insect predation can have a major impact on seed viability. Some batches of seeds can have virtually all of the seeds damaged by insects which bore into the seeds. Fumigation is essential for seeds which have been collected from the soil

surface (Dixon 1997). Again if some seeds in a batch contain seed eating insects these can rapidly spread to other healthy seeds unless the batch of seeds is fumigated.

Human factors include picking time, cleaning, handling and storage. How the seed is harvested has a major impact on viability. Seed age can have a major effect on seed viability. If seeds are collected too soon the seeds may not be able to continue to develop to maturity. The seeds should also be collected from many plants to overcome genetic and localised environmental variation in quality. Seeds then generally need to be kept in dry conditions and protected from insects. Exceptions are seeds of a few plants, particularly large seeded rainforest species, which are killed if the seeds are dried. These recalcitrant seeded species can have seed longevities of only weeks or months (Dixon 1997). Seeds will also retain viability for longer if they are cool and many commercial seed stores are air-conditioned. Seeds of Australian native species will generally retain viability for many months at room temperature. Generally hard seeded legume species store well whereas other plants, particularly of the Cyperaceae, Restionaceae and Epacridaceae suffer endosperm degradation within two-three years without treatment or freezing (Dixon 1997). A further complication is that some plants produce seeds that are not fully developed when they are shed from the plant and may require a further six months to develop before they are able to germinate. Seeds of some Restionaceae and Cyperaceae appear to be filled and viable two months after fertilisation but actually take up to 11 months to become potentially germinable (Dixon 1997). Storing such seeds at low temperatures can prevent or slow the development of the seed. Seed supply companies should be able to provide information on recommended storage for commonly used species.

It should also be recognised that seed viability can be assessed by several methods and different methods may be quoted by different seed supply companies. A cut test involves cutting the seed in half to determine if a turgid, creamy white endosperm is present. Furthermore the presence or absence of the embryo can be noted. Seed vitality can also be assessed using chemical stains such as tetrazolium chloride which stains metabolically active tissue red. Alternately germination of the seeds can be determined. The seeds may be treated with dormancy breaking agents and germination should be carried out under controlled conditions. Germination tests will typically identify a lower proportion of the seeds than viability assessed by the tetrazolium chloride test which will be lower than viability assessed using the cut test.

SEED GERMINATION AND DORMANCY

Many crop and fodder species have been selected for planting by humans over thousands of years. One feature which has been selected is that the seeds germinate quickly and uniformly when the crop is sown. Native species have not had farmers selecting the optimum conditions for sowing and seedling establishment but rely on the seed sensing the best environmental conditions to germinate. In many regions of Australia seedling survival tends only to occur naturally if the seeds germinate after fire as this reduces competition with established plants. Thus seeds of many species are designed to germinate only after they receive stimuli that they would get from a fire – heat, smoke or changes in light due to removal of vegetation. When carrying out revegetation programs we require that the seeds establish under conditions that we have chosen and we want maximal germination whereas often species will naturally have staggered germination of a proportion of the seeds.

Thus if just kept in oxygenated, warm, moist conditions most native species will have poor germination because many of the seeds will be dormant. Bell *et al.* (1993) suggested that two thirds of Western Australian native species had dormancy mechanisms present. Many of the mechanisms imposing dormancy are in the seed coat while others occur in the embryo of the seed (Adkins and Bellairs 1997). In many species the seed coat prevents water or oxygen from entering the seed. It may also be of such mechanical strength that it prevents the seed from germinating. This can often be overcome by scarifying the seed. This is often carried out by boiling the seeds or by tumbling the seeds in a metal drum to physically chip the seed coats (Dalton 1993).

Seed coat dormancy can also be due to inhibitors in the seed coat. Treatment of the seeds with smoke may be required as this changes the seed coat structure. Leaching the seeds in water

may be required to remove chemicals in the coat. Other considerations which may affect the seed coat or embryo dormancy include the temperature and light conditions into which the seeds are sown. Some seeds will only germinate if exposed to light and won't germinate if sown into the soil or under a vegetation canopy. Other seeds will only germinate if in darkness and need to be buried to germinate (Adkins and Bellairs 1997).

Seed dormancy of Australian native species is complex and many major research projects have been sponsored by the mining industry to increase knowledge in this area. It will be a major area of research for many years to determine how to optimise the germination of the majority of Australian native plant species. However already many species are able to have the seeds simply treated to maximise germination. Treatments can be applied to the seeds and, following many of the treatments, the seeds can be stored for several months and the treatment will remain effective. The use of native species for direct seeding requires forward planning so that seeds of the most appropriate species can be collected and the seeds can be treated to overcome dormancy and maximise establishment.

SEEDLING ESTABLISHMENT

Once seeds of high quality have been obtained and the seeds treated to maximise germination the next stage in the process is seedling emergence and establishment of the native vegetation. Major issues with native vegetation establishment from direct seeding for the mining industry are the timing of sowing, ground preparation and competition with weeds.

Timing of operations is critical to success. In some strongly seasonal climatic areas successful establishment of native seedlings will only occur in a few months of the year. In summer rainfall regions of central Queensland sowing tends to be most successful if carried out between October and December, although sowing in February or March can still be successful. In the coalfields of New South Wales sowing tends to occur in autumn or spring. In the south west of Western Australia sowing tends to be most successful in mid to late autumn. Ripping the soil or creating soil structures that concentrate water and hold water can increase soil moisture and may extend the period for successful seedling establishment.

As well as the time of sowing, the timing of other operations is also important. Sowing needs to occur soon after ground preparation to allow the seeds to establish good contact with the roughened soil surface and become slightly buried. Seeds of most native plants will only emerge from shallow depths (0.5 – 1 cm) and so the seeds are often broadcast rather than drilled into the soil. *Acacia* (wattle) seeds which are relatively large will generally germinate from several centimetres while some native grasses require exposure of the seed to light to germinate and therefore can only be buried a few millimetres deep.

Weed and grass competition can have a major impact on native plant establishment (Dalton 1993). Often exotic grasses can germinate very quickly and grow vigorously. They can completely cover and result in the death of native seedlings. Competition can be controlled by reducing the weed seed bank prior to sowing, by removing the weed seeds from near the applied seeds when sowing, by herbicide application, by fertiliser control and again by timing of operations. Selection of species is also important as some native species are much better able to compete with weeds and grasses.

The weed seed bank can be reduced prior to sowing by reducing the period of disturbance of the soil which allows weeds to establish and produce seeds. Many weed species can produce thousands of seeds per plant within a few months. Allowing uncontrolled weed growth over long periods of time prior to native vegetation establishment will necessitate more expensive weed control later. The weed seed bank will decrease with depth and turning the soil over to bury the soil containing the weed seeds may be necessary prior to sowing with native species. This can be carried out on a small scale using hand tools and spot seeding, in single rows or in belts using agricultural equipment. Some direct seeding equipment is able to remove the surface layer of soil from a strip of soil and sow the native seeds into that exposed soil. This also produces rip lines which assist in retaining soil moisture and reducing erosion. Dalton (1993) has descriptions of equipment and techniques that can be used. Cultivation of the soil several times prior to

sowing can reduce the population of weeds and pre- and post-emergent herbicides can also be applied. If native shrubs and trees are to be grown, grass specific herbicides can be useful. Fertiliser control is important, excess fertiliser greatly increases weed growth over native species and makes control difficult. Sowing of seeds needs to occur soon after soil cultivation so that weeds and grasses are not able to establish before the native plants are sown. While ground preparation and weed control are added expenses they are far less expensive than establishment failure and resowing of the native species.

RECOMMENDATIONS

Species Selection

Species should be selected for which seed viability is high, seed germination and dormancy treatments are understood, and the species chosen should be capable of achieving the end land use requirements. Meeting the end land use requirements is likely to require a combination of species.

Seed Quality

Seed lots should be purchased according to the number of viable seeds present. Buying cheap bulk quantities of seed is a waste of money if most of the seeds are not viable.

Seeds should be purchased from experienced seed collectors so that seeds are picked when mature, protected from insects and stored appropriately.

Planning is important so that seed collectors are able to collect the most appropriate species for the location rather than just supplying whatever species they have available.

Seed Dormancy

Forward planning is important so that seeds can be stored for the appropriate length of time to overcome seed maturity dormancy mechanisms.

Seed dormancy mechanisms must be considered to ensure that either the seed supply company or the revegetation officer treats and sows the seeds to maximise germination.

Seedling Establishment

Revegetation needs to be planned so that sowing occurs in an appropriate season and the seedlings receive sufficient rain, avoid frosts and avoid hot dry weather.

Herb and grass weed control needs to be effective through the use of appropriate:

- pre-sowing weed and soil management;
- sowing techniques;
- subsequent weed control; and
- avoidance of excess fertiliser application.

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Appendix 1. Indicative costs associated with direct seeding operations on minesites.

Seed testing $50 per species

Seed dormancy breaking treatments – generally insignificant
Acacia seed $150 per kg 60,000 seeds/kg
Eucalyptus seed $200 per kg 200,000 seeds/kg
Total seed mix for 6 *Eucalyptus*/6 *Acacia* plus other trees and shrubs $1500/ha

Seeding and ripping with D10 dozer $600 /ha
Seeding with tractor mounted air seeder $350 /ha
General weed control measures usually not undertaken.

PRACTICAL CONSIDERATION IN USING CONTAINERISED SEEDLINGS FOR TRANSPORT CORRIDORS

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ABSTRACT

The economics of vegetation establishment in transport corridors is controlled by a number of factors. The most important of these are the purpose of establishment and the site characteristics. Both influence cost (individually and interactively) through their impact on site amelioration requirements.

Direct seeding may be the most economical tool where site amelioration requirements are low: such as under amenable site conditions and where plant type and placement are of limited importance. Where these factors are of greater importance, or where a higher intensity of management is required, container seedlings are the best option. In the former case (direct seeding), costs are estimated to be between $1500 and $ 2,000/ha. In the latter case, costs are likely to range between $1000 and $3000/ha and will depend on the type of container, the nursery practices used, and the levels of site preparation, weed control and fertilisation.

Key words: *containerised seedlings, direct seeding, costs, establishment*

INTRODUCTION

Identification of the most effective establishment method relies on an understanding of two related factors. These are (a) the purpose of establishment, and (b) limitations of the site. Vegetation may be established for a range of reasons including:

- The revegetation and rehabilitation of degraded land.
- The control of water flow and to assist in erosion control.
- To facilitate the process of natural regeneration, including increased species diversity.
- To provide screens or barriers for noise reduction or beautification of the landscape.
- To achieve commercial returns from the harvesting of timber or for potential monetary returns from carbon credits.

The purpose of the vegetation will impact on cost through the need to employ different management systems to achieve the desired outcomes. These systems will differ in species selection, nursery regimes and methods of establishment and management.

Similarly site characteristics influence the cost of vegetation management in transport corridors in a range of ways. They include:

- The soil type and previous land use which, will influence the nature and level of site preparation required.
- The level of weed control required.
- The need for watering or the application of mulch for water conservation.
- Site location and isolation, which will influence the level of protection required from browsers, eg. cattle, hares or wallabies.
- Factors such as site access, slope, area of land to be planted, which will influence the nature and extent of the management input required.

Two main methods for establishing vegetation cover are the use of direct seeding and by the planting of containerised seedlings. The most appropriate method to use will largely be determined by the purpose for the vegetation, the nature of the site, and by the money available. Although the primary focus of this paper is on using containerised seedlings, some features of direct seeding are also discussed.

REVEGETATION BY DIRECT SEEDING

Direct seeding has a role in the establishment of vegetation cover where costs are to be minimised and random tree placement is preferred (Snell and Brooks, 1998). In a study on four sites in north Queensland, Snell and Brooks (1998) reported costs around $1700/ha for the establishment of vegetation by direct seeding and quoted costs of around $4,000/ha for the establishment of containerised stock by hand planting. However, it is possible to reduce this cost for containerised seedlings quite considerably (see below).

For purposes of rehabilitation, site protection and the encouragement of regeneration, direct seeding has a definite role. Direct seeding generally leads to high plant densities (Fig. 1) which provide site protection from factors such as erosion and also provide the environment that encourages natural regeneration. Snell and Brooks (1998) found in a north Queensland study that within two years after the direct seeding of three pioneer rainforest species, the natural regeneration of an additional 20 rainforest species had occurred. However, the growth of seedlings established by direct seeding is generally slower than that of planted seedlings (Fig. 2). Hence, in situations where more rapid growth is required, planted seedlings will be more advantageous.

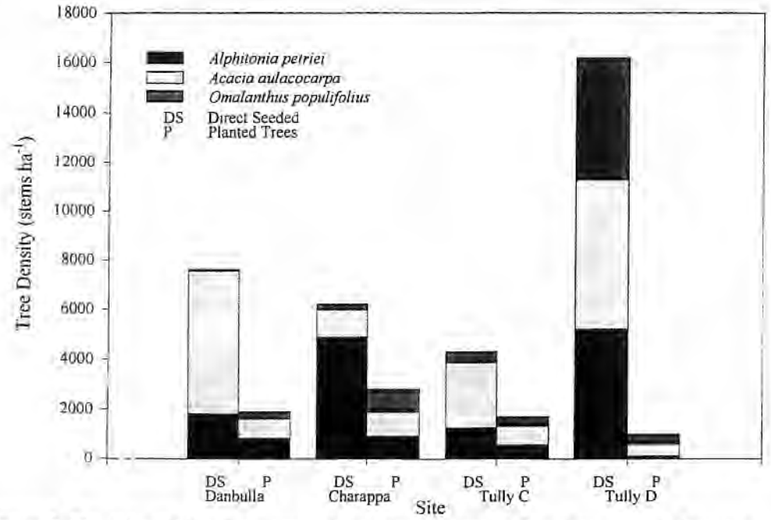


Figure 1. Plant density for direct seeded and planted trees at four sites in north Queensland, two years after establishment. (from Snell, A. J. and Brooks, S. J. 1998).

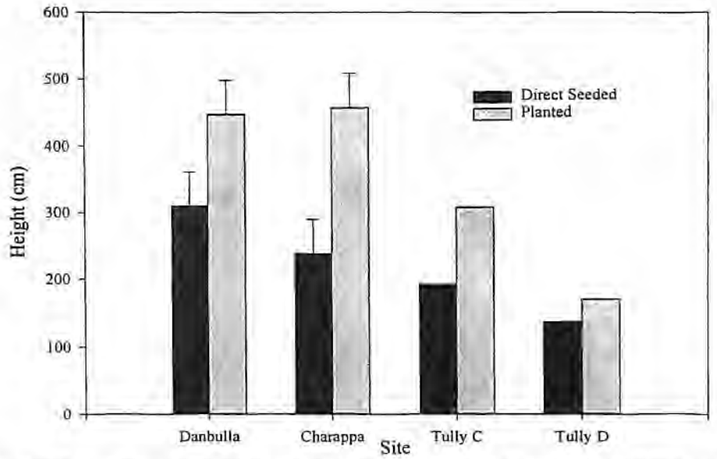


Figure 2. Mean height at two years of trees established by direct seeding or planting at four sites in north Queensland from Snell, A. J. and Brooks, S. J. 1998).

REVEGETATION BY PLANTING CONTAINERISED SEEDLINGS

The use of containerised plants for the establishment of vegetation is the preferred method where:

- The control over individual species or mix of species is required.
- The planting configuration, stocking and placement of the seedlings is to be controlled.
- High levels of management are required to ensure good survival and growth.
- The site conditions do not allow for direct seeding.
- Economic returns are to be sought from the plantings some time in the future.

The two components that impact on the cost and growth performance of planted seedlings are the nursery regimes and the establishment techniques applied.

NURSERY REGIMES

The application of the most appropriate nursery regime is important in terms of the cost of the seedlings and also the performance of the seedlings after planting out in the field. The cost of seedlings will be influenced by the container type being used, the potting mix, the nursery management regimes and the total production capacity and through put of the nursery (Lewty et al, 1998). Large containers (> 150 cc) are more expensive than smaller ones (< 100cc), and potting mixes with peat or vermiculite as the major component are more expensive than those where pine bark is the primary component. Where small containers are used, eg. 70 – 90 cc, a relatively simple management system operates and the nursery output of plants is high, the costs of plants should be in the vicinity of 25 cents per seedling. With larger containers (200 cc), more complicated management requirements and lower production capacity and rates, costs could vary between $1.00 and $1.50 per seedling.

Costs should not be the only factor considered in the production of containerised plants. Field performance in terms of survival and growth should also be taken into account (Lewty et al, 1998). Trials undertaken by QFRI have shown that in general, better field survival occurs with seedlings grown in larger size containers (Table 1). Although very dependent on conditions, the most recent series of trials has also shown that better growth also occurs with seedlings grown in the large containers and were grown in the nursery under low watering and high fertiliser regimes (Fig. 3).

Table 1. Effect of container type on survival at two years of eucalypt seedlings planted at two sites. Vic pots are 200 cc and Net pots 70 cc.

Site	*Container*	Survival (%)
Benarkin	Vic pot	87
	Net pot	68
Gatton	Vic pot	93
	Net pot	86

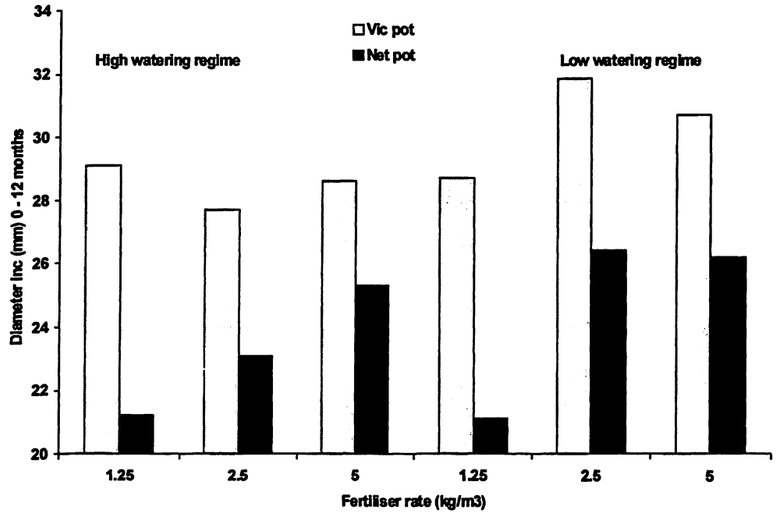


Figure 3. Effect of the container type and nursery watering and fertiliser regimes on the field performance of *Eucalypts cloeziana* plants at Benarkin.

The recommendations for the production of nursery seedlings for potentially harsh field conditions are listed below (Lewty et al 1998). Depending on the capacity of the nursery, the cost of producing seedlings under these criteria would be in the vicinity of 50 cents to $1.00 per plant.

- Use potting mix which is light, readily available and economic, eg. pine bark mixes.
- If planting is to occur under harsh conditions, eg. low soil moisture or high temperatures, large pots (> 150 cc) are preferable. However, small pots are acceptable if seedlings are planted before they become too large and soil moisture is good and allows for deep planting to occur. Note that prior to planting with any size container, the potting mix must be fully saturated.
- The use of chemical root pruning should be considered if the species is known to be susceptible to root coiling, eg. *Eucalyptus cloeziana* (Gympie messmate), the pots do not have internal root trainers, or there is the possibility that the plants will need to be carried over in the nursery.
- Conditioning through the implementation of reduced frequency of watering is strongly recommended.
- Medium levels of slow release fertilisers are recommended. Although, when watering has been reduced, higher levels of fertiliser are acceptable. Problems are likely to occur where a combination of high fertiliser and regular or continuous watering occurs. This will lead to excessive growth in the nursery, which in turn results in soft and unconditioned planting stock for the field.

FIELD ESTABLISHMENT

Given that the costs of plants could vary between 25 cents to $1.50 per seedling, the plant cost alone could vary between $250 and $1,500/ha based on a stocking of 1,000 stems per hectare. Hence, to ensure benefits from this cost, it is essential that there is good survival and acceptable growth in the field. To achieve this will require various levels of inputs into the preparation of the planting sites and the management of the seedlings after planting, especially in the first 12 months. Depending on the site and the purpose of a planting, costs over 12 months at 1,000 stems per hectare, could vary from around $ 350/ha where the only operation is planting, to around $4,000/ha where heavy equipment is used for site preparation and prolific weed regrowth requires repeated applications of herbicides.

QFRI has recently established a series of trials across a range of site types to address the question of what levels of site preparation; weed control and fertilisation are required to optimise growth at minimum cost to the grower. Although these trials are only around 12 months of age, the early results illustrate some of the principles that need to be taken into consideration when evaluating the use of containerised plants in the establishment of vegetation.

The cost of establishing container seedlings using minimum inputs of site preparation, weed control and fertilisation will be in the vicinity of $910/ha (Table 2). With maximum input in these areas, establishment costs over the first 12 months will increase to around $2,000/ha. It appears that the growth response to additional inputs will only be minimal on ex-forest sites, and even at this early stage of growth, not economical. This would be due to the uncompacted nature of the soil and the relatively low levels of weed competition. However, there has been a greater difference in the response between zero input and the maximum inputs on the ex-pasture site (Table 2). This is not surprising considering that the soil had been compacted through cattle grazing and that pasture is highly competitive against eucalypts.

CONCLUSION

The purpose of the vegetation and the site characteristics will determine the most economical approach with regards to the method of revegetation. Where limited species diversity and selection are required, site conditions are amenable and random tree placement is no problem, direct seeding maybe the most economical tool. Costs for this method are estimated to be between $1500 to $ 2,000/ha. However, where more control is required on the species being planted and the planting configuration, and where a higher intensity of management input is required, container seedlings are the best option. Costs will depend on the type of container, the nursery practices used, and the levels of site preparation, weed control and fertilisation. A possible scenario for revegetation in a transport corridor could be to establish vegetation for site enhancement, with no perceived economic benefits. A recommended method in this instance would be to plant robust stock in large containers to ensure good survival together with minimum site preparation, a single post-plant application of herbicide and the application of a starter dose of fertiliser. At a stocking of 1,000 stems per hectare, this would equate to a cost of around $1,600 per hectare.

REFERENCES

Lewty, M.J., Huth, J.R. and Hunt, M. 1998, *The Effect of Nursery Practice on Hardwood Seedling Field Performance*. Paper presented to Managing and Growing Trees Training Conference, 19-21 October, Kooralbyn, 1996.

Snell, A.J. and Brokks, S.J. 1998, *Direct Seeding as a Method of Revegetating Degraded Land in the Wet Tropics*. Paper presented to Managing and Growing Trees Training Conference, 19-21 October, Kooralbyn, 1998.

Table 2. Effect of different levels of establishment input on the growth of eucalypt plants on two contrasting site types; ex pine plantation and ex improved pasture. The relative costs of these inputs are given.

	Minimum input		Maximum input		Mean height (m) at age 12 months			
					Ex forest site		Ex pasture site	
Operation	**Technique**	**Cost ($/ha)**	**Technique**	**Cost ($/ha)**	**Min. Input**	**Max input**	**Min input**	**Max input**
Site preparation	Nil	0	Deep rip + disc cultivate	200		3.5	2.5	3.0
	Disc cultivate	140			3.5			
Weed control	Nil	0	Preplant + 3 post plant applications	950		3.4	2.1	3.4
	Preplant + one post plant application	470			3.6			
Fertilisation	Nil	0	Starter dose plus 2 split nitrogen applications	850		3.4	2.2	3.3
	Stater dose of NPK	300			3.6			
Total		910		2,000				

HYDROSEEDING AS A TOOL FOR VEGETATION ESTABLISHMENT

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ABSTRACT

Hydroseeding as a method for establishing species such as turf grass is widely practiced in Australia. The use of hydroseeding as a strategy for revegetation sowing purely native species is relatively recent in south eastern Australia with projects occurring around the late 1960s.

The effective application of hydroseeding is dependent on a number of issues. Consideration of seed supply, site preparation, and soil climatic conditions are of primary importance.

At first mention, hydroseeding sounds an easy acquired "solution" for revegetation. Given the practical and material limitations on its use, it may be better to view hydroseeding as one among a variety of revegetation strategies.

This article considers the planning and implementing of hydroseeding in the context of roadside or similar environments and is prefaced by an overview of the performance of Australian local or "indigenous" species in direct seeding.

Lack of detailed data concerning the performance of these species using hydroseeding has limited potential commentary or conclusions. One trial result is noted.

Key words: *Hydroseeding, Australian native seed, direct seeding, germination.*

CONTEXT

In this paper, the revegetation method of hydroseeding is discussed for the purpose of creating stands of vegetation using local Australian native species. This discussion assumes the use of plant materials of local provenance. The subject of "how local is local" is not discussed but is subject to interpretation depending on how practitioners may view the importance of the matter. The author is comfortable in stating that if a "local" character or landscape type is an objective of a roadside revegetation program, then local species logically would suite this purpose. Ultimately, the performance of local provenance species would be subject to a gamut of variables such as altered site soil or climatic conditions, and the influence of weed competition.

INTRODUCTION

Hydroseeding is essentially a form of direct seeding using hydraulic means for the distribution of seed. Additives such as fibres, tackifiers, soil conditioners or growth promotents are used meaning it can have multiple benefits. Hydroseeding as a method for establishing species such as turf grass is widely practised in Australia. The use of hydroseeding specifically as a strategy for revegetation is relatively recent in south eastern Australia with projects sowing purely native species occurring around the late 1960s.

Many successful revegetation projects using hydroseeding can be seen. However, there have also been notable failures.

Hydroseeding possibly has connotations of being high-tech - a means of "spraycanning" a successful landscape. The technique has potential to broaden the scope of revegetation activities carried out on roadside and highway landscapes especially in otherwise difficult terrain or where the benefit of randomised plant placement is desired. Whilst the method has apparent advantages, in a practical sense, its full potential is dependent on our establishing a better working knowledge of the cultivation of native plants. I have therefore included a general discussion on our current stocks of information concerning the cultivation of Australian native species by direct seeding.

Mostly, our knowledge of local species, their performance under cultivation, specific germination requirements and appropriate long-term management is rudimentary. Compounding issues are the uncertainty of commercial seed supply and there being little in the way of domestication of native species (which is more common-place in the U.S.A. where the practice of hydroseeding for its local flora is of industry proportions).

Practitioners seeking to establish purely native species would no doubt be encouraged by the potential of many of our local native plants as rapid colonisers and for aesthetic and conservation reasons. Hydroseeding may only be practised with confidence once some fundamental understanding of plant performance is attained. Issues such as the availability of species, obtaining optimum germination through timing and calculating establishment rates are amongst those in need of consideration.

The relative cost, the availability of machinery and the ability of hydroseeding to be used in a broad range of situations (particularly steep terrain) means that it is an important component in the total suite of revegetation methods. Whether it becomes the more popular means of revegetation is dependent on many factors expanded on through this paper. Lack of data about the performance of hydroseeding has led the author to rely on personal observation and extrapolate the results from trials of other direct seeding methods.

LOCAL NATIVE PLANTS BY DIRECT SEEDING

There are reasons to be confident in the performance and/or potential of local native seed to establish through direct seeding. In Victoria as early as the 1870s, plantations of the South Australian sugar gum (*Eucalyptus cladocalyx*) were established with great success using hand direct seeding immediately after ploughing. Tree and shrub species are routinely sown using tractor mounted and vehicle drawn equipment frequently in response to land repair programs. Berkeley & Cross (1986) established nine herbaceous species in field trials. Landcamp (Ed. 1987) reported on the extensive application of direct seeding use in mine-site rehabilitation. In 1990, 38 species suitable for cultivation in Victoria's south west were evaluated for field germination recording a variable but acceptable economic outcome (Bird, P.R., Cumming K.N. 1990). Dalton (1993) and Bonney (1996) have added to the depth of knowledge in direct seeding practice particularly with shrub species. Murphy and Dalton (1996) experimented with a broad range of under-storey species through a range of controlled trials in sites in South Australia. Their work examined the role of certain pre-treatments and the potential role of soil microorganisms in either germination or establishment. Their reports on species not emerging from field trials are important for those who may be "ambitious" about the potential of direct seeding.

Through trials and observations, a picture of consistently successfully candidate species for direct seeding is beginning to develop. A most useful measure of success is the emergence of seedlings within the field expressed as a percentage of total germinable seeds.

To date, species for direct seeding mixes are dominated by species of the plant families' Allocasuarinaceae, Asteraceae, Chenopodiaceae, Mimosaceae, Myrtaceae, and Poaceae.

There is a strong correlation between the size of seed and percentage of field germination. The wide use of acacia species or those of a similar seed type exemplify this. Being a physically robust seed, with larger food reserves and generally emerging more freely at greater depths from within the soil profile may account for its performance. Smaller seeded species such as eucalyptus and melaleuca are typically at the other end of the scale in terms of field germination where performance is comparatively lower due to less food reserves. These species may be more susceptible to both weed competition and have less tolerance of moisture stress.

As a broad guide, the table below lists approximated field germination ranges that occur for the following genera as drawn from data in S.A. Victoria and N.S.W.

Genera	Range of germination (Expressed as seedlings emerging as percentage of total germinable seeds)
Acacia	5 to 60 % with 20% considered average
Allocasuarina	5 to 15%
Danthonia	5 to 10%
Dodonea	8 to 15%
Eucalyptus	0.5 to 3%
Melaleuca	0.1 to 3%
Themeda	5 to 15%

Some Consistent Factors in Successful Direct Seeding

In south east Australia, direct seeding appears to be most successful in situations where the following procedures have been followed or circumstances prevail:

- Viable seed has been used in sufficient quantities (rate of 150 to 500 gm / linear km)
- Seed is applied to freshly cultivated soils which is rough rather than finely tilled
- There has been reasonable follow-up rains directly after sowing (however seedlings can and do emerge many years after sowing)
- Weed growth is limited or deliberately controlled
- Insect pests such as red legged earth-mite (RLEM) and hoppers are absent or controlled

Note. The significance of soil surface condition for direct seeding relative to hydroseeding is expanded upon further in this paper.

Timing of Sowing

The optimum timing of seeding may vary according to climatic and resource considerations. There are broadly two categories of practice:

1. On-seasonal - sowing with expectation that seasonal conditions will support germination virtually immediately after sowing, and
2. Off-seasonal - sowing with no specific reference to season. Germination occurs once seasonal factors are conducive

Both approaches have been used in Australia. The main issues determining practice appear to be based on a number of factors.

On-seasonal seeding is used:

- Where there are reliable rains and temperature ranges suit a broad range of species, often termed the "window" of sowing opportunity
- When there is a need to raise seedlings quickly before the onset of aggressively competitive weeds

Advantages:

- There is often rapid germination of seed and establishment of plants
- Seed is less likely to by robbed by ants or deteriorate through aging
- Gives users confidence of a quick result for effort

Disadvantages:

- "False start" seasons may mean seeds germinate only to die before establishing
- Species may not germinate if they require environmental "conditioning" such as vernalisation or long lead-time imbibition

Off-seasonal seeding is used:

- In arid systems where seeds may remain in the soil until the onset of rains
- Where there is little or no other aggressive weed or native plants present or likely to compete at the time of germination
- Where there are lower numbers of seed harvesting insects present
- Where seeds are naturally or otherwise incorporated in materials such as branches or straw thatch and release to the soil over a period of time
- When it is operationally convenient or necessary to sow seeds due to availability of equipment, human resources or for access to sites
- Where thatch-containing seed such as kangaroo grass needs to be sown within sufficient time-span for seeds to mechanically engage with the soil

Advantages:

- May be done at the any time (frequently in dry months allowing machinery access)
- Seasonal conditioning of seed may assist some species
- Seeds may use this time to mechanically engage with the soil such as grasses via awns or lemma

Disadvantages:

- Seed may deteriorate over prolonged periods of drought
- Seed can be robbed by ants
- Sites may be susceptible to erosion thus seed is transported away or buried within the soil profile

Summary of Direct Seeding of Native Species

These factors consistently appear for the success of native plants in direct seeding:

- Depth of sowing is critical with near or at surface sowing generally being the most successful
- Light influences some species which is again implicated in sowing depth and the quantity of surface trash present
- Temperature required for optimum germination varies considerably with many species exhibiting preference for specific ranges
- Soils which have been cultivated or which are "receptive' (ie. provide moisture and seed-to-soil contact) produce better results in comparison to non-cultivated or "glazed" soils
- Many native species exhibit dormancy mechanisms
- Germination can occur over prolonged periods of time
- Seed viability changes over time whilst in storage or once sown
- Timing of sowing may be critical
- Insects or pathogens can effect the success of direct seeding
- Uncontrolled weed growth will most likely out-compete native seedlings for light, moisture, nutrient and physical space
- Soil microorganisms can be important in the establishment of plants particularly on highly degraded or impoverished sites

It is worth briefly expanding on the significance of soil surface conditions and preparation for direct seeding. Dalton (1993) Watson (1994), Coffey and Horlock (1999 Unpublished) and Cole and Hundy (1999) conclude or observe that soil-seed contact and microclimates created by a roughened soil surface contributes to successful germination. Hydroseeding contractors similarly concur that freshly "groomed" or profiled materials (provided they are not "fluffy") are preferred for hydroseeding (Leggatt 1992 Pers Com.). Sowing should proceed as quickly as practicable following cultivation.

It is amply apparent that seed applied to a harsh, unyielding site is less likely to germinate in comparison to seed settling on cultivated soils.

Note. It must be qualified that most of the data on direct seeding in Australia principally comes from the surface application of seed in a dry state, occasionally with bulking agents such as sand. In other words, the seed is more or less free to move around within the environment. The use of hydroseeding combining materials such as binders and fibres with the seed may need to be viewed differently. Theoretically, if seed was strongly "bound" within a surface crust of glued fibre, this confinement may limit germination.

WHY DIRECT SEEDING IS "TRICKY BUSINESS" - A "REALITY CHECK"

At a landscape management level, constraints arise (perhaps more proactively termed "challenges") concerning the use of native seed for direct seeding at the larger scale.

These are summarised:

- Very few native species are domesticated
- In many instances there is a lack of local vegetation for the harvesting of seed or the total number of species is limited
- Seed development is frequently seasonal
- Seed collecting services specifically for local provenance plants is an industry largely in its infancy and predominantly focused on the mining industry (Mortlock 1999)
- Standards of practice, quality assurance and seed testing are not comprehensively codified (in comparison to other economic species) and based largely on contractor trust and reputation
- Lead-times to collect sufficient quantities of seed are rarely less than two years and may be as long as five
- Road construction and project completion timelines (including project launches) rarely synchronise with biologically based sowing or planting activities

HYDROSEEDING - OPERATIONS AND APPLICATIONS

Hydroseeding is a distribution of seed in an aqueous suspension often in combination with other materials, particularly cellulose fibres, binders or tackifiers and polymers. The first uses of the method in a crude sense are known in the USA around the late 1930s where soil, water and seed were mixed into slurry and pumped.

Hydroseeding has been a popular method for turf-grass establishment on road embankments and practically all types of playing surfaces such as golf and bowling greens. It has favour in areas where the combination of short to medium term surface soil binding is advantageous before the eventual establishment of a stabilising vegetation cover. The surface binding effect of fibre and glue is generally insufficient to cope with high velocities of water or wind erosion although some recently developed formulations have potential in this regard.

Hydroseeding has been used in combination with straw-blowing or thatching as much for its convenience as means of distributing seed. The straw mulch material that is applied over the seed can be bound in place by a spray of bituminous emulsion.

If seed is evenly suspended through the mix, hydroseeding potentially allows for the even spreading of seed over a given area. Fine seeds, which otherwise may become airborne, are generally easy to distribute in a jet of water. The fact that a suspension can be pumped at pressure means that coverage over steep areas is able to be done with less operator risk in areas such as quarry faces or road embankments.

The use of hydroseeding strictly to establish a variety of native species is possibly under-recognised as a strategy for revegetation of roadsides and other applications such as minesite rehabilitation. Some examples of the successful use of the method can be found where a diverse range of ground, middle and over-storey species have been sown and created functional and stable landscapes. The Hydro Electric Corporation of Tasmania has used hydroseeding extensively on embankments.

Equipment

Modern types of pumping apparatus consist of purpose built truck or trailer mounted units (often de-mountable) complete with holding tank, paddle agitator, positive displacement pump such as an Archimedes screw or 'Mono Pump" and a delivery hose line to a ridged truck-mounted nozzle. Hose lines may be run-out from the machine for some distance.



Hydroseeding Using an Extension Hose

General Operating Procedure for Hydroseeding

In practically all cases, seed is sown to ground prepared through cultivation that is free of weed plants. The preparation of a roughened soil surface finish (preferably immediately before sowing) is regarded as desirable. Back-clawing with toothed excavator buckets or "stepping" the area with dozer tracks to form crevices across the slope to minimise surface water and soil movement can easily achieve this finish. Unless there is poor subsurface drainage, it is generally inadvisable to cultivate to great depths as this may cause substantial air voids in the soil. This may reduce the movement of moisture to the soil surface through capillary action. Creating "character" in the soil forms niches or micro-topographic relief's which form the microclimates supporting germination.



Hydroseeder working at Tripovich Reserve Brunswick Victoria

Steeper slopes that have ledges or clefts are particularly suitable for hydroseeding where seeds may have "purchase" where moisture is retained. Direct contact of the seed to the soil is essential for germination. Sowing onto a well-degraded layer of humus may also be effective.

There are advantages in sowing larger seeded species in the first pass of hydrosowing, and then covering this with further layers of fine seeds mixed with fibres tackified with guar gum (a food product thickener). A popular fibre is paper pulp (such as ground-up phone books used as insulation) which forms an homogenous slurry within the tank mix. Fibre may be sprayed or "built up" to a layer of 2·4 mm thickness. In general, a depth of no greater than 6 mm is recommended for native species to assure emergence of seedlings. (Again, there has been no specific literature located discussing this issue.)

Materials such as glues, polymer gels for moisture retention and marker dyes can also be added. There is also some potential to add other activating agents such as smoke infused water or microbes such as rhizobium, but extensive controlled experiments using hydroseeding as a delivery have not been found.

It is essential that machinery is washed free of potential contaminants prior to sowing native seeds. Contract supervisors must request that operating companies demonstrate a quality procedure in this regard.

Other Aspects of Soil Preparation – Scalping and Surface Soil Coating

Scalping of surface soils has some merit in preparation for hydroseeding as does the coating of areas using clean sub surface soils provided this material has reasonable structure and is not completely alien to plants.

Typically, roadsides and medians are areas where soils are comprehensively blended and profiled into mosaics of weed communities. Therefore the prospect of scalping to remove weed seed is probably too little effect unless on unworked ground. In these circumstances it may be cost effective to mine a "fillet" of sub soils (normally greater than 100mm depth from surface) and retain this material for topping the completed surfaces. This material may be keyed into a surface by ripping (provided no weed-contaminated material rises to the top) and then graded and groomed to an appropriate finish. Provided the material is of reasonable structure and fertility, it should be adequate as a seedbed for direct sowing.

Summary of Success Factors for Hydroseeding

As a general operating principle, sites perform best where the following circumstances prevail:

- There is little in the way of invasive or aggressive weed species
- There is recent soil disturbance or grooming of the site
- The soils are generally stable in structure and not prone to cracking or "caking"
- Where provision is made for the control of ants, vermin or stock
- Where there is consistent rain over a period of time favouring germination
- Where there has not been any deluge of rain that has washed or buried seed or affected the site before the setting of binding glues

Costs of Hydroseeding

Comparative to standard surface sowing, hydroseeding is more expensive (approx. 15c to 60c per m^2 on large-scale work) depending on location or site access. Hydroseeding is highly suitable for tasks such as embankment stabilising (which would otherwise be dangerous or un-traversable by foot) so cost would be well justified.

Seed Sowing Rates and Costs

Rates of sowing ranges considerably due to differences in species compositions, individual seed-counts and desired establishment rates. Generally, sowing rates are between 3 kg to as great as 15 kg per hectare. This may put seed costs alone at between $360/Ha for a narrow range of easily collected species, to over $10,000/Ha if an ambitiously diverse range of species was to be acquired.

TRIAL RESULTS AND DISCUSSION

Field Germination from Hydroseeding - Frank Tripovich Reserve - Brunswick Victoria

The following report was extracted from the Greening Australia - Urban direct seeding reference sites register 1992.

Site: Jack Tripovich Reserve (Brunswick Rd overpass)
Date Sown: April 13th, 1999
Groups involved: ATCV, City of Brunswick, DNRE (Tree Victoria) and Green Task force
Technical Support: Greening Australia Victoria
Funding support: One Billion Trees, Tree Victoria, Alcoa of Australia

Objectives

This trial was established to:

- Evaluate the use of Hydroseeding for local native species
- Provide an educational and training resource
- Establish local vegetation for amenity and conservation values

Site Description

The area is part of a road embankment oriented south to south west at a grade of 15% to 20%. The soil is principally clay fill material with some heavy western plains basaltic topsoil in places. Generally the area is exposed with roadway and car park surrounds.

The area for sowing is approx. 3290 m^2 in total. An area was retained within the area due to the presence of local grasses (principally *Danthonia* spp.) which were colonising the site since the construction of the overpass around 1971. A weed species compositional report was also prepared.

Summary of Actions

1/10/1991	Scalping to a depth of 8 cm with a Drott 4 in 1 excavator
4/10/1991	Boundaries and patches in area sprayed with Glyphosate 1:100 and Gesatop
14/10/1991	Ripping at 1.5 m spacings to 300 mm depth
19/2/92	Area sprayed with Glyphosate 1:100 and Garlon
2/5/1992	Area sprayed with Glyphosate 1:100 and Garlon
13/5/1992	Hydrosowing with seed mix (attached) and paper pulp and tackifier
From April 1992 to June 1994	Various spot spraying, hand weeding and slashing
21/12/1993	Quadrats recording germination

Species List and Germination Results

Species	Grams Seed Sown	Viable Seeds Per Gram	No. of Seeds	No. Germinated in Field	% Establishment
Acacia implexa	337	47	15839	2140	13.5
Acacia mearnsii	150	73	10950	475	4.3
Acacia melanoxylon	180	87	15660	713	4.6
Acacia paradoxa	60	*	*	475	*
Acacia pycnantha	225	60	13500	1426	10.6
Aceana sp.	*	*		3328	*
Allocasuarina verticillata	90	280	25200	951	3.8
Bursaria spinosa var. *macrophylla*	375	191	71625	45881	64.1
Chloris truncata	*			3566	*
Danthonia spp.	*			1189	*
Dodonea viscosa var. cuneata	12	16	192	20	10.4
Eucalyptus camaldulensis	682				
Eucalyptus melliodora	181				
Total	**2292**			**152966**	
Equivalent to +/-46 plants / m2 Sowing rate = 6.96 kg / H					

**Denotes insufficient data or no record*

Summary Comments

This trial records field establishment percentage rates (as a total of germinable seeds) to be generally less than direct seeding by other means such as one-pass scalping, but still at favourable levels. This is possibly due to a number of factors related to hysdroseeding as a method, or the physical state of the site such as:

- Seed falling on, or adhering to un-receptive ground such as clods or rocks
- Some glazing or surface consolidation of the soil
- Loss of seed due to ants
- Attrition of seedlings due to competition

The favourable germination of *Bursaria spinosa* is worthy of comment. This species is generally considered to be variable under a nursery propagation regime. The excellent germination of *B. spinosa* may be attributable to the onset of winter conditions and the effect of vernalisation. This is comparable to the practice of nurseries that routinely have success by sowing seed through late autumn with no artificial heat.

Sowing rates equivalent to 6.96 kg /Ha is economically acceptable.

Refinement of Methods

There are several areas where further investigations are worthy and recommended to determine the potential application of hydroseeding.

Emergence of Seedlings from "Bound" Fibres

Many native species have some specific mechanical methods of engaging in the soil and others are generally "free" to find a place in readiness for germination. The binding or constricting nature of glue and fibre (as used in some forms of hydroseeding) requires evaluation to determine its impact on germination.

Nursery Crops

The sowing of an accompanying nursery crop (such as sterile rye-corn, *Secale cereal*) has been advocated by some operators. The objective is generally to provide a surface cover to stabilise an area (often more rapidly than may be provided by the native plants). This practice requires careful consideration given the likely effect from competition on native species. Trials evaluating the value or optimum minimum rates of nursery crop sowing are required.

Potential for Pre-Germination or "Priming" Of Seeds

Recent work in Victoria on hand or "niche" sowing indicates that manipulation of seeds prior to sowing though a pre-germination treatment régime leads to rapid germination and establishment in the field. Allowing for the specific seasonal nature of such work, there is a need to examine this method as a means of increasing the success of hydroseeding.

A broader investigation into the benefits of using active agents such as smoke infused water, again would be valuable.

CONCLUDING REMARKS

Hydroseeding - Heaven on A Stick, Or A Stick You Could Be Hit With?

Highly successful results have been achieved and some spectacular failures. Fair to excellent result have been achieved on a number of roadsides with seemingly little expense spare the effort of collecting seed well in advance of sowing and general adherence to the site preparation procedures outlined in this paper.

In relation to failures, there have been various reasons including:

- Torrential rain falling within moments of sowing scouring the entire soil surface
- Under-informed road workers destroying emerging seedlings with an excavator
- a project supervisor who abandoned a hydroseeding site because there were no trees visible after three months
- Persistent drought
- Grass (weed) seeds being introduced to a site due to contaminated equipment
- Competition to desirable species (potentially) from the intentional sowing of "nursery" crops such as rye-corn
- Weed growth, rabbits and cattle

Generally, the routine use of hydroseeding as a method for native vegetation establishment (as with other direct sowing methods using Australian species) appears constrained principally by a general lack of knowledge about species performance and issues associated with the supply and availability of appropriate seed. Hydroseeding will, however, be an important part of the "toolbox" in combination with a broad range of revegetation strategies.

Road and transport corridor managers (indeed all who work in land restoration) need to acquire a basic understanding of the principles and practice of direct seeding (including hysdroseeding). This will serve to achieve several important outcomes:

- Achieving diverse plant communities, economically
- The setting of reasonable project specifications and adequate supervision of contractors
- Due consideration of time-lines for programming and completing works

Accordingly, employment of, or access to staff skilled in evaluating and applying a broad range of revegetation techniques, should be considered an investment rather than a cost.

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MANAGING FIRE IN TRANSPORT CORRIDORS

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ABSTRACT

There is little one can do to protect roads against wild fire as those experienced in Victoria on Ash Wednesday 1983.

However there are techniques that reduce the intensity and risk of fires spreading along roadsides from less severe fires without slashing the native vegetation to ground level.

Roadside fire management practices have developed from the historical simple indiscriminate slashing of all roadside vegetation to the provision of more sophisticated fire management plans. These plans view the fire risk more holistically and look for alternatives to providing the fuel reduction on the roadside, or combining vegetation clearances for fire with vegetation clearances for other purposes such as roadside assets, eg. power lines.

This paper examines the current techniques used to prepare Roadside Fire Management Plans and some of the innovative, but simple solutions, to achieve a balance between the need to reduce fuel loads and protect the native vegetation.

Remember the same fire that destroys, also brings new life to native vegetation.

FIRE

Many Australians, particularly those living in the southern and eastern states of the country, have learnt to live with the threat of wild fires. Living in environments that are lush green in the winter months but brown and tinder dry in the summer months, these people have witnessed the destructive nature of a wild fire as it destroys vegetation, fauna, livestock houses and even lives. Yet at the same time they have also witnessed in the aftermath of these fires, the renewed life of forests and grasslands. Seeds that require fire for germination begin to sprout and grow and replace the lost vegetation.

As a consequence, the threat of fire is accepted as a way of life and imposes the need to make special preparations for the summer fire season. To see preparation of fire breaks through fuel reduction around houses and properties, including roadsides, is common in the higher fire risk areas. It is the role that roadsides play in this pre fire preparation that is looked at in more detail in this paper.

ROLE OF ROADSIDES

Roadside Management Plans

Local Government in Victoria is a leader in the preparation of comprehensive roadside management plans in order to protect and enhance native vegetation on roadsides. These plans address many issues that can impact on the roadside vegetation including road construction practices, utility installation practices, siltation, erosion, droving tree clearance around power lines, and many more, anything up to some 30 issues in all. Equally important is that of fire management works.

Eighty percent of the municipalities in Victoria have now either prepared or are in the process of preparing these roadside management plans. Each of these plans includes a section addressing the issue of the management of fire on roadsides.

Assessment of Roadside Vegetation

Essential to the preparation of roadside management plans is having knowledge of the value of the native vegetation on all of the roads under the control of councils.

Victorian local government is responsible for over 80% of the road network throughout the state. Many councils have carried out assessments of the native vegetation on the roadsides. This has enabled them classify it into three categories: high conservation value; medium conservation value; and low conservation value.

Methods for carrying out these vegetation assessments will be addressed by other speakers at this conference. However the Victorian Roadsides Conservation Committee has developed guidelines and procedures to assist with the valuation of roadside vegetation which uses a scoring system for the categorisation of vegetation into the three conservation values.

The conservation value influences the degree of care that must be taken or types of works that can be carried out on that particular road. That is, roads of high conservation value require more care when carrying out any types of work or activities than a road with low conservation value. Low conservation roadsides have vegetation that has been highly modified, in most cases comprising introduced species of plants or grasses.

FIRE MANAGEMENT ON ROADSIDES

For many years roadsides have been used extensively for the implementation of fire prevention works. Historically this has been slashing of roadsides to reduce the amount of fuel. Most of this has been indiscriminate and without any consideration of the impact on the native vegetation.

The carrying out of fire management works on roadsides is generally undertaken to achieve a number of adjectives:

- to prevent fires on roadsides;
- to contain roadside fires;
- to manage road safety of road uses during a fire; and
- to provide control lines for fire fighting purposes.

Fire management works are undertaken in response to Municipal Fire Prevention Plans which identify roads that are considered to be strategic from a fire fighter's perspective, and generally prescribes the type of works that should be undertaken on those roadsides. Until very recently these plans were prepared in isolation to and without knowledge of the value of the vegetation on those roadsides, and in many cases the works prescribed and carried out were destructive to high conservation value vegetation.

MUNICIPAL FIRE PREVENTION PLANS

In Victoria the CFA Act (*Country Fire Authority Act*) 1958, specifically refers to the management of roadsides for fire prevention stating that:

It shall be the duty of every municipal council and public authority to take all practicable steps to prevent the occurrences of fires on and to minimise the danger of the spread of fires on or from:

- any land vested in it or under its control or management; and
- any highway, road, street, lane or thoroughfare the maintenance of which is charged upon it.

The CFA Act also states that:

- A municipal council must prepare and maintain a Municipal Fire Prevention plan in accordance with the advice and recommendation of the Municipal Fire Prevention Committee;
- the Plan must identify areas which are at particular risk;
- specify how these are to be treated; and
- specify who is responsible for treating those risks.

As a consequence, fire management in the country area of Victoria is carried out under the direction of the Municipal Fire Prevention Committee. The Committee comprises representatives from local fire brigades, the local council, CFA and others, who develop the Municipal Fire Prevention Plan in response to the CFA Act.

The works are generally undertaken by the road managers, being the local council and Vic Roads, with some being undertaken by the local fire brigades themselves.

In Victoria, the Country Fire Authority has full-time officers who train and oversee a network of local fire brigades who are generally staffed by volunteers. In recognition of the high risk of fires, generally every town in Victoria has its own local fire brigade that is equipped, trained and managed by the Country Fire Authority.

THE TRANSFORMATION OF FIRE PREVENTION PLANNING AND WORKS

In recent years there has been a shift in the way that fire prevention planning and works have been undertaken. Historically, fire prevention works on roadsides have been done in isolation of other needs on roadsides, have not been cost effective, or in balance with the importance of the roadside native vegetation.

The transition from the isolationist approach, which often imposed high dollar costs on councils to carry out the work with adverse environmental consequences, to a broader more holistic approach, is best demonstrated by the following case study of the former Shire of Gisborne (now Macedon Ranges Shire Council). This case study concentrates on the Macedon and Mt Macedon areas, located fifty kilometres north west of metropolitan Melbourne.

CASE STUDY – MACEDON/MT MACEDON

First Comprehensive Local Government Roadside Management Plan

The Gisborne Shire (now Macedon Ranges Shire), located 50 kilometres north west of metropolitan Melbourne, had over a number of years, in response to local community demands, adopted environmentally sensitive practices to minimise vegetation destruction. This reflected in many areas of the Shires operations, but in particular in the way it had initiated many sensitive work practices in road construction and maintenance, and the co-ordination of other roadside works, to minimise negative impact on the roadside native vegetation. However none of the roadside practices had been documented.

In 1991 the Gisborne Shire, working with the Roadside Conservation Committee, produced the first comprehensive Roadside Management Plan, incorporating the good practices already in place and extending the same principles to cover many other issues that could potentially affect roadside vegetation. The Plan enables potentially competing uses of the roadside to co-exist through a coordinated approach and limits the unnecessary removal and destruction of habitat vegetation through adopting best practices.

The success of the Plan was dependent upon ownership and adoption by all key stakeholders. To achieve this a Working Party was established with representation from all key players including local community representation from environmental groups, farmers, town planners, utility service providers, Road Constructing Authority, Country Fire Authority, Council, etc. The preparation of the plan was coordinated through the Council and an appointed facilitator.

In 1983 the "Ash Wednesday" bushfires destroyed over 500 houses, burnt out the commercial centres of the two small townships of Macedon and Mount Macedon and took seven lives within the small Gisborne Shire. For a Shire with a total of only 2,500 houses this was devastating to the community.

A natural initial reaction to the Ash Wednesday fires was to blame the intensity and ferocity of the fire on the native vegetation, which covers much of the municipality in state forests, along roadsides and in private property. Consequently for a period of time the community was divided. Some wanted roadsides to be 'made safe' and cleared of all native vegetation. Others who realised the attraction of the area was the vegetation, especially along roadsides, and the habitats it provided to the wide range of wildlife in the area, wanted to retain the cover of native vegetation on the roadsides.

It was in the aftermath of the fire that the Gisborne Shire Roadside Management Plan evolved.

At about the same time as preparing the Gisborne Roadside Management Plan, the local Municipal Fire Prevention Committee had prepared a Municipal Fire Prevention Plan in isolation to the Gisborne Roadside Management Plan. This plan designated roads within the municipality that were required as strategic and tactical fire breaks, with recommendations for degrees of roadside work to be undertaken to achieve the desired 'fire-safe' environment.

In some instances the recommended roadside works, such as removing all the valuable understorey vegetation by slashing from fence line to fence line, conflicted with the high conservation value of the roadside vegetation. To remove all the under story through slashing would degrade the biodiversity value of the roadside.

Through the cooperation of the local brigades and the Municipal Fire Prevention Committee, the Fire Prevention Plan was overlaid with the plan showing the conservation value rating of the roadside vegetation. Areas of potential conflict between listed fire prevention works and conservation values were identified. To resolve the potential conflict, on-site meetings were held and appropriate treatments agreed to which satisfied the need to protect the biodiversity of the roadside vegetation and yet achieve a reduction in the fuel load.

At the same time, other solutions emerged that saw the combination of fire prevention works with other utility requirements, such as tree clearing around powerlines. Overall they agreed to works were environmentally sensitive, achieved the desired goals of the fire prevention plan and other utility authorities and helped spread the cost of the works.

The following illustrates some of the treatments agreed to and successfully implemented as a consequence.

Block Treatment – Mount Macedon Road (Fire Prevention and Regeneration)

Mount Macedon Road, assigned a high conservation value rating, is also classified as a strategic fire break road in the Fire Prevention Plan. Much of the roadside vegetation was burnt in the 1983 "Ash Wednesday" fires, requiring a large number of advanced trees to be removed. The fire also initiated vigorous regeneration. During the conservation assessment survey localised areas of rare native orchids were also identified.

The vegetation on the road reserve provides habitat and a corridor for koalas, echidnas and kangaroos. The potential conflict of extensive roadside clearing to achieve the required strategic fire break, and the need to retain the roadside biodiversity, was resolved by establishing "blocks" of undisturbed revegetation and native orchids. The balance of the vegetation around the blocks was mown.

The 'blocks' varied in size from 1000 to 20 metres in length by the width of one side of the roadside reserve. The smaller blocks were physically roped off and the larger areas marked by stakes in the ground.

The result has been the retention of important native vegetation ecosystems, the assurance of a seed source for future replanting programs, the preservation of the orchids and a satisfactory fire prevention fuel reduction.

Another consequence in Mt Macedon Road as a result of the slashing of the areas around these regeneration blocks, is that by either good management or good luck, the native kangaroo grass began to reappear.

Now although the slashing in the undesignated areas was modifying the environment, there was a good environmental consequence, in that we had some native grasslands being restored in those areas.

Strip Clearing – Along Fence Lines (Fire Prevention and Power Line Clearance)

Another method of achieving a suitable fire break and retaining the important native vegetation was to combine the fire break required under the Fire Prevention Plan with the need for clearing along an overhead electric power line located along one of the fence lines of the road reserve.

The area from the fence line to the code distance required from the power line towards the road pavement was cleared of all vegetation and slashed. This left substantial undisturbed ground cover, shrubs and advanced trees between the fire prevention works and the road pavement, thus retaining a continuous strip of relatively undisturbed native vegetation.

Litter Fuel Reduction

Many roads within the Shire have large well-established trees as the roadside vegetation with introduced non-native grasses growing underneath. The conservation value of these roads is weighted high due to the large trees that often form continuous canopies along the road reserve. To maintain the habitat of the large trees and to attain adequate fire prevention standards, the grass is mown and the trees left undisturbed. This leaves the larger trees for the use of animals such as koalas and the squirrel glider, for food, and as a corridor for movement from one area to another.

Fire as A Method of Fire Prevention

In many rural areas the local brigades 'burn off' roadside vegetation as a method to reduce the fuel load. In some instances, probably by more good luck than good management, the particular fire frequency has lead to a prolific growth of indigenous native vegetation producing some very pristine native vegetation.

Preservation of Existing Trees

After the 1983 bushfires, there were few roadsides remaining on Mt Macedon that retained their former canopy of trees. Only two such areas were untouched by the fire and were on designated tourist routes.

Both these sections of road contained overhead powerlines that in their current configuration, with close proximity of branches and trees to the bare conductors posed a risk of clashing and causing a fire.

To reduce the risk of a fire starting in these locations, the power authority's solution was to remove the remaining live, green trees. After much discussion, the solution to this problem was to underground 1.3 kilometres of powerlines with funding being shared by the power authority, state government grants and the council.

The end result was the retention of the vegetation (although in one case not native but of historical and tourist value). It also removed the risk of fire from a clash between trees and the power lines, and provided an economic benefit in that an important tourist road had been preserved, and the general amenity of the area maintained.

Undergrounding Of Powerlines To Aid Regeneration

Devonshire Lane on Mt Macedon, was renowned for its magnificent avenue of mountain ash prior to the 1983 fires. The trees were burnt in the fire, and required removal. Again, power authority assets were overhead and ran the full length of the south side of this road. Due to the potential risk of fires being commenced, or being ignited from clashes between the overhead powerlines and the regenerating mountain ash, the power authority wanted all the regenerating regrowth removed.

However, the local residents and council were keen to re-establish the lane, and in order to achieve it, the local residents raised sufficient funding to attract a government grant to underground the power lines. This removed the risk of a fire from clash between the power lines and the trees, and also allowed the regrowth of the naturally regenerating mountain ash to once again form the magnificent avenue.

Other Techniques to Reduce Fire Ignition From Powerlines

In order to reduce the risk of fire from the clash between power lines and trees, other techniques are also being used. Through the use of aerial bundled cables, which are the three heavily insulated conducting cables twisted together as a single cable, a lot less tree removal is required.

The Second Fire Prevention Plan

Under the CFA Act, municipal fire prevention plans must be reviewed every two years. The next fire prevention plan prepared following the one mentioned in the case study that was carried out in isolation, saw a wonderful transition in the way the local fire brigade members approached the fire prevention works.

In preparing the plan, the local brigade members examined the conservation value of the roads where they were recommending works be undertaken, and assessed if the works proposed would conflict with the conservation value of the road. If potential conflict was evident they looked at alternative solutions, often looking beyond the roadside boundaries, and made recommendations for works that were sensitive to the conservation value of the roads.

For example, in one instance, the land adjacent to the road with a high conservation value, was being used for farming and often grazed very close to the ground prior to the summer period? In this instance the brigade members recommended that the fire prevention works be undertaken in the private property and no works, apart from a single pass of a slasher over the shoulder of the road, be undertaken on a high conservation road.

ECONOMIC, SOCIAL AND ENVIRONMENTAL BENEFITS

By 'looking outside of the square' where an isolationist approach would have resulted in the destruction of the roadside vegetation at a high environmental and dollar cost, solutions were found that had many benefits:

- improvement of the environment through the preservation of more roadside vegetation;
- protection of tourist assets of which roadside vegetation is very important in the Macedon/Mt Macedon area, thus protecting the economy of the tourist trade in the district;
- reduction in overall costs of works undertaken, in that it was often shared between different authorities, people, sources of funding, and was not burdened totally upon the municipal council; and
- maintained the required reduction in fuel for fire management purposes.

MUNICIPAL FIRE PREVENTION PLANS – THE NEXT GENERATION

The case study mentioned above occurred over a number of years. The process developed was seen as being so successful that the Country Fire Authority now promotes it throughout its member brigades in Victoria.

The CFA has also undertaken further work on the behaviour of fires on roadsides in respect to the amount of fuel within the roadside, and whether the clearing of that vegetation has impact on the speed or flame height of fires.

As a consequence of the further research, and in recognition that there are other roadside objectives apart from fire prevention, the Country Fire Authority has produced new roadside Fire Management Guidelines that look at a roadside risk assessment process in the preparation of roadside Fire Management Plans.

The process has a number of steps, and these are:

- identify the objective for management of fire on the roadsides (the five objectives are to prevent fires on roadsides, contain roadsides fire, manage safety of road users, provide control lines and recovery from roadside fires);
- identify roads where it is important to meet the objective;
- assess if the objective can be realistically achieved (if no, identify alternative locations or treatments; if yes, go to next stage);
- consider and evaluate the treatment options that may achieve the objective;
- determine if the treatment will have a detrimental effect on other roadside objectives (if yes, consider and evaluate alternative treatment; if no, go to the next stage);
- assess if the treatment is cost effective (if no, go back to consider, evaluate an alternative treatment; if yes, go to next stage);
- develop a treatment program; and
- incorporate into the municipal fire prevention plan.

The guidelines go on to look at each of the five objectives in detail and for each of these objectives, considers the following:

- methods of achieving the objectives;
- alternative treatments to be considered;
- methods of evaluation of the treatments proposed; and
- recommended treatments to meet the objective.

The remaining section is a roadside risk assessment process. The risk assessment process involves the assessment of wild fire related risk of roadside reserves. This process provides a systematic risk assessment of categories of roadside reserves, and specific sites, which enables high risk, or high priority areas to be identified and addressed. That is, the process involves:

Stage 1 – Research – identifies risk environments and specific sites to be assessed and consider the likely impact on the community;

Stage 2 – Assessment – for each risk environment or site, consider the management objectives, and from this select the objectives to be addressed and select the treatments to help achieve the objectives that need to be addressed; and

Stage 3 – Recommendations – identify high priorities for the community, develop implementation programs, incorporate recommendations into the Municipal Fire Prevention Plans.

The guidelines then provide a summary of the treatment options available to achieve roadside risk management objectives. That is, the choice of treatment for a given risk environment or site will depend upon the characteristics of the site and the likely impact on the community.

CONCLUSION

Over the last ten years there has been a transformation of the way that fire in transport corridors has been addressed. This has changed from a 'slash-and-burn' approach to carrying out works on roadsides, to one of a community risk evaluation. The risk evaluation considers a number of objectives to be obtained, identifying the main objectives for a particular site and looking at the needs of that site. Understanding the need to satisfy other objectives is important, including the vegetation conservation value of the roadside vegetation, and looking at alternative treatments and the potential impact on both the objectives of the fire prevention plan and objectives from other sources is part of the process.

The guidelines that have now been produced by the Country Fire Authority also provide evaluation of alternative treatments. This makes it easier for the Municipal Fire Prevention Committees in preparing Fire Management Plans to have access to and comment on alternative solutions given the particular site characteristics and risks needed to be addressed.

GREEN FIREBREAKS - FIRE RETARDANT PLANTS

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ABSTRACT

Fire is an integral part of the Australian landscape, with many plants dependent upon fire for survival. This dependence upon fire, coupled with Australia's dry environment, makes our landscape the world's most fire-prone. With an increasing number of people living in semi-rural regions (the so-called 'wildlife-urban interface') a larger proportion of the general population will face the common occurrence of bushfires. Moreover, expansion of this wildlife-urban interface creates further infrastructure problems with setting up communication and essential services. This indirectly increases the wildfire risk of transport corridors, which can be mitigated, with the use of fire-retardant species in the place of cleared corridors or existing (flammable) native vegetation. The advantages of maintaining a 'green firebreak' include: (a) preventing wildfire spreading across large areas, (b) absorbing radiant heat, (c) deflecting smoke away from corridors, (d) diffusing and absorbing high winds, (e) prevent burning brands from starting fires in other areas, and (f) provide safe, evacuation points in extreme climatic conditions. Furthermore, there are significant cost savings of implementing and maintaining a corridor of vegetation from the alternative of maintaining cleared areas. Case studies from wildfires in southern Australia in 1983, and New South Wales in 1994 clearly show that areas maintaining boundaries of vegetation adjacent to transport corridors had lessened impacts from wildfires and allowed access for both the evacuation of residents and passage of fire-fighting authorities. Native and exotic vegetation from the south-east Queensland region is systematically ignited in an ignition chamber, which is designed to accurately simulate wildfire conditions (high winds, high temperatures etc.). The thermal heat output and gases released are measured, which provides a direct indication of the plant's flammability characteristics. In addition to the laboratory flammability assessment, extensive fieldwork examining areas burnt in a wildfire (or prescribed fire) has also been undertaken. In these areas, plants that did not burn as readily as other adjacent vegetation are identified and samples taken for laboratory analysis. It is envisaged that by the conclusion of this study, (a) that a standard and accurate technique for determining plant flammability is devised, (b) characteristics which enhance the fire retardant potential of plants is quantified, and (c) a reliable list of fire-retardant vegetation is produced.

***Key words**: Fire Retardant Plants, Plant Flammability, Combustion, and Ignition*

INTRODUCTION

Fire has been a part of natural ecosystems since the origin of flora on the surface of the earth (Wright and Bailey 1982). Fire has exerted a dominant influence on the Australian landscape, whether artificially or naturally induced. In Australia, there is a marked and significant increase in charcoal in lake deposits dating from 120,000 years ago (Attiwill 1994). This indicates that fire has played a role in shaping the landscape well before the first permanent human settlement by the Aborigines, approximately 40–50,000 years ago. The Australian sclerophyll flora is dominated by *Eucalyptus* spp., which is highly fire prone, due mainly to the highly volatile oil content in the leaves.

Mount (1964) stated that there may be competitive advantages for having flammable leaves and bark etc., since the fires will increase in intensity (due to the presence of oils etc.) and the more flammable vegetation has developed mechanisms (epicormic shoots and lignotubers in the case of *Eucalyptus*) that will ensure the plant survives the fire. Therefore, these plants gain an advantage from having the other plants (such as sub-tropical rainforests) destroyed during the fire, where the canopy is opened up to seeds that germinated during the fire.

The areas where the sub-tropical rainforests would also be diminished as the fire would encroach onto previously unburnt (or rarely burnt) land.

A similar view was proposed many years later by Mutch (1970) which caused a great deal of discussion, and while the theory has been deemed group–selectionists, Mutch's Hypothesis raised several questions about plant flammability, some of which are the focus of this research.

Australia is widely regarded for having the world's most flammable landscape, followed closely by the ecological communities of southern California and the Mediterranean, which often contain many species of native Australian flora. Many plants depend upon the forces of fire and the heat that is generated to stimulate plant growth, so that fire has become an integral part of a plant's life cycle. The introduction of many eucalypt species to California and

the Mediterranean (both of which already contain many flammable native species), in addition to other species such as *Melaleuca* and *Leptospermum* has certainly altered and changed the fire regimes, resulting in more bushfires, more regularly. The combination of a flammable landscape and an ever increasing population living in the 'urban–wildland' interface, presents many problems for fire-fighting authorities. Previous fire management strategies, such as fire-suppression have lead to many devastating fires, particularly evident during the early years of European settlement in Australia which caused an enormous amount of damage. These conflagrations lead to many changes in fire-fighting and management practices, and presently, the most widely used management practice is controlled or 'prescribed' burning. This practice involves the periodic burning of forests in low fire seasons (in most cases–during the cool and mild winters) to reduce the amount of potentially flammable fuel litter (Johnson and Miyanishi 1995). By reducing the amount of flammable litter, any fires that may occur can be more efficiently controlled because the intensity of the fires is lowered. Despite global adoption of this management strategy, there are many criticisms of prescribed burning, which are mainly concerned with the ecological implications of altering the natural fire regimes of ecological communities. Furthermore, regardless of the concerted efforts of many fire authorities, many devastating fires will continue to occur.

For many years, a small amount of research has been conducted in the determination of what plants are suitable for planting around homes and other properties that are less flammable, so the risks of property destruction are significantly reduced. The notion that plants may actively retard the spread and reduce the intensity of a fire is difficult to picture, but there is strong evidence that many plants are fire-retardant. If these plants are landscaped and situated correctly, they can effectively deflect smoke and burning embers away from properties; act as a spark arrester for fire-brands, reduce wind velocity and, most importantly act as a heat absorber to shield against strong radiant heat generated by the bushfire (Sheridan 1996). Natural 'green firebreaks' are often used by many fire authorities as a shield to help fight oncoming bushfires and have been shown to work quite effectively (Hall *pers.comm*. 1998), but it is possible to effectively plant and maintain these firebreaks around properties. While the majority of this work stems from anecdotal evidence, there has been little to no work done to determine the actual factors that most influence the flammability of a plant. Additionally, the species list of less-flammable or fire-retardant plants is subject to much criticism as there are no statements of what research was conducted to determine the level of flammability, nor have any methods been listed, so the results cannot be reproduced and verified. This lack of knowledge would show that the majority of the lists are unreliable and potentially hazardous, as they may contain species that could enhance or increase the flammability risk. Certainly, more work is required to definitively determine the true flammability of a plant species.

The definition of what constitutes 'flammability' is especially important *in lieu* of this investigation. Presently, the most widely accepted and used definition of flammability is that of Anderson (1970) who stated that flammability consists of three unique stages: Ignitability, Sustainability, and Combustibility. These stages were defined as:

IGNITABILITY–The *time taken,* from when the heat source is applied, until ignition occurs;

SUSTAINABILITY–The measure of *how well* a fire will continue to burn (with or without the heat source); and

COMBUSTIBILITY–The reflection of the *rapidity* with which a fire burns.
It was later suggested by Martin *et al.* (1993) that an another component of flammability be included:

CONSUMABILITY–The measure of *how much* of the plant burns.

Generally, many researchers have focused on only one or more of these components, however, no literature has been found that has considered all four components, due mainly to the difficulty in finding qualitative measures for each component. Additionally, there has been no study to consider the effects of exposure to fire weather and how this affects flammability, which would certainly be a more accurate measure than current existing measures of flammability. Furthermcre, the amount of heat that is produced by the pyrolysis of a single leaf and its influences on the flammability of other foliage and bark is still undetermined, and is worth researching.

It is obvious that this type of work is in its infancy, and much more work on defining flammability is needed, and the fate of plants in bushfire weather needs to be resolved. Additionally, the amount of exposure to the actual fire-front is quite crucial in affecting a plant's flammability, and this will also be studied. When this is achieved, an informative and accurate list of fire-retardant plants and their level of retardance can be produced. Such information will provide home and property owners with more time.

METHODOLOGY

It is clear from previous studies that many individual influences have been studied for their effects in altering the flammability and pyrolysis of foliage, bark and forest litter. However, what is still unclear and unresolved, is how do plants react during bushfire weather and the forces involved with an oncoming fire-front? By simulating the conditions of bushfires, we can determine a plant's true level of retardance against burning. Typically, fire weather can be classed as low, medium, high and extreme (Just 1978), and the conditions that are most vital in altering these conditions are wind-speed, relative humidity, and ambient air temperature. Additionally, if fires do occur, the speed and intensity of a fire is dependent upon the topography, landscape, forest community structure, and most importantly, the prevailing weather conditions. Many previous pyrolysis and burning studies have been based upon the use of subjective assessment of burning (ie observations by the experimenters etc.). However, while such experiments are informative, they do not provide exact information on how plants react to extreme amounts of heat stress and what changes occur once a plant is ignited.

In an effort to overcome these oversights in experimentation, we have designed and constructed an ignition chamber which accurately simulates the weather conditions similar to bushfires that occur in Australia, which is illustrated in Figure 1. By exposing foliage to these conditions, we can ignite the specimen and determine the heat output and other variables to ascertain the level of retardance to burning as precisely as is currently possible.

Changes in temperature, once the foliage is ignited, relates to the amount of heat that the specimen contributes to the fire, will show the level of heat released from the burning vegetation, something that has not been possible previously.

The technique is similar to thermal analysis, but used in such a way that facilitates a clearer understanding of the processes that occur during vegetation pyrolysis.

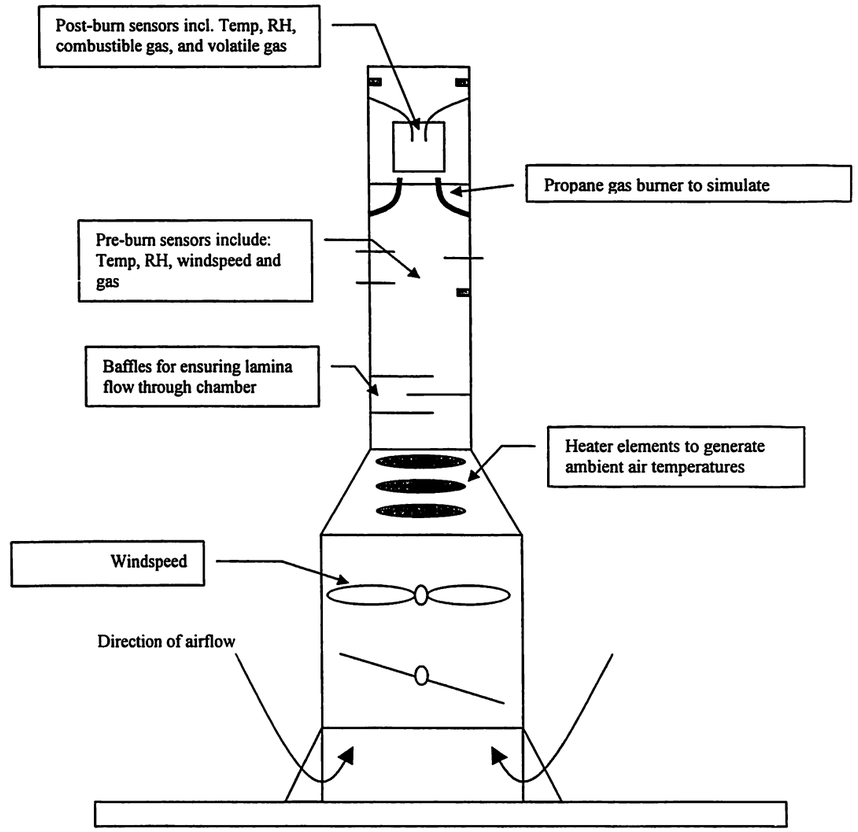


Figure 1. Layout of combustion chamber for use in flammability experiments

The experiments conducted using the ignition/combustion chamber can be varied on three main parameters. These are considered to be the most important parameters in relation to determining the intensity of a fire, and consequently, the amount of damage (or potentially) that it may cause. It is assumed that in these experiments, there is already a progressing bushfire approaching the specimen, and that it is inevitable that the fire will encounter the plant tested.

More specifically, fire intensities rely on (1) ambient air temperature; (2) wind-speed; and (3) exposure to flame-front. Individually, these parameters can decide what velocity the fire travels along a perimeter, how much is burnt in any specific area, and the degree of pre-heating of the foliage. Collectively, without these factors, bushfires would not occur.

1. PRE-HEATING (HEAT STRESS) STAGE
   This involves the amount of time that the plant is exposed to the ambient conditions before the onset of the flame. This is hypothesised to be one of the predominating factors which will affect how efficiently the plant will ignite and maintain ignition. The specimens will be exposed to favourable bushfire conditions ranging from – 0, 5, 10, 30 and 60 mins.
2. WIND-SPEED
   The wind-speed is one of the most important variables that is underestimated in its potential in determining the severity of bushfires. Higher wind-speeds are usually well correlated with very-high intensity bushfires. The ignition chamber is designed to simulate conditions ranging from 1 m/s to 20 m/s. These ranges are equivalent to 3.6 and 72 km/hr respectively. The specimens will be exposed to three (possibly more) changes in wind-speed. These include: 2 m/s, 10 m/s and 20 m/s, to accurately simulate the three fire weather conditions.

3. EXPOSURE TO NAKED FLAME–FRONT
   The amount of time that foliage (or any other part of the plant) is physically in contact with the actual fire will undoubtedly influence the flammability and ignition potential of a plant. It is envisaged that the more time that the plant is exposed to the flame, the more will burn and an increased flammability quotient will emerge. This is worth testing and quantifying. The rates of spread can also be calculated by measuring the amount that is burnt divided by the period (of time) that the foliage is ignited. The ignition chamber allows for a variety of different 'flame' times. Presently, the times that coincide with the three different fire intensities (low, medium and high) to be simulated will be: 2, 4, and 6 seconds respectively. Extreme fire exposure can also be achieved by increasing the amount of time the specimen is exposed to the flame.

There will be a number of specimens tested, but the majority of the plants will originate from already published plants' lists, to verify whether these plants are suitable for use in green firebreaks. Native Australian plants will be used for testing, and although some exotic species will be tested (some species may have a lower flammability), the use of exotics is not encouraged. Additionally, the energy content, moisture content, leaf area index, ash content, silica free ash content and the physical form of the plants studied will also be examined to locate any correlations that may be able to provide an indication of the flammability of the specimens.

According to Rudolph (1993) the physical characteristics of vegetation will also affect the properties of ignition and pyrolysis. Rudolph (1993) listed the following characteristics:

Growing Plant Attributes

CHEMICAL COMPOSITION ATTRIBUTES
1. Leaf moisture content
2. Leaf volatile oil content
3. Mineral content of leaves

ARCHITECTURE OF THE LEAF ATTRIBUTES
4. Leaf fineness
5. Density of foliage
6. Plant form continuity
7. Height of lowest foliage
8. Size of plant–volume and spread
9. Dead foliage on plant
10. Bark texture

GROUND FUEL ATTRIBUTES
11. Quantity of fuel in fire season
12. Fineness of ground fuel
13. Ground fuel compactability
14. Mineral content of ground fuel

In addition to the laboratory assessment of vegetation flammability, fieldwork conducted in sub-tropical rainforest and sclerophyll forests will use the above criteria (from 4–14) to determine the extent that these physical characteristics exert on flammability. Furthermore, fuel litter loads will also be collected and examined for decomposition rates, which may provide further insights to the flammability ratings of certain vegetation and forest communities.

It is expected that by the completion of the project, a clearer definition of what constitutes vegetation flammability will be known. Additionally, a true list of fire retardant plants may become available for the south east Australian region which could become incorporated into fire management plans, as has been the case with the Gold Coast City Council (GCCC 1998).

If this is accomplished, then property owners living in the 'urban-wildland' interface will be better protected and more prepared for the oncoming fire seasons.

RESULTS AND DISCUSSION

Flammability Assessment : Figure 2 outlines a typical output of the flammability experiments.

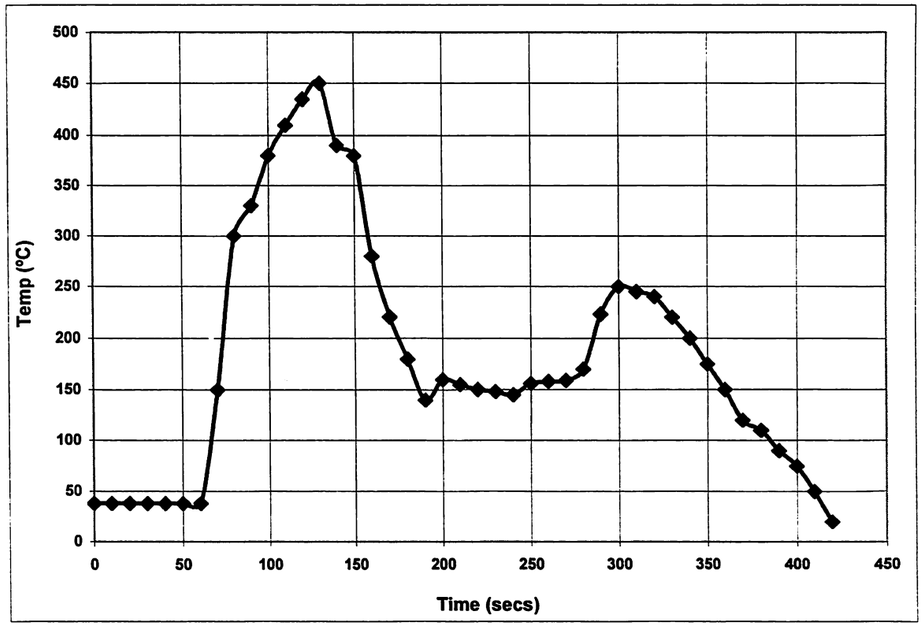


Figure 2. Temperature peaks in flammability experiments

As the figure clearly shows, two distinct peaks are observed during the experiment. The first indicates the peak temperature of the ignited vegetation material. The time taken to reach this temperature is indicative of the ignitability aspect of the flammability equation. The second peak shows the second ignition phase of the vegetation after the ignition source has been removed. The time taken to reach this second peak is indicative of the combustibility and sustainability of the plant. Plants are weighed prior to ignition and re-weighed post-fire. This provides an indication of the consumability aspect of flammability. Table 2 is a list of the plant species that have been tested. These plants are currently undergoing a second and third series of experiments for replication of existing results. These results are only preliminary and more work is required to confirm these findings.

Table 2. Plants tested for flammability

Scientific Name	common name	Scientific Name	common name
Acacia melanoxylon	sallee wattle/blackwood	*Floydia praelta*	ball nut
Acacia orites	nightcap wattle	*Geissois benthamii*	red carabeen
Acmena australis	red apple	*Glochidion ferdinandii*	cheese tree
Acmena smithii	lilly pilly	*Gmelina leichardtii*	white beech
Acronychia laevis	hard aspen	*Guioa semiglauca*	guioa
Acronychia pubescens	hairy acronychia	*Halfordia kendack*	saffron heart
Acronychia suberosa	corky acronychia	*Harpullia alata*	wing-leaved tulip
Agrophyllum nullumense	silver-leaf	*Helicia ferruginea*	rusty helicia
Agyrodendron actinophyllum	blush tulip oak	*Hymenosporum flavum*	native frangipani
Agyrodendron trifoliolatum	brown tulip oak	*Jagera pseudorhus*	foam-bark tree
Akania lucens	turnip-wood	*Litsea leefeana*	brown bollywood
Alphitonia excelsa	red ash	*Litsea reticulata*	bolly gum
Alyxia ruscifolia	chain-fruit bush	*Lophostemon confertus*	brush box
Anopterus macleayanus	Macleay laurel	*Melia azaderach*	white cedar
Aphananthe philippinensis	rough-leaved elm	*Melicope octandra*	doughwood
Austromyrtus lasioclada	velvet myrtle	*Mischocarpus lachnocarpus*	wooly pear fruit
Baloghia lucida	scrub bloodwood	*Mollotius philippensis*	red kamala
Brachychiton acerifolius	flame tree	*Nothofagus mooreii*	antarctic beech
Breynia oblongifolia	coffee bush	*Neolitsea dealbata*	white bolly gum
Callicoma serratifolia	white alder	*Notelaea longifolia*	native olive
Canthium coprosmoides	coast canthium	*Oreocallis pinnata*	Dorrigo waratah
Castanospermom australe	black bean	*Orites excelsa*	prickly ash
Castanospora alphandii	brown tamarind	*Omalanthus populifolius*	bleeding heart
Celdeluvia paniculosa	soft corkwood	*Pennantia cunninghamii*	brown beech
Cinnamomum oliveri	Oliver's sassafras	*Pittosporum undulatum*	sweet pittosporum
Citronella moorei	silky beech	*Pittosporum revolutum*	hairy pittosporum
Cryptocarya erythroxylum	pigeonberry ash	*Planchonella australis*	black apple
Cryptocarya foveolata	mountain walnut	*Podocapus elatus*	brown pine
Cryptocarya meissnerana	thick-leaved laurel	*Pseudoweinmannia lachnocarpa*	marara
Cryptocarya obovata	pepper berry tree	*Polycias elegans*	silver basswood
Cryptocarya rigida	forest maple	*Polycias murrayi*	pencil cedar
Cryptocarya triplinervis	brown laurel	*Polyosma cunninghamii*	featherwood
Cupaniopsis serrata var. tomentella	rusty tuckeroo	*Psychotria simmondsii*	small psychotria
Cuttsia vibernea	cuttsia	*Quintinia sieberi*	rough possum wood
Daphnandra micrantha	socketwood	*Quintinia verdonii*	grey possum wood
Dendrocnide excelsa	giant stinging tree	*Randia benthamiana*	native gardenia
Dendrocnide photinophylla	shiny-leaved stinger	*Rapanea variabilis*	muttonwood
Denhamia pittosporoides	denhamia	*Rhodamnia maideniana*	smooth scrub turpentine
Diploglottis australis	native tamarind	*Rhodamnia trinervia*	brown malletwood
Doryphora sassafras	sassafras	*Rhodosphaera rhodanthema*	deep yellow-wood
Drospyros pentamera	myrtle ebony	*Sarcopteryx stipitata*	steelwood
Duboisia myoporoides	duboisia - corkwood	*Schizomeria ovata*	crabapple
Dysoxylum fraseranum	rosewood	*Sloanea australis*	maiden's blush
Dysoxylum muellerii	red bean	*Sloanea woolsii*	yellow carabeen
Dysoxylum rufum	rusty mahogany	*Stenocarpus sinuatus*	wheel of fire tree
Elaeocarpos cyaneus	dwarf quandong	*Symplocus sp.*	hazelwood
Elaeocarpus grandis	blue quandong	*Synoum glandulosum*	scentless rosewood
Elaeodendrum australe	southern olive	*Syzygium coolminianum*	blue lilly pilly
Endiandra discolor	rose walnut	*Syzygium paniculatum*	scrub cherry
Endiandra pubens	hairy walnut	*Stenocarpus slaignus*	scrub beefwood
Euodia micrococca	white euodia	*Syzygium corynathum*	sour cherry
Euodia micrococca	white euodia	*Syzygium floribundum*	weeping myrtle
Eupomatia laurina	bolwarra	*Toona australis*	red cedar
Euroschinus falcata	ribbonwood	*Tristaniopsisa laurina*	water gum
Ficus coronata	sandpaper fig	*Trochocarpa laurina*	tree heath
Ficus fraseri	creek sandpaper fig	*Triunia youngiana*	spice bush/honeysuckle bush
Ficus macrophylla	Moreton Bay fig	*Wilkiea huegeliana*	veiny wilkea
Ficus watkinsiana	green-leaved strangler	*Zanthoxylum brachyacanthum*	thorny yellow-wood
Flindersia australis	teak		

Costs of Maintaining Vegetation in Transport Corridors

The costs of planting and maintaining vegetation within transport corridors may vary significantly. According to recent estimates the costs of maintaining corridors devoid of any vegetation varies between \$0.14–\$1.00/m^2, though some estimates have been as high as \$6.00/m^2, which incorporates removal of existing vegetation using brush-cutting etc. These costs cover maintenance of lawn, general clearance and slashing. Invariably, as discussed earlier, there is a significant increase in the fire risk in cleared areas. Managers have to decide whether to consider maintaining vegetation within corridors on a purely economical scale or for maximising the protection values in these vital areas.

The costs of maintaining fire-retardant vegetation in transport corridors are identical to planting 'typical' vegetation in these areas. Recent estimates also vary from \$4.00–\$6.00/m^2, though the actual costs are probably much lower. Maintenance levels associated with the use of fire-retardant plants depend upon the species incorporated in the firebreak. Species which are evergreen, contain smooth bark and release a minimal amount of litter (through bark etc.) would be highly recommended. Priority will also be given to native species, though the results to date indicate that some exotic species are also less flammable, so consideration to these species must be taken into account.

CONCLUSION

Wildfires pose a serious threat to communities in the wildland/urban interface. Transport corridors play an important role in providing access for fire-fighting authorities, in addition to allowing for prompt evacuation in large conflagrations. It has been shown that there are many advantages in using less-flammable vegetation along these corridors to maximise the level of protection. Cleared regions will form no barrier to smoke, high winds, firebrands, high temperatures, or radiant heat that is experienced in wildfires. Careful selection of appropriate plant species is needed to ensure the green firebreak acts to slow or stop fire-spread and not become easily ignitable fuel for the fire-front. This is the first study to develop experimental guidelines to test plant flammability accurately. The outcomes of the work will allow managers to incorporate and implement, at a relatively low cost, fire retardant plants into management plans and increase the level of protection offered to those residing in these areas.

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EROSION & SEDIMENT CONTROL BEST PRACTICE IN NORTH QUEENSLAND - A ROAD CONSTRUCTION INDUSTRY PERSPECTIVE

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ABSTRACT

Far North Queensland is characterised by a monsoonal climate with a distinct wet season/dry season climate. This combined with high intensity rainfall results in many challenges for erosion and sediment control in the road construction industry. Erosion and sediment control best practice in Australia has evolved in NSW where the climate is less extreme. Queensland practitioners have attempted to use NSW derived best practice with limited success. Increasing environmental risk and asset degradation has necessitated a re-think of best practice and the development of new technology focusing on point source control of erosion and sedimentation.

INTRODUCTION

Far North Queensland (FNQ) refers to the geographic region to the north of Townsville and Mt Isa. It includes the Gulf of Carpentaria, the wet tropics, Cape York and the Torres Straits. FNQ is characterised by a monsoonal climate with rainfall ranging from 400 mm per year in the Gulf Savannah (Environment North, 1998) up to over 8000 mm per year in the wet tropics (GHD, 1997). The majority of which falls between November and April each year. Tropical cyclones are a feature of the region's climate during this time.

As a consequence of the characteristic monsoonal climate and erodible soils, the potential for erosion in the region is very high. Failure to consider the high erosion potential in the road planning, design and construction poses considerable risk from both an environmental management and asset management perspective.

TRENDS IN ROAD CONSTRUCTION

Major population centres in FNQ such as Townsville and Cairns are experiencing high population growth increasing pressure on the existing road network. Expansion of the mining, cattle, sugar, defence and tourism industries requires the upgrading of the existing road network to provide safe and efficient roads for large multiple trailer trucks such as B-Doubles and Road Trains. Industry and the public expect improved flood immunity.

To meet these demands, road design has changed to include improved vertical and horizontal alignment, improved flood immunity, increased radius curves and wider lanes. Such design requirements can impact negatively on the environment. Road designers are no longer able to "fit" roads within the constraints of the existing environment. New road construction works have resulted in greater land disturbance due to increased road easement width, increased cut and fill and increased embankment and bridge heights.

CONSTRAINTS

As stated previously, the majority of rain falls between November and April. Unlike southern climates, high intensity rainfall events are the norm. This combined with highly erodible, low nutrient soils and increased disturbance limits the options available to road designers and constructors.

Due to the long "dry" season, erosion and sediment control practitioners cannot always rely on permanent vegetation cover for erosion control. Road construction sites can go from extremely dry to extremely wet in a couple of hours.

Ideally all major disturbance should occur during the dry season. Resource allocation and political reality often do not allow this to occur. Major construction works often do not begin until September as a result of budget approvals. Road construction crews cannot "stand down" for five months every year so major disturbance during the wet season must be anticipated.

FNQ EROSION AND SEDIMENT CONTROL FUNDAMENTALS

Scheduling of Works

It may seem obvious to state that different procedures and timeframes are required during wet and dry periods. The wet season requires the immediate stabilisation of disturbed areas. The results of poor timing during the wet season, can not only mean the rebuilding of structures and development works, but can result in significant environmental harm.

Efficiency in staging of works will result in the least amount of exposed area at any one time. This reduces the potential for erosion and sedimentation significantly.

Minimising Disturbance

Disturbance to areas with intact vegetation and soil leaves the area open to the erosive forces of water and wind. Forward clearing should be kept to a minimum to retain as much of the existing vegetation as possible, especially adjacent to sensitive areas such as drainage lines.

Install Erosion and Sediment Control Measures Prior to Disturbance

Install temporary and permanent erosion and sediment control measures before disturbing the site. This will ensure the construction site is protected from erosion and downslope lands and downstream waters are protected from sedimentation.

Point Source Control of Erosion and Sedimentation

Sediment can only be generated when erosion occurs. The prevention or minimisation of erosion must therefore be the first priority of any erosion and sediment control strategy.

It is environmentally sound, easier and more cost effective to prevent erosion than to trap sediment from eroding areas. Run-off volumes in FNQ are such that it is almost impossible to design and construct structures capable of containing sediments from large, unprotected disturbed areas.

Separate Clean and Dirty Water

"Clean" run-on water from undisturbed areas up slope of the construction site must be intercepted and diverted clear of the works. This will reduce the volume of "dirty" or "contaminated" water that would otherwise require treatment on-site. There will be a corresponding reduction in the design capacity and room required for the construction of sediment traps and basins.

Save Topsoil

Topsoil is a critical factor in the successful rehabilitation of a disturbed area. Topsoil contains the majority of the seeds and other plant propagules, soil micro-organisms, organic matter and much of the available plant nutrients.

Once removed, topsoil should be directly re-spread on disturbed areas to assist revegetation rather than storing it in stockpiles for later use. The advantages of this are that it reduces the land requirement of stockpiles, avoids double handling and the loss of biological integrity brought about by stockpiling.

Rehabilitate Disturbed Areas Progressively

Prompt rehabilitation of disturbed areas is critical in the minimisation of erosion and sedimentation and weed invasion as well as the improvement of visual amenity.

If permanent rehabilitation is delayed, temporary measures such as hydromulching should be applied to protect the soil surface.

EROSION AND SEDIMENT CONTROL TECHNIQUES

The erosion and sediment control practitioner is often bombarded by a mass of products and services claimed to be the solution to all erosion and sediment control problems. Experience has shown that there are a number of proven techniques that have prevailed over time. In addition, there are a range of new techniques that also have proven to work effectively in FNQ. These techniques and aspects of design and implementation will be discussed in the two following sections.

EROSION CONTROL

Surface Roughening

Surface roughening in one of the most basic erosion techniques available. It aims to increase infiltration and the time of concentration, reduce flow velocities and trap sediment. Typical measures include contour ripping and leaving blade spillage windrows on the contour. This technique is applicable in sheet flow environments. Soil conservation texts promote track walking as a surface roughening techniques. In FNQ this technique can accelerate erosion if the grousers are allowed to sink too far into the soil, thus forming longitudinal channels allowing water to concentrate.

Turf and Reinforced Turf

Turf and Reinforced Turf is useful technique for protecting bare earth channels in low flow environments. Reinforced turf is grass that has been grown through an erosion control grid, or 2-dimensional or 3-dimensional erosion control matting. This technique relies on regular rainfall to maintain healthy grass growth.

In FNQ, experience has shown in a high rainfall area around Mission Beach that conventional turf has demonstrated a higher success rate than reinforced turf. This was due to how both products were grown. Turf is harvested directly from the paddock and transported to site. When placed on the bare soil surface to be protected, the grass roots grow relatively quickly into the soil thus binding the turf to the soil. Reinforced turf is grown on an impermeable surface such as builders plastic. In this environment the grass roots can be "root bound". When placed on site the roots take longer to grow into the soil. If rainfall occurs soon after placement, the reinforced turf can fail.

Erosion Control Matting and Blankets

It is important to differentiate between erosion control, matting and erosion control blankets. Erosion control mats are used in concentrated flow environments such as table drains. Erosion control blankets are used in sheets flow environments such as road fill embankments.

There is a massive range of erosion control matts and blankets made from materials such as jute, coconut fibre, nylon and poly propylene. Failure of these products is usually due to poor installation. Correct surface preparation and installation of cut-off trenches are critical to the successful application of these products.

When selecting an erosion control mat or blanket, seek advice from an independent erosion control practitioner in regard to the type of mat/blanket to be used. In many instances sales people have specified an inappropriate product simply to make a sale.

The NSW Department of Land and Water Conservation and NSW Roads and Traffic Authority have used a jute mesh product successfully in concentrated flow environments for many years. A bitumen emulsion is applied on top of the installed jute mesh to provide additional erosion protection.
This technique has yet to be trialed in FNQ. A coconut fibre mesh would be more appropriate for use in FNQ due to the more durable nature of the coconut fibre.

Erosion mats and blankets provide only temporary protection and ultimately rely on vegetation for stability.

Cellular Confinement

Cellular confinement products were originally designed to provide a trafficable surface in a constrained environment such as a sandy stream crossing or desert. The Americans used cellular confinement products during the Gulf War to allow heavy vehicles to traverse the soft desert sands.

The products have been used with success in the control of erosion in sheets flow environments, such as fill embankments, although more cost-effective techniques are available. One problem with the product is that water can be trapped in the cells or voids saturating the soil in the cell, although the product is now available with holes in the cells to minimise this problem.

Erosion control practitioners in FNQ have attempted to use gravel/rock filled cellular confinement in concentrated flow environments as an alternative to traditional hard armour with limited success.

The main cause of failure are due to the material lifting in high flows allowing the rocks/gravel to be washed out from underneath.

Rock

Rock is one of the most useful erosion control resources in the road construction industry. Rock can be used in both sheet and concentrated flow environments. In the sheets flow environment, rock is normally used to armour a batter. This technique is often referred to as rock mulching. In the concentrated flow environment, rock can be used to protect the channel, beds and banks, as outlet protection for culverts and drop structures as well as to dissipate energy and reduce flow velocities.

Critical aspects in the use of rock include ensuring rock size is adequate for the anticipated flow velocities and that cut-off trenches are installed to prevent tunnelling under the structure. Concrete is the preferred material for the in filling of cut-off trenches.

The minimum average rock size should be 200mm. Rock size can be determined by:

$D_{50} = 40(v)^2$

Where D_{50} is the average rock size (mm) and v is the average channel velocity (ms^{-1}). Maximum rock size should be no larger than 1.5 x D_{50}. Rock thickness should be 1.5 times the maximum rock size (Soil Services, 1998).

Erosion control texts recommend placing geotextile on the soil surface before placing the rock. Revegetation Contractors, a North Queensland based revegetation firm, have had success in "keying" large rocks into the soil surface and then placing the remaining rock on and around the larger rocks (pers comm D Bolton, 1997).

Rock can be grouted with concrete to provide additional erosion protection. Rock grouting is labour intensive and consequently can be expensive. Failure of the grouted rock can occur if differential settling occurs in the substrate.

Rock Filled Wire Baskets

Rock filled wire baskets offer the flexibility of rock combined with the ability to use smaller rocks and the ability to withstand higher flow velocities. These are more commonly known as gabions and reno-mattress.

Gabions are triple twisted wire cages which when filled with rocks provide both an engineering and erosion protection function. The reno-mattress is a thinner, flatter and wider version of the gabion.

Gabions have many advantages over other hard armours. These include:

- Flexibility - Gabions are flexible and can be used on fill or areas where settlement can be expected.
- Visual Amenity - Gabions look more natural than concrete structures and ultimately can be revegetated.
- Energy Dissipation - Gabions are excellent energy dissipaters and can retain substantial quantities of sediment.

Concrete

Concrete is a useful material for erosion control if used correctly. Concrete should not be used on uncompacted fill material or where differential settlement is anticipated.

Road construction authorities commonly use concrete in concentrated flow environments such as channel liners and drop structures.

The use of pre-cast concrete structures for erosion control such as batter chutes and kerb and channel is decreasing in FNQ due to the inability of the structures to contain the volumes of run-off experienced. In many instances these structures overtop and erode around the sides. Formless structures are easier to design and install and are therefore considered to be more effective.

Pump grouted mattress is also used widely in the road construction industry with varying success. The main reason for failure is the inability to install adequate cut-off walls. In high flow situations and in dispersible soils, soil can erode from under the pump-grouted mattress: the structure cracks and ultimately fails.

A common practice is to spray paint the structures to blend in with the surrounding environment. After 1 to 2 wet seasons the paint wears off leaving an unattractive blotchy surface.

Vetiver Grass

The Queensland Department of Natural Resources have promoted the use of Vetiver Grass in Queensland. Vetiver Grass has been used extensively in Malaysia, Thailand, the Philippines, China, South Africa, Zimbabwe and Latin America for erosion and sediment control in road construction (Truong, 1998). Vetiver has been used successfully to stabilise embankments and gully erosion in FNQ.

Monto Vetiver (*Vetiveria zizaniodes*) is a native of India. It does not produce seed and has proven to be non-invasive. Paul Truong from the Queensland Department of Natural Resources advises that Vetiver grass has an extremely deep and finely structured root system that can grow down some 2 – 3m in the first year. It also has stiff and erect stems which can withstand water flow to a depth of 0.6 – 0.8m.

Vetiver grass is usually planted in rows and in concentrated flow environments functions like a check dam by slowing flow velocities and allowing sediment to drop out.

The Queensland Department of Main Roads has trialed Vetiver Grass on two road construction projects in FNQ. The trials showed that Vetiver Grass was particularly effective in controlling erosion in sheet flow environments and was less effective in concentrated flow environments

Mulch

Mulches are used to provide a protective cover over the soil surface to protect it from the erosive effects of raindrop impact and shallow sheet flows. Commonly used mulches in the road construction industry include straw, wood fibre, bagasse, wood chip, brush matting, gravel or rock.

In urban environments or where intensive landscaping is required, chipped vegetative matter is commonly used as a mulch and these are generally applied using tip trucks and a BobCat or Backhoe.

For larger areas or difficult to reach areas a mechanically applied straw or hydraulically applied paper/bagasse mulch is commonly used.

Finn Mulcher is a proprietary name for a machine that chops hay or straw and blows it out a nozzle. A jet of bitumen emulsion is also sprayed out under pressure to tack the straw to the substrate. This is generally referred to as straw mulching. Straw mulches are more durable than hydromulches and are therefore preferred for use in less arable environments. One of the constraints for using straw mulch in FNQ is the difficulty in obtaining weed free straw. Hay can be used as an alternative, although unwanted weeds can be introduced as a result of seed laden hay.

Hydro-mulch refers to a mixture of seed, fertiliser, paper, bagasse, water and glue that is mixed in a tank and pumped under pressure out a nozzle. The glues or tackifiers in hydromulch are generally water soluble PVA's. Which means the hydromulch can re-wet and slump.

This problem has been overcome by using non-water soluble glues and additional organic material. These products are known as a Bonded Fibre Matrix. Due to the high intensity rainfall experienced in FNQ, the use of a Bonded Fibre Matrix over conventional hydromulches is recommended.

SEDIMENT

Sediment Fence

A sediment fence is used to trap coarse sediments in sheet flow environments. It works by ponding run-off thus reducing flow velocities allowing course sediment to drop out. A common misconception is that sediment fence filters sediment from contaminated run-off. Although the voids in the sediment fence will allow some water to filter through, the voids quickly block up.

The NSW Department of Land and Water Conservation recommend a maximum catchment area of 0.6 ha. To work successfully in FNQ this should be halved to approximately 0.3ha.

The main causes of sediment fence failure include:

- Installation in concentrated flow environments.
- Failure to bury the bottom portion of the sediment fence.
- Installation of support posts too far apart.

Straw Bales

Straw bales have limited application for erosion and sediment control in FNQ. This is mainly due to their inability to withstand the volume and velocity of run-off experienced during high intensity rainfall events. Another reason is the limited availability of clean straw in FNQ.

It is interesting to note that the use of straw bales as best practice has been omitted from the NSW Environmental Protection Authority Draft Code of Practice "Managing Urban Stormwater – Construction Activities".

Check Dams

Check dams are useful for both erosion and sediment control in concentrated flow environments. They are small temporary structures constructed across a drainage way or channel. Their purpose is to reduce erosion of the channel invert by restricting the velocity of flow in the channel. Sediment deposition and entrapment is a secondary function of the reduction in flow velocity.

Check dams should not be used in large watercourses or "live" (wet) streams. Check dams can also be constructed from rocks, logs and sandbags. The construction material must contain sufficient mass to withstand the energy of a concentrated flow.

In NSW the recommended catchment area for the structures should not exceed 4 ha. This should be reduced for FNQ. The maximum height of the check dam should be 0.6 – 1.0m and the centre should be a minimum of 0.15m lower than the outer edges to form a spillway (Soil Services, 1998).

The main cause of failure for check dams is due to insufficient spillway depth allowing run-off to flow around the unprotected edge of the dam instead of over the protected spillway. If the construction material is not sufficiently "keyed" into the substrate, erosion under the structure can occur.

Sediment Traps

Sediment traps are temporary structures formed by the excavation and/or construction of an embankment to intercept contaminated runoff and retain the sediment. They function by slowing the velocity of flow.

The size of the structure is dependent on the space available, the catchment area and soil type. The NSW Department of Land and Water Conservation recommend a maximum catchment size of 2ha. This should be at least halved for FNQ. The modified universal soil loss equation is useful for calculating the sediment yield from a catchment for design purposes.

The size of the sediment traps can be reduced if point source control of erosion and sediment is implemented on-site. Sediment can only be generated when erosion occurs.

Sediment trap embankments can be constructed from a range of materials. In the road construction industry in FNQ rock is a common construction medium due to its permeability. A sediment trap can only work if it has the capacity to slow down flow velocity. A permeable wall will allow water to seep out leaving the sediment behind. This can be further enhanced by placing a layer of geotextile on the inner batter of the rock embankment, allowing the sediment to settle out on the geotextile instead of the rock. This allows the rock to be reused.

Sediment Basins

Sediment basins function in a similar way to sediment traps, except that they are generally permanent structures, larger in size, and designed to settle out both coarse and fine soil particles.

Permanent sediment basins have not been used in the road construction industry in FNQ due to their size requirements. The run-off volumes in FNQ are such, that to apply NSW design parameters, the structure would be too large to be built in the road reserve.

In FNQ sediment basins should not be regarded as the principle measure to contain sediment generated on construction sites. They are essentially a backup system if the point source control methods for erosion and sedimentation fail.

The NSW Roads and Traffic Authority recommend a design 5 year ARI, 3 hour duration rainfall event. The NSW Department of Housing nominate a range of design rainfall events based on soil type. They refer to a Type C and Type F soils based on particle size:

Type C – less than 33% of particles are finer than 0.02mm.
Type F – more than 33% of particles are finer than 0.02mm.

Design criteria for a Type C soil:

- The maximum volume of water that will enter in 6 minutes in a 5 year ARI, 1 hour storm event.
- The volume of soil (subsoil) indicated by the modified universal soil loss equations when the vegetation cover and topsoil are removed.

For Type F soils and/or where more than 10% of the soil comprises dispersible fines.

- To contain the whole a 2 to 5 year ARI, time of concentration storm event.
- Plus an additional safety margin of 10 to 30%.

GHD indicated that for an urban subdivision in FNQ they successfully designed and constructed a sediment basin to contain a 5-year ARI, time of concentration rainfall event. They were able to achieve this by making the basin a water/ recreational feature for the subdivision where space wasn't an issue. For road construction works to achieve the 5 year ARI design criteria catchment sizes had to be smaller, hence greater reliance on site management practices, such as diversion of "clean" run-on water and the point source control of erosion and sediment (pers comm. B Berry).

CONCLUSION

For erosion and sediment control to work effectively in FNQ a number of basic, fundamental site management practices must be used. These are:

- Minimise disturbance.
- Schedule major disturbance for the dry season.
- Install temporary and permanent erosion and sediment control measures prior to disturbance.
- Separate clean run-on water from dirty site run-off.
- Strip and save topsoil for rehabilitation purposes.
- Rehabilitate disturbed areas progressively.

The assessment of erosion and sediment control measures described in this paper is the result of 11 years field experience in the rural, mining and road construction industries, and represents the professional opinion of the author who has no affiliation with any erosion or sediment control product or service. The list of techniques described in this paper is by no-means exhaustive, and there are other techniques and proprietary products that may work equally well for a particular situation. It is recommended however, when attempting to decide what product or techniques to use seek advise from an independent erosion and sediment control expert.

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EROSION & SEDIMENT CONTROL - ROAD CORRIDORS

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ABSTRACT

The Problem
Erosion occurs on the road surface, in table drains, in mitre drains, in creek and gully crossings and on lands adjacent to road easements. The results of this erosion can have a significant effect on the environment and a huge cost to authorities charged with the responsibility of providing safe and effective road transport systems. Erosion and sedimentation is evident in many forms: rills and gullies on the road surface; gullies and sedimentation within road corridors; clogging of associated infrastructure such as pipes; culverts and drains; destruction of standing vegetation; and the degeneration of pasture and crops on adjacent lands. Turbidity, contamination and salinity in sub catchments are the less evident aspects of road corridor erosion.

The Causes
Exposure of the underlying soil layers leaving soil particles subject to raindrop impact, overland water flow, concentrated flow and wind erosion.

The Solutions
Planning and operator awareness is the key to prevention and the mitigation of road corridor erosion. The initial road design should consider the "big picture", where does the water come from, where does it go, how will the flow pattern be affected by works on the ground? How to mitigate the impact on existing works given the limited area to work with on road easements? Liase and communicate with landowners adjacent to the road, they may benefit from road works. Operators need to understand the benefits of leaving disturbed ground rough to encourage plant regeneration and a comprehension of the erosive capacity of water.

Travel any road or track, sealed or unsealed, in any State or Shire, and you will see erosion and sedimentation occurring. Some erosion and sedimentation is glaringly obvious; other cases are less evident.

Erosion is a natural process that has occurred over millions of years, although this process has been accelerated by human development through continued use of the land as we work it or travel over it.



Plate 1. Excellerated erosion due to landuse

Road corridors generate massive volumes of sedimentation. For this sedimentation there is an equal amount of erosion occurring for which there will be a cost in monetary terms to repair and maintain. The other often unseen cost is to our fragile ecosystem.

Run off from a gravel road yields 60% of annual rainfall; 90% for a sealed surface. Where does this water go as it is shed from the road surface? Into an often less than adequate drainage system within the road corridor and beyond.

If water diversion works are incorrectly designed and poorly located, the unrestricted flow can generate massive amounts of erosion and sedimentation.

- A section of gravel road 10 metres in width and one (1) kilometre in length can yield up to 15 tonnes of sediment annually.
- The same section of road can yield from its surface up to 10 megalitres or 1,000,000 litres annually.

The massive yield of both sediment and water subsequently flows, sometimes at considerable speed, into the infrastructure supporting the carriageway. A doubling of run off volume equates to a fourfold increase in the detachment and transportation of soil particles.

- An eroding table drain 0.3 metres wide, 0.3 metres deep and 200 metres in length can yield 18m^3 or 27 tonnes of material.
- A gully resulting from a poorly located mitre drain, 1.5 metres wide, 1.5 metres deep and 200 metres in length will yield 675 tonnes of material or 56 tip truck loads.

This material will then move on down through the catchment choking streams and causing extensive damage to the ecosystem.

THE EFFECTS of erosion and sedimentation on road and track infrastructure include:

- Road trafficability, safety and vehicle damage.
- Unserviceable pipes, culverts and bridges due to undermining, siltation and damage as a result of the volume of water exceeding design capabilities.
- Gullies affecting road stability.
- Gulling and sedimentation affecting fencing and other structural works.
- Sediment deposition altering flow patterns in drainage lines within the road corridor and in adjoining lands.
- Sediment deposition on native vegetation affecting germination and growth rates.
- Sediment deposition on crops and exotic pastures affecting germination, growth rate and yields.
- The proliferation of noxious weeds as a result of silt deposition and the exposure of potential seed beds by gulling and sheet erosion.
- The destruction of habitat in riparian zones by altering the ecosystem.
- The turbidity of streams and the effect on water quality downstream.

THE COST in dollar terms of inadequate planning, location and maintenance include:

- Higher maintenance costs for the road surface and shoulders due to the need for regravelling and frequent grading as a result of inadequate surface drainage.
- Higher maintenance and repair costs to the supporting drainage system due to steep grades and/or large volumes of water.
- Erosion extending outward from the carriageway; its effects multiplying as volume and velocity increase. It is costly to replace eroded material and to armour drains with rock, jute mesh, concrete or bitumen.
- Replacement of damaged fencing and barriers.
- The cost of clearing blocked pipes and culverts of sediment and debris.
- The cost of re-shaping, mulching and seeding of gullies and exposed batters.
- The cost of dam de-silting.
- The cost of re-constructing riparian habitats.
- The cost of compensation for vehicle damage and personal injury.
- The cost of compensation for rehabilitation of degraded pasture and cropping land.

THE COST to the environment may include:

- Destruction and degradation of riparian habitat through sedimentation and turbidity.
- Destruction and degradation of vegetation by siltation, salinisation and the undermining of existing vegetation.

THE CAUSE of erosion within road corridors may be due to one event or a culmination of many factors. The erosion of soil primarily by water is the detachment and transportation of soil particles, and their deposition at another location. This is a natural process but can be accelerated through changes to how we use the land, more especially through removal of the soils armouring (vegetation and rock cover) and changes to drainage patterns.

The single most important factor is the removal of topsoil leading to a reduced vegetative cover and restricted infiltration of water into the soil. The topsoil contains the necessary elements, organic material, nutrients and minerals to promote the healthy growth of plants.

The reduction of vegetative cover, and the breakdown of soil structure through compaction and reduced organic matter, reduces the capacity of water to infiltrate the soil. As a result rainwater will run off; soil particles will be detached through raindrop impact and will be transported by the flow. Run off occurs when the rain intensity is greater than the soil infiltration rate. Soil particles contained in the topsoil have a greater capacity to cling together and resist the detachment by raindrop impact and overland flow.

Raindrop splash erosion occurs when drops falling on bare soil break individual soil particles loose, allowing them to be picked up and carried by subsequent run off. These particles settle, and due to their minute size, block water and air pathways into the soil, resulting in decreased infiltration and a greater increase in run off (Figure 1). This effect will also influence the ability of germinating seeds to push through this barrier and will deny roots of their ability to breathe.

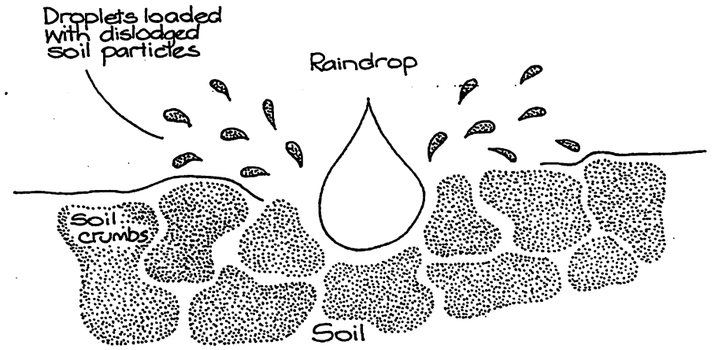


Figure 1. Effect of rain drop splash on bare soil

The velocity and size of raindrops determine their ability to dislodge soil particles. The higher the intensity of the rain event, the greater the destructive power of the rain drops. Other factors affecting the magnitude of splash erosion include the steepness of slope (grade), the length of slope, soil type and vegetative cover if present.

Vegetative cover and surface litter including stones in gibber desert areas absorb energy from rain drops reducing the amount of soil splash. In addition, the cover reduces the amount of direct contact between the drops and the soil surface. Increasing the roughness of a soil surface also tends to reduce the impact of splash (Figure 2).

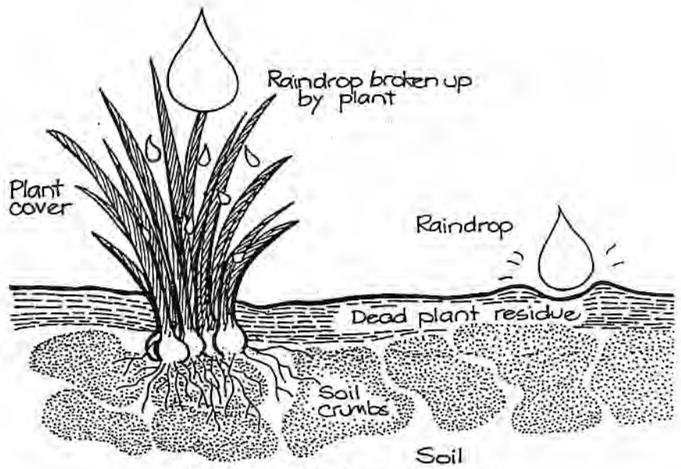


Figure 2. Effect of vegetative cover

Sheet erosion occurs when loose or detached soil is transported in a uniform layer, with no channelised flow. Small particles are carried in suspension, while larger particles are "bounced" along. Sheet erosion, in a road corridor, can be the result of heavy compaction due to concentrated vehicle movement along a hard track, or around a camp compound.

Blading off the vegetative cover and continued deposition of fine silt over a given area can also cause sheet erosion.

A substantial vegetative cover and/or surface litter will protect the soil surface slowing the velocity of run off allowing water to infiltrate.

Rill erosion occurs when water concentrates into small channels and is flowing quickly. Rills are generally no more than 30 centimetres in depth. They however can be quite long and numerous over a given area.

Water flows more quickly in a rill because it is concentrated. This increases the detachment and transportation of soil particles. The faster water travels, the greater its scouring and cutting force. Rills often lead to the formation of gullies. Rills can occur on cut and fill batters, in table and mitre drains, and below water floodout points.

Rill erosion can be mitigated by diversion of run off, reducing the volume of flows, or by using vegetation and ground cover to spread the flow over a wider area, reducing its velocity.

Gullies occur when rills become deeper channels. Gullies flow intermittently during and/or shortly after rainfall events.


Plate 2. Erosion of drainage line with gully head (overfall)

The formation of gullies begins with the scouring of topsoil within a channel. The gully head then usually moves upslope due to the incision by concentrated run off or slumping caused by subsoil dispersion. This causes the channel to become longer and wider. A waterfall may form at the gully head (overfall), which can lead to undercutting and further slumping of material into the gully floor, also contributing to gully head advancement.

Run off may enter a gully from the sides, causing secondary gullies or branching. When this occurs, the erosion is classed as severe.

Factors include the slope of the channel (the steeper the slope the greater the erosive power of the flow), and the size and shape of the gully. Other factors affecting the rate of gully erosion are the size and nature of the catchment, the soil type and vegetation.



Plate 3. Erosion on drainage line with branches

The most significant factor in causing erosion is the disturbance or removal of the all-important vegetation cover and topsoil layers. The major outcomes that follow are:

- Detachment of soil particles by raindrop impact.
- Surface sealing by rain drop impact.
- Overland flow.
- Channelled flow.
- Exposure of dispersible, highly erodible, subsoil layers.
- Progression of gullies.
- Sedimentation.

These factors can be exacerbated by incorrect or inappropriate road construction and maintenance works including:

- Concentration of flows by failing to divert run off, reduce the 'length of run', or reduce velocity and volume, along table drains and mitre drains.
- Concentration of flows toward unstable areas such as existing gullies and non vegetated areas.
- Using 'V' shaped drains rather than flat bottom or parabolic drains.
- Channel grades too steep.
- Gradual lowering of the road surface below natural ground level making drainage difficult.
- Inappropriate flow disposal points.
- Road verge windrows not allowing flow to disperse into surrounding vegetation.



Plate 4. Eroded road surface below natural ground level

THE SOLUTIONS

Sound planning from a soil conservation perspective is essential for proposed construction upgrading and maintenance programs.

The solutions to preventing and mitigating erosion and sedimentation are varied and complex. Sound planning is the first step toward minimisation of soil erosion and lowering of maintenance costs. An understanding of the erosion process and the methods used to mitigate the impact of erosion on road corridors is essential for planners and also machine operators. Monitoring and evaluation by operators will lead to a greater understanding and an involvement or 'ownership' of planning and maintenance programs. Additional funding spent in the initial stages of construction or upgrading road systems will mean less expenditure for future maintenance budgets.

PLANNING FOR PROPOSED WORKS

Look beyond the corridor and view the 'big picture'.

When planning for proposed works, the physical attributes of each catchment will need to be taken into consideration. Proposed developments and activities should be compatible with the local soils, climate, vegetation and landform characteristics (slope, drainage patterns, general and local topography, rainfall patterns etc.).

Recognising the capability of different areas allows for the protection of sensitive areas and the appropriate design of required works.

A field inspection is the best way of confirming the suitability of land for road works and should always be used in conjunction with other available information, such as:

- Aerial photographs.
- Topographical maps.
- Land capability surveys.
- Land resource surveys.
- Soil survey maps.
- Local knowledge.

Field inspections should view the catchment above the corridor to determine the size of the catchment, soil type, vegetative cover and landuse. From these observations and by using other known factors, technical details such as catchment yield for a particular storm event can be calculated. Local knowledge is another relevant indicator of catchment volume and flowpath. Calculations can be made for the capacity of pipes, culverts, open drains and drop structures.

Inspection of the catchment above the road will also reveal the flow pattern of water not only in defined watercourses but also overland flows that will have an impact on drainage works and road elevation.

An inspection of the catchment immediately below the road corridor may reveal environmentally sensitive sites and other issues that may impact upon the proposed works.

Areas of erosion, both active and inactive; areas of erosion hazard requiring stabilisation works, such as chemical treatment for the soil; and areas of ecological and Aboriginal significance should be taken into account and recorded on a base plan.

During the planning stage records should be made with regard to the location of drainage works, in particular mitre drains to intercept table drain flows, and catch drains to divert flows from cut batters.

DRAINAGE

Road surface drainage is dependent upon the free flow of water from the sides of the road, and provision for safe disposal away from the road alignment.

The most effective method of taking water off the road surface is by **crowning** the road, which produces a low-grade fall from the centre line to both sides of the carriageway. For greater efficiency the crown of the road will be higher than the natural surface. Water can then be dispersed onto stable areas along the road verges, or into table drains.

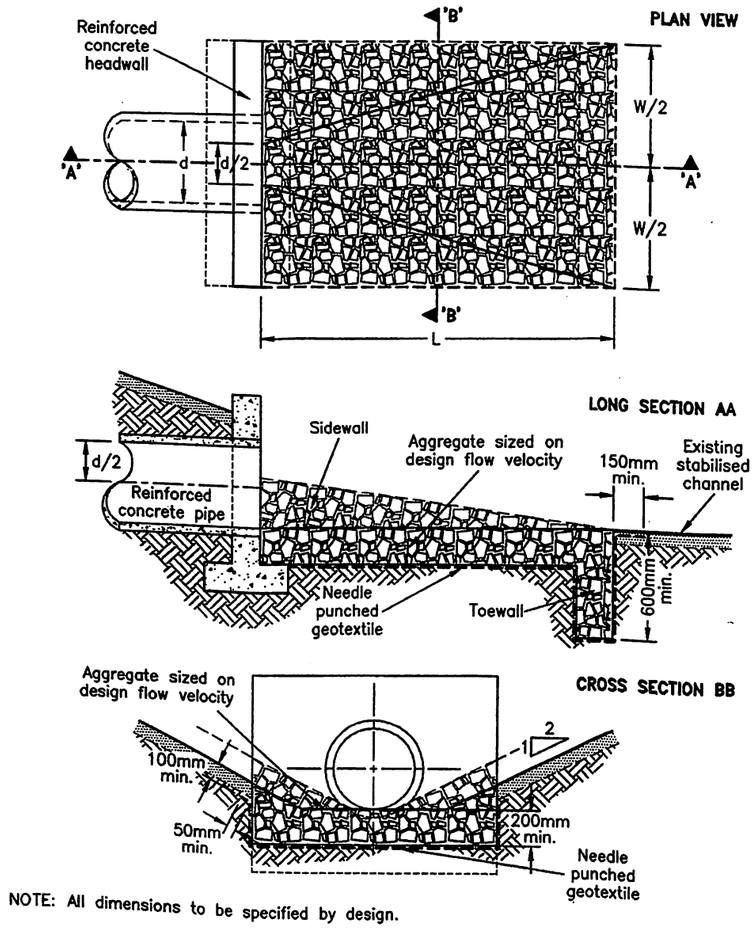


Plate 5. Road shaping and crowning

If the road surface is below natural ground level, it will tend to collect and concentrate run off, and act as a drainage line. This can lead to severe scouring, and sediment deposition where the flow slows down. This situation may be aggravated by continual grading with no effort to divert flows from this 'drainage line'. On roads where traffic is lighter and less frequent cross fall drainage can be used. Generally these roads are constructed across the slope and parallel to the contour. As the name implies the flow is directed over the road surface for disposal on the lower side of the road. Outfall drainage is preferable to infall drainage (inclining the road into the slope). Where infall drainage is necessary, then table drains and culverts must be constructed to eventually direct the water to safe disposal points on the down slope side.

Cross fall drainage should be as flat as possible while still ensuring adequate drainage. If the fall is too steep, then scouring will occur. If the fall is too flat water will pond on the road surface. A grade of 1% (one (1) centimetre in one (1) metre) is recommended.

Box culverts and pipe location, spacing and type required will depend on the flow volume, soil erodibility and the extent of other drainage works. Culverts will require armouring on the inlet and discharge point to prevent undermining and road collapse. The area below the outlet will require physical protection so that velocities are reduced to non-erosive rates at the natural ground surface. This protection can be achieved by armouring the drain downstream of the outlet or by constructing a dissipating device. The armouring or dissipation must be established at existing gully level to avoid creating an over fall. (Figure 3)



NOTE: All dimensions to be specified by design.

Figure 3. Pipe outlet protection rock construction

Table drains when constructed along roadsides should be 0.6 to 1.0 metres wide at the base with side batters built to a three (3) horizontal to one (1) vertical ratio (Figure 4). They should be grassed as soon as possible after construction. Grassed table drains should not be graded as grading destroys established vegetation (armouring), weakening the surface and increasing the risk of erosion.

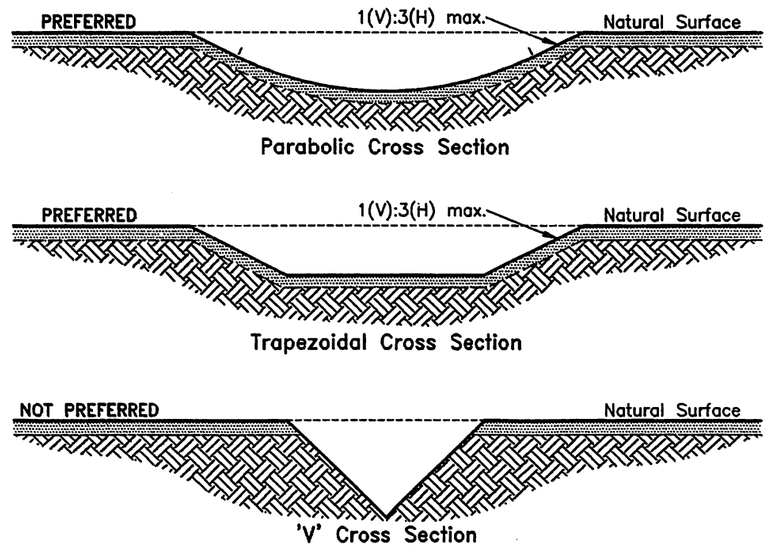


Figure 4. Typical earth drain cross sections

Where grass is difficult to establish, and mulch does not provide enough protection, there may be a requirement for rock lining, fibre matting or turfing of the channel.

Where steep slopes cannot be avoided, further protection in the form of rock and concrete lining, or the construction of drop structures may be required.

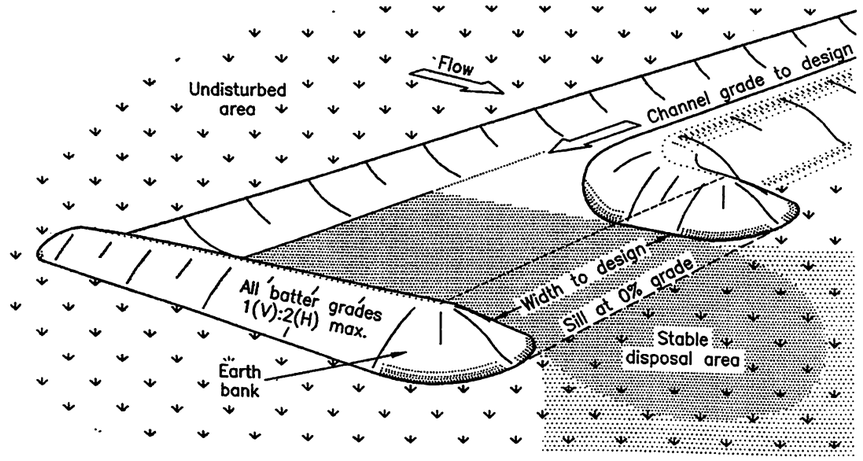
Mitre drains should be used to take water out of table drains at regular intervals. Mitre drains divert run off from table drains (or directly away from road shoulders where table drains are absent), and dispose of the flow away from the road alignment into stable disposal areas.

Mitre drains are important because without them water will accumulate in table drains, increasing in volume and velocity. As velocity increases then so does the erosive power of the flow.

Mitre drains should be constructed so that they have a broad flat base in excess of one (1) metre wide (or wide enough to accommodate machinery), with side batters built to a three (3) horizontal to one (1) vertical ratio (Figure 4). Mitre drains constructed with a 'V' base are prone to eroding or accumulate silt and require frequent cleaning. Frequent cleaning with a machine may expose underlying soil and destroy any established vegetation.

Although more difficult and time consuming to construct, trapezoidal shaped channels require substantially less maintenance, and vegetation can be left to establish, reducing the risk of erosion.

Drains must slope downwards to facilitate the flow of water. To keep velocities at non-erosive levels, the grade of the channel should be no greater than 1% (25 centimetres in 25 metres). Mitre drain outlets are areas of concentrated flow and therefore it is very important outlets have a level (surveyed) and unimpeded sill and are located in stable undisturbed areas (Figure 5).



NOTES: Without design level spreaders (or sills) are limited to a minimum width of two (2) metres.
Compact bank and revegetate after construction.

Figure 5. Level spreader (or sill)

Spacing will depend upon local factors such as soil erodibility and topography, but a rule of thumb measure is every 50 metres for slopes less than 3% and every 25 metres for slopes greater than 3%. Drain placement should commence at the top of a slope and proceed at regular intervals downhill.

Road Batters

Where cut road batters have been formed 'V' channels may have been cut to protect the exposed batter. Often with these drains, eroding is due to the steepness of the grade. If drains are required above the cut batter they should be constructed on the contour so as to reduce the grade. If this is not achievable due to the confines of the road corridor, several short drains may be constructed spilling the flow from one to another below, until safe disposal can be achieved. Alternatively, cut batters should be top soiled and hydro-mulched/seeded to provide protection from erosion.

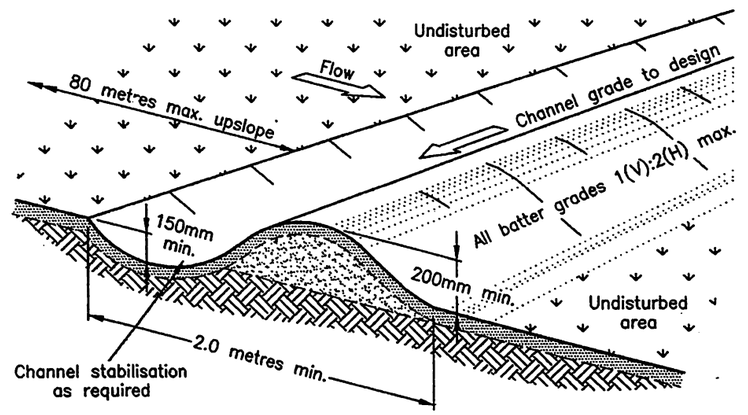
Benches or ledges can be cut horizontally across the face to step the cut batter. Water must be diverted to stable disposal areas.

It is essential that cut and fill road batters are progressively topsoiled to establish a protective vegetative cover.

Creek Crossings and Drainage Lines

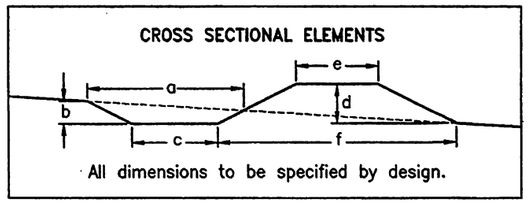
Table drains on roads approaching creek crossings and drainage lines need to be diverted into the vegetation via mitre drains well before the defined flow line. This will allow run off to spread, dropping the sediment load prior to entering the main flow line.

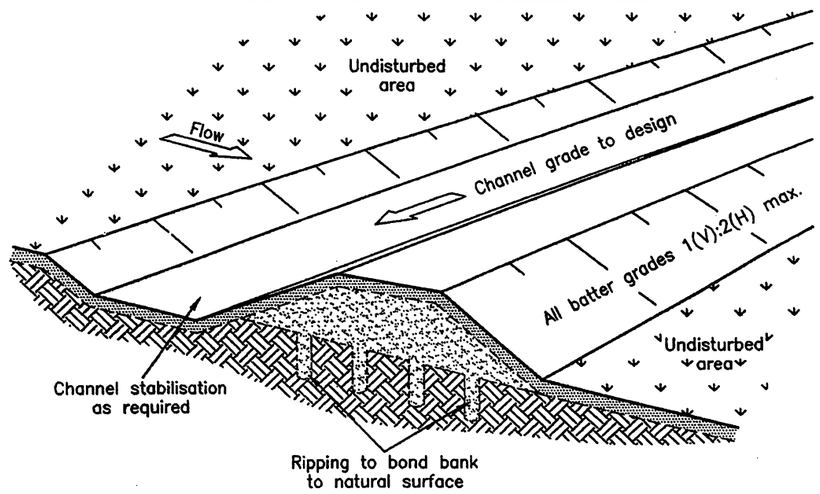
Diversion banks may be required to divert flows away from the carriageway or to carry flows from the road works to a safe disposal point. The same conditions apply as for table and mitre drains with regard to channel grade, channel shape and the armouring of channels, if high volume flows cannot be avoided. (Figure 6, Figure 7)



NOTES: Without design, earth banks (low flows) are limited to slopes less than 10% and maximum upslope length of 80 metres.
Compact bank and revegetate after construction.

Figure 6. Earth bank (low flows)





NOTE: Compact bank and revegetate after construction.

Figure 7. Earth banks (high flows)

CONSTRUCTION

The expected usage and life of a track will determine its standard of construction. When funds are limited, it is more economical, long term, to build shorter sections of well designed road than to build longer sections of road that will require repeated maintenance and rehabilitation work. This is where longer term planning is beneficial; saving money, time and minimising environmental damage.

It is preferable to involve operators in all aspects of the pre-construction stage so that they have a complete understanding of the outcomes for the project.

Some points to consider:

- Stockpile topsoil for later re-spreading.
- The work area should be progressively drained and rehabilitated as work proceeds.
- Minimal disturbance to areas outside the construction area.
- Machinery to be kept out of creeks and drainage lines.
- Minimise damage and disturbance to vegetation.
- While sown or natural grasses are establishing within drainage lines, surface protection in the form of hay mulch, hydro-seeding, matting or mesh products (Figure 8) should be used to provide immediate protection. Where vegetation is not suitable, permanent products such as rock and concrete may be required.

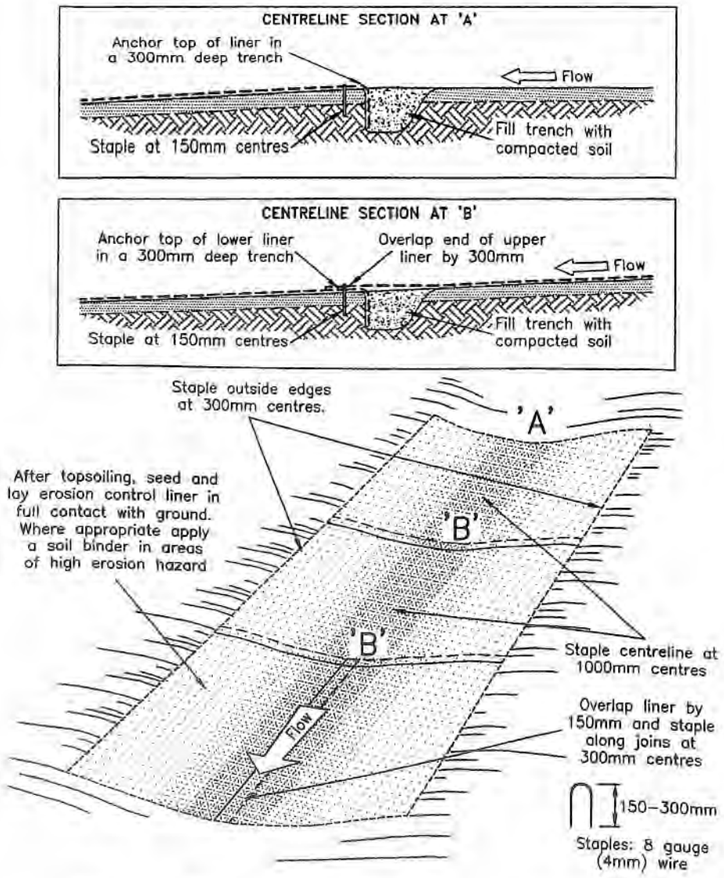


Figure 8. Flowline protection technique erosion control liner

EXISTING WORKS

Roads should be routinely inspected to identify existing and potential problems. Look beyond the road corridor.

Consider the points covered in the previous 'planning' section.

When carrying out regular maintenance, the following points should be kept in mind:

- Windrows on the road verge should be removed, as water cannot flow freely off the road as it concentrates and causes erosion.
- Ensure mitre drains and table drains are not blocked after surface grading of the road shoulders in order to avoid carrying more material from road corridor.
- If table drains and mitre drains are showing signs of scouring or erosion re-evaluate the situation.

Some common problems with drains.

- Is the grade too steep? – survey and relocate or armour the channel.
- Is the volume too great? – construct additional drains.
- Is the channel 'V' shaped (too narrow)? – convert to flat bottom minimum width one (1) metre.
- Is there erosion at the ends of mitre drains? – excessive amounts of water being concentrated or discharged onto unstable areas. These drains will need to be rehabilitated or relocated. Engineered drop structures may be.



Plate 6. Table drain with excessive grade and length

Other problems:

- Erosion around culverts is generally caused by inadequate protection of the inlet or outlet or because the volume of water is too great. Permanent repair may include loose rockwork, rock mattresses and gabion baskets, or concrete and/or culvert replacement/enlargement.
- Riling or gullying down the sides of the road may be caused by the run off being unable to disperse into surrounding vegetation. Mitre drains constructed at appropriate intervals will redirect water. If mitre drains are already present they may be blocked or too far apart. Existing mitre drains should also be checked to ensure they are properly surveyed and not sloping back onto the road.
- Check culverts for blockages.
- Level sills and armoured outlets should be checked for scouring. Survey and reconstruction may be required.

REVEGETATION

As discussed elsewhere in this document a protective cover of vegetation is essential in preventing the erosion of disturbed areas.

Revegetation may be a low key activity such as hand broadcasting a suitable seed type, including native trees and shrubs, over disturbed areas as work progresses. On the other hand using a hydro-mulcher to treat large and difficult areas; for example steep cut and fill batters.

The area to be treated should ideally be a rough loose surface (Figure 9) and not hard compacted with a smooth drum roller for example. A loose or rough surface will allow the broadcast seed to fall into cracks and crevices and when it rains or the area is watered, the seed will be covered by the crumbling action of the soil. This then will give the germinating seed protection from the drying sun; will allow roots to penetrate and the plant to establish.

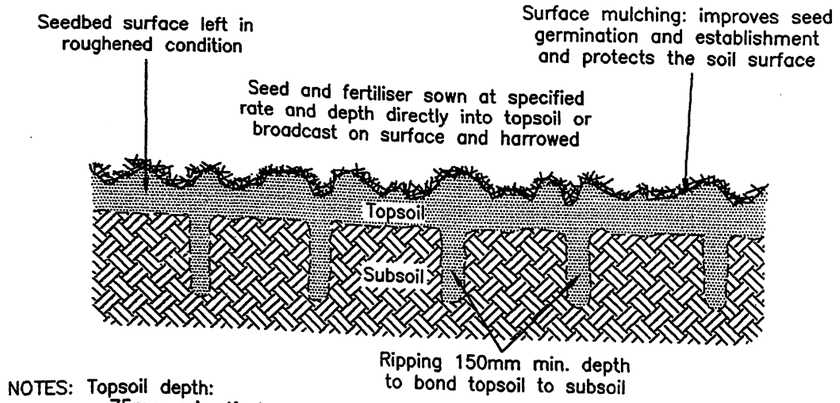


Figure 9. Seedbed preparation

With application of seed and fertiliser a mulch will also provide a protective cover for the germinating seed with the mulch (70% ground cover recommended) providing a barrier against the effects of raindrop impact and surface sealing.

Advice can be sought from seed suppliers, local agronomists and other local authorities, such as Greening Australia, as to the more suitable seed to be used based on the season, tolerance to conditions, new varieties and availability. Native, exotic, shrub and tree varieties may be used as well as tube stock.

Revegetation and rehabilitation should be progressive although may be dependant upon seasonal conditions.

MAINTENANCE

Maintenance in the upkeep of an area or system should be to a pre-determined standard. This allows the continued use of the land without its decline or degradation.

Regular maintenance is an important part of managing for soil conservation, as it keeps systems functioning in the way they were designed, or allows systems to be modified and changed according to the effects of use and the elements.

A regular maintenance program will help to avoid unexpected and expensive repair work.

Regular inspections or monitoring of road systems will reveal the first indications of decline and degradation, and problems can be treated before permanent damage occurs.

Areas to be monitored include:

- Newly developed areas.
- Areas surrounding new developments - especially down slope.
- Environmentally sensitive areas such as wetlands and vegetation stands.
- Erosion hazard areas.
- Sites of existing soil erosion.
- Heavily used roads and tracks.
- Rehabilitation areas (to see if the rehabilitation is working as planned).

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GLOSSARY OF TERMS

Armour	A layer of material placed on the soil surface to protect it from erosion. Includes concrete, rock, geotextile, gabions, reno mattresses and turf.
Batter	An earth slope formed from placed fill material or cut into natural hillside, during road construction.
Blading off	The removal of the top layer of soil and vegetation.
Cross fall drainage	Drainage which occurs when the surface of a road, trail or other access-way has sufficient cross slope to cause the water to flow across and off the surface, rather than along it.
Culvert	One or more adjacent enclosed conduits for conveying a watercourse, stream or run off underneath a roadway or other structure.
Disturbed area	An area which is susceptible to erosion because the vegetative soil cover has been removed or altered. This may be accompanied by mixing or removal of some soil horizons.
Drainage line	A channel down which surface water naturally concentrates and flows, conveying water only during and/or immediately after periods of rainfall. Drainage lines may be stable and grassed or unstable as in an active gully.
Drop structure	A hydraulic structure to allow water to fall to a lower level and have its energy dissipated so as not to cause erosion.
Dissipater	A device at the base of a channel or running water that will dissipate the energy (velocity) of water by spreading the water over a large area. They may be constructed from rocks, logs and concrete blocks.
Erosion	In this document it refers to accelerated erosion due to earthmoving operations. These guidelines aim at minimising any acceleration of natural erosion.
Ground cover	A vegetative layer of grasses and/or other low growing plants or plant residues providing protection to the soil against erosive agents.
Headwall	A watertight barrier at the entrance to a structure such as a pipe or culvert, to prevent seepage from undermining the structure.
Hydro mulching	The procedure where by a mixture of seed fertiliser and a mulch material in applied in a water slurry to exposed soil surfaces for revegetation surfaces.
Mitre drain	A drain to conduct run off from a road shoulder or table drain to a safe disposal area away from the road alignment.
Mulch	A natural or artificial layer of plant residue or other material on the soil surface, which provides protection against erosion and aids plant establishment mainly by restricting moisture loss.
Outlet	The point at which water discharges from a river, creek or other flowline; lake, tidal basin or drainage depression; or pipe, channel, dam, or other hydrologic structure.
Rehabilitate	To return an area of land or a road or track surface to an original, proper and stable condition. This may involve reshaping, spreading topsoil, construction of banks and revegetation.
Revegetate	The re-establishment of plants on ground that is depleted or devoid of vegetation, by either natural regeneration or sowing with seed and fertiliser mixture, in order to provide protection against erosion.

Run off	That portion of the precipitation falling on a catchment area that flows from the catchment past a specified point.
Sill	A horizontal or level section at the outlet of a soil conservation or hydrologic structure which spreads water flowing from the structure, hence preventing it from concentrating and forming gullies.
Stabilisation	The provision of adequate measures, vegetative, structural and/or mechanical, to prevent or control erosion.
Table drains	The side drain of a road adjacent to the shoulders and comprising part of the road formation.
Topsoil	That part of the soil profile, typically the A1 horizon, containing material which is usually more fertile and better structured than underlying layers. Topsoil is the most important part of the soil with respect to growth of pastures and crops and its loss or degradation represents the most serious aspect of soil erosion. Its retention is particularly important in the revegetation of exposed batters or earthworks.
Windrow	An accumulation or mound of soil material on the edge of a road or snig track usually formed by spillage from the edge of a bulldozer blade or other similar machinery during earthmoving operations. Windrows may also be formed by general log snigging operations.

WEED CONTROL METHODS AND ROADSIDES

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ABSTRACT

Use of one method alone to control many weeds on roadsides can be a waste of money and time as well as being damaging to the environment. All roadsides are different so the methods used to control weeds on roadsides must vary from area-to-area.

The following paper describes the influence of local factors in deciding which control method to use in which situation. The weed control methods described are based on those produced for the Bellingen and Nymboida Shire's Roadside Management / Environment Plans, both of which are located in north eastern New South Wales.

Due to the lack of funding to undertake weed control, the methods developed attempted to reduce the spread of weeds in the first place, involve all stakeholders including the community, encourage nature to do as much of the work as possible and reduce the incidence of long-term repeated spray programs. As weeds are only one issue on roadsides, it was also important that weed control did not adversely affect other issues such as protection of rare plants and erosion control.

BELLINGEN AND NYMBOIDA SHIRES

Both Bellingen and Nymboida Shires support diverse landscapes with elevations from sea level (or near sea level for Nymboida Shire) to over 1400 metres. Due to the high rainfall and warm climate in many areas the Shires provide an ideal place for weed establishment. The worst noxious weed near the road pavement on roadsides in both Shires is giant parramatta grass (*Sporobolus indicus var. major*) with red-flowered lantana (*Lantana camara*) the worst away from the pavement. Environmental weeds such as camphor laurel (*Cinnamomum camphora*) and small-leaf privet (*Ligustrum sinense*) are also widespread in some areas.

The important factor linking many of the problem weed species is that they generally need light and / or disturbance to germinate. Part of the reason giant parramatta grass is not as prolific in Nymboida Shire is because they stopped slashing most roadsides several years ago. Most roadsides now support three metre tall trees and 1.5 metre tall grasses (predominantly native). When the trees are established those grasses will be shaded out, hence reducing safety and fire risks.

The weed control methods seek to encourage native vegetation, your long-term weed control, as well as work towards minimising impact on soil and vegetation wherever possible.

THE NEED FOR INFORMATION

Substantial benefits can be gained through effective weed management planning before control is undertaken (Ward and James 1999). To do this there is a need for information. When commencing work with both Bellingen and Nymboida Shires there were no useable maps or written descriptions of the locations of weed distributions. In NSW there is now a new system for noxious weed funding where local control authorities must produce management plans before applying for funding. This is hard to do without clear weed distribution information.

As part of the Bellingen Roadside Plan, I purchased a PC-based Geographical Information System (GIS) for approximately $800 and basic maps of roads, watercourses, urban areas and topography for around $500. I utilised a GIS from Department of Land and Water whilst working at Nymboida Shire Council.

Roadside surveys were undertaken in both shires with assistance from the community. The surveys noted all weeds including, importantly, whether they were also on the adjoining land. Other features such as rare plants, heritage items and safety problem areas were also noted and an Aboriginal site survey through Local Aboriginal Land Councils was undertaken for $300 in each shire.

Weed control activities can now be undertaken knowing all relevant information. Updateable maps of any weed infestations (and other information) can now be printed out at any time and

any scale. It meant an initial outlay of money, although partly funded through Natural Heritage Trust (NHT) Grants, but will help reduce long-term costs.

CONTROL METHODS INFLUENCED BY VEGETATION

All roadsides in each shire have been categorised by the quality of vegetation.

- A category roadsides are roadsides supporting good habitat values, few weeds and generally little disturbance;
- B category roadsides generally support a mixture of natives and introduced species; and
- C category roadsides are high maintenance roadsides dominated by weeds or pasture grasses.

Weed control methods used in A category roadsides differ to those utilised in C category roadsides because of the greater need to protect native vegetation and minimise impact in A category roadsides.

Where possible, control isolated weed infestations first in an attempt to reduce the distribution of the weed.

SPECIFIC CONTROL TECHNIQUES FOR DIFFERENT SITUATIONS

A lot of weed research has found that integrated weed control, where a variety of methods are used, is by far the best form of weed control (Storrie and Cook 1999, Joseph 1999). Following is a list of some of the methods used in Bellingen and Nymboida Shires:

Weed Bug and wick-wiping techniques are used to control giant parramatta grass on some relatively flat roadsides. The technique is useful where there is a mixture of grass species. The area is slashed in around September and wick-wiped in around November. The fastest growing grasses after slashing are giant parramatta grass and (two metre) tall growing pasture grasses which cause safety problems on corners (due to the "shade producing" native vegetation being previously removed on corners for safety reasons!). The tractor-based wick-wipers can be set at whatever height so that only the taller grasses are controlled. This method cannot be used where ALL grasses are tall, as it will lead to bare earth.

One of the most important points about using wick-wipers in the above situations is that within approximately three years the roadsides are dominated by low-growing grasses, hence forming an effective weed control and reducing the need for further control. It also does not involve the spraying of herbicides, which is particularly favoured by many Bellingen Shire residents.

Selective herbicides are favoured wherever possible to encourage native vegetation and reduce the threat of weed seeds within the soil establishing. Frenock® has been used to control giant parramatta grass in undulating roadsides away from dairy farms. The replacement product Tussock®, due out in 2000, will also be used in these areas.

Swarzee grass trial plots have been established on some corners within Bellingen Shire to further restrict tall-growing grasses. Swarzee grass is a low-growing extremely competitive grass that is palatable to stock, produces few or no seeds and spreads slowly.

Community Assistance

The community can assist in weed control activities. This has been found to be extremely successful in Tasmania where community action is the main force behind weed control activities in the Tamar valley area (Welsh et. al. 1999).

In Bellingen Shire there are many certified organic properties and others against the use of herbicides in their area. "No spray zone" signs have been erected by these landholders and they are encouraged to control weeds themselves through "Adopt-a-road" agreements. Some roadsides that are either weed free or heavily infested are increasingly being slashed by

landholders in both shires. By slashing their own roadsides they further reduce the spread of weed seeds.
Mulch/wood chip has been used to help stabilise sites and reduce weeds, especially following tree removal. This can only be used in relatively flat areas so that it does not cause drainage problems. It is particularly good near native vegetation.

Significant roadsides supporting rare plants or high conservation value vegetation are given a high priority for control and are often areas supporting few weeds. The methods used must ensure that native vegetation is protected. Non-chemical methods are used wherever possible.

Stem-Injection, Cut-Stump and Cut, Scrape and Paint

Before the Roadside Plans both shires had used one basic method to control all weeds, ie herbicide spraying. In some situations stem-injection, cut, scrape and paint or cut-and-paint are the best control methods to use. Staff were encouraged to use these methods where practicable. These methods are the best control method to use for many environmental weeds such as camphor laurel, small-leaf privet and madeira vine (*Anredera cordifolia*). As there is no noxious weed funding available for most environmental weeds there is a need to encourage community assistance. This process has commenced through holding field days. Council staff are encouraged to control them whilst undertaking other activities wherever possible.

MINIMISING THE OCCURRENCE OF WEEDS

Lack of funding for environmental weeds highlights the important need to reduce opportunities for weeds to establish in the first place. Production of Roadside Management /Environment Plans includes the training of staff on ways to minimise impact. Since implementing training some New South Wales and Victorian councils have been able to reduce road construction costs in the short-term by up to 2% per year (Connor, pers. comm. 1999; Lewis, pers. comm. 1998). This has mainly been due to doing the job right the first time. This figure does not even include reduction in weed expenditure. Weeds love disturbance so the less disturbance the less weeds. Weeds usually grow faster than natives so less weeds means less maintenance. Some ways that Council staff are able to reduce the spread of weeds and save money are:

- Don't "clean up" the site after roadworks;
- Mark out and stay within construction areas;
- Use the smallest machine suitable for the job;
- Trim trees using the three-cut method in significant environments instead of a bank slasher. This reduces disease in trees, looks more attractive and stops the slashing and hence "growth explosion" of small-leaved privet; and
- Brush off or hose down vehicles / machinery before leaving weed infested sites.

RECOMMENDATIONS (TAKE HOME MESSAGES)

- Take a step back before undertaking weed control. Have a look at the impacts of your activities and ways that you may be able to do it better;
- Train staff in ways of minimising their impact on roadsides so that you aren't controlling the weeds that they are spreading!
- Work with the community and public utility organisations. Weeds are everyone's problem!
- Encourage native vegetation wherever possible; and
- Utilise a range of weed control methods depending on the situation.

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USE OF HERBICIDE TO CONTROL WEEDS IN TRANSPORT CORRIDORS

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ABSTRACT

Herbicides provide an efficient and effective means for controlling vegetation on linear transport reserves. Used correctly, and as part of an integrated approach to vegetation management, herbicides can afford many benefits to transport corridors - including enhancing and protecting their ecological, cultural, landcare and economic values - at minimal costs to both management organisations and the natural environment. Herbicides are a vital tool in the management and preservation of vegetation within linear reserves. However, like any workman's tool, herbicides are most efficient and effective when they are used correctly. An inaccurately wielded axe can create unnecessary damage, waste time and money - so too can incorrectly wielded herbicides.

The efficacy and safety of herbicides within corridors depends upon those dealing with the herbicides knowing five important factors:
1. knowing the weeds to be dealt with;
2. knowing the herbicides (and appropriate equipment) available for use;
3. knowing the situation in which the control crews and herbicides will be operating;
4. knowing the qualifications, responsibilities and capabilities of staff and contractors;
5. knowing the operations procedure to be used.

Knowing the importance of following these procedures and documenting work actions in order to satisfy duty of care responsibilities and also to allow for monitoring, evaluation and necessary follow up.

The following paper discusses the importance and practicalities associated with considering and implementing these five important factors when using herbicides within transport corridors. It will also briefly outline those steps transport corridor vegetation managers and controllers can take to ensure that herbicides are used efficiently and effectively within corridors - with minimal costs to the environment and management organisations.

INTRODUCTION

Herbicides provide an efficient and effective means for controlling vegetation on linear transport reserves. Used correctly and as part of an integrated approach to vegetation management, herbicides can afford many benefits to transport corridors - including enhancing and protecting their ecological, cultural, land care and economic values - at minimal costs to both management organisations and the natural environment. Herbicides are a vital tool in the management and preservation of vegetation within linear reserves.

However, like any workman's tool, herbicides are most efficient and effective when they are used correctly. An inaccurately wielded axe can create unnecessary damage, waste time and money – so too can incorrectly used herbicides. The efficacy and safety of herbicides within corridors depends upon those dealing with the herbicides knowing five important factors:
1. knowing the weeds to be dealt with;
2. knowing the herbicides (and appropriate equipment) available for use;
3. knowing the situation in which the control crews and herbicides will be operating;
4. knowing the qualifications, responsibilities and capabilities of staff and contractors; and
5. knowing the operations procedure to be used – knowing the importance of following these procedures and documenting work actions in order to satisfy duty of care responsibilities and also to allow for monitoring, evaluation and necessary follow up.

KNOWING THE WEEDS TO BE DEALT WITH

It is important to correctly identify and become familiar with significant weed species in the linear reserve. It is important to know the plants:
1. ecological, economic and/or social significance and classification (eg. environmental or declared weed) and obligations regarding their control; and
2. form or growth habits in the field and basic ecology – flower, seeding and growth times, distribution mechanisms and habitat or area of the corridor where the weed is likely to exist.

Knowing why a particular plant species is a problem can assist in:
- determining the level of control and/or extent of control needed to be gained from the use of a herbicide;
- determining resources, equipment and methods used to apply the herbicide; and
- what type of herbicides can best deal with the problems caused by the weed.

Information about the significance of weed species within a certain area can be obtained from sources such as:
- the Department of Primary Industries CD-ROM packages "Infopest – pest management information system" and "Woody Weeds Adviser";
- Department of Natural Resources "Pest Info' and local land protection officers and "Pest Fact" sheets;
- Community groups such catchment groups and Greening Australia;
- publications such as "Weeds of Queensland" and "Flora and Fauna of South East-Queensland" and local government weed management strategies; and
- various Internet sites.

Information about the significance of weed species can also be obtained from its classification status. Declared weeds are likely to have economic or social significance, while environmental weeds are likely to have greater environmental significance - although there is no hard and fast rule to the impacts weeds generate.

Classifications can assist in determining the urgency and levels of control required – and therefore assist in prioritising and focusing weed control efforts.

The two basic weed classifications are:
- declared weeds – "pest plants targeted for legislative control, which have or could have serious economic, environmental or social impact. Declaration imposes legal responsibilities for control – under the Rural Lands Protection Act, all landholders, local government and state government agencies are required to control declared plants on land under their control." (Department of Natural Resources Pest Fact, Declared Plants of Queensland, May 1998); and
- environmental weeds – "Those species that invade native communities or ecosystems - they are undesirable from an ecological perspective, but not necessarily an economic one. Serious environmental weeds are defined as those that cause major modification to species richness, abundance or ecosystem function. Very serious environmental weeds are those that totally destroy an ecosystem." (Humpheries, et al. 1991 in Csurhes and Edwards, 1998).

These classifications can be further refined to suit control efforts on varying local, state and/or national levels, and may include classifications under particular management strategies or policies, such as the National Weeds Strategy or local council by-laws. Weed classifications are however only as good as the data they are based upon. Data may be incomplete, its integrity and the methods used to collect it may be questionable and where data is scarce, classifications (such as potential risks associated with a species) may rely heavily upon anecdotal evidence. Nevertheless, classification provides at least some guidance to the legislative and environmental importance of controlling a weed species and it can assist in focusing and justifying weed control efforts.

Knowing the different forms or growth habits of a weed can help avoid mis-identification and consequent non-target fatalities, or the use of incorrect herbicide types and application methods. Uptake rates and quantities of herbicides will vary between horizontally and vertically growing stems, between stem diameters, between age cohorts of plants and also between cultivars of species.

Knowing the basic ecology of the weed species – such as flowering and seeding times, other reproduction methods, dispersal mechanisms and growth seasons - can also assist in determining the most appropriate herbicide application methods and the best times to treat. Knowing where a weed is likely to be found can help concentrate control efforts and prevent herbicide wastage and non-target damage. Other information that may be of assistance includes country of origin, scientific name, distribution and its importance in particular industries (eg. such as a landscape plant, or as an agricultural escape).

KNOW THE HERBICIDES AVAILABLE FOR USE

Herbicides should never be used simply because they are "on the shelf", (QWRC, 1981). Herbicides are precision tools – each herbicide is tailored or 'built' to suit a given set of conditions within a given situation. The efficacy of a herbicide is a result of its interaction with the plant species or plant form, the herbicide application method and rate, the accuracy of the application and the environmental conditions existing in the situation. Incorrect herbicide usage increases health and safety risks, decreases herbicide efficacy and wastes valuable time and money. Herbicides should be chosen carefully and they must be used according to label instructions. Choosing the right herbicide to use may be made less complicated by knowing:

1. the type of herbicide, its purpose and formulation;
2. the selectivity, persistence and potential herbicide hazards; and
3. the legal status of the herbicide.

Herbicide action may range from superficial defoliation to complete root and stem death, with discriminatory or non-discriminatory action. Selectivity of a herbicide relates to how well the herbicide controls undesired plants without harming desired plants. Selectivity depends upon the dose rate, formulation and plant tolerance to the herbicide (QWRC, 1981).

Persistent or residual herbicides may have usefulness in controlling weeds for extended periods of time – but they do pose certain hazards to the surrounding environment such as:

- leeching from the soil and non-selectivity;
- contamination risks to water ways; and
- restricting the uses of an area once it has been treated (QWRC, 1981).

Knowing the more immediate hazards associated with the handling, mixing and use of some herbicides can also help to minimise health risks to both the environment and operators. Herbicide hazard should not be confused with herbicide toxicity. Herbicide toxicity is a measure of the poisonousness of the herbicide (QWRC, 1981).

Many other factors render a herbicide hazardous, such as:

- target area (eg. On or near water course);
- type of herbicide (eg. Its mode of action – foliar or stem injection application);
- herbicide formulation (eg. Volatile liquid);
- concentration and dosage of herbicide; and
- conscientiousness and skill of operator (QWRC, 1981).

Herbicides used must be registered (for species and situation) by the National Registration Authority. Possession, supply and use of unregistered of unapproved active constituents is illegal, unless the NRA has issued a special permit for certain restricted circumstances. Registration of herbicides ensures that herbicides are:

- approved for use;
- correctly packaged and labelled with all necessary limitations, precautions and directions for use stated;
- that products on the market pose minimal risk to the safety of humans and animals;
- are effective when used, with no adverse effects on the environment; and
- have no unacceptable residues remaining in agriculture or in food for human or animal consumption in Australia or export markets. (NRA, 1999).

Further details on registered herbicides can be obtained from CD-ROM packages such as "Chemwatch – Chemical database and management systems" and Department of Primary Industries "Infopest – pest management information system", the NRAs' web page (http:/www.dpie.gov.au/nra/registering.html) and on-line database PUBCRIS or from herbicide formulation and distribution companies.

KNOWING THE SITUATION IN WHICH CONTROL CREWS AND HERBICIDES WILL BE OPERATING

The accuracy of herbicides is influenced by their suitability to certain situations. Factors such as those listed below will influence the type, quantity and application methods of herbicides used – if they are used at all:

- prevailing atmospheric/climatic conditions;
- season;
- geography and slope of the area;
- site access and site stability;
- presence of non-target species;
- desired use of the area;
- desired level of vegetation control;
- proximity to other land uses (eg; urban development); and
- regulations imposed on a site by state, local and federal governments.

Knowing the specifics of a situation can help prevent problems such as spray drift, run-off, non-target kills and breeches of legislation. Documenting special site situations or requirements can help to justify particular actions, project results and project expenses. Special site requirements for controlling weeds should be specified within tender contracts before weed control takes place. This allows for the development of fair contract costing and effective and efficient weed control activities.

KNOWING THE QUALIFICATIONS, RESPONSIBILITIES AND CAPABILITIES OF STAFF AND CONTRACTORS

Staff involved with herbicide use must be both capable and qualified to use herbicides. Using unqualified and incapable staff increases the possibility of breeches of health and safety and environmental protection regulations, leaves management open to prosecution and litigation and wastes time, money and resources.

All commercial spray operators should have a current Agricultural Chemicals Distribution and Control Licence (ACDC Licence) which has two levels of qualification:

- Restricted – which limits the type of application equipment and/or the type of herbicides allowed to be used by an operator; and
- Unrestricted – within the limitations imposed by the Agricultural Chemicals Distribution Control and Regulation Acts and related Acts and Regulations, operators are not restricted to any particular types of herbicides or spray equipment. As commercial operators are likely to be dealing with a variety of plants in a variety of situations, they are encouraged to obtain an unrestricted licence. In some circumstances however, a restricted licence may be appropriate (QDPI, no date).

In obtaining the ACDC licence, operators should become familiar with various aspects of herbicide use including:

- spray application methods;
- calibration processes;
- factors and conditions influencing herbicide use; and
- particular regulations and responsibilities /obligations of owners and operators(QDPI, no date).

Practical experience in spraying herbicides needs to be demonstrated before operators can be left unsupervised.

Other state and nationally recognised or accredited qualifications in horticultural, agricultural and/or environmental management are recommended (but not compulsory). Universities, TAFEs and other private educational firms frequently provide opportunities to obtain accredited certificate, diploma and degree qualifications in these fields.

KNOW THE OPERATIONS PROCEDURE TO BE USED AND DOCUMENTING WORK ACTIONS

Under various environmental, health and safety regulations and insurance requirements, weed control operators and management (private and government) have an obligation to maintain a duty of care which minimises hazards and reduces risks to the environment, staff and the public. (QDEH, 1992 and LPB, 1996)

Documented standard operating procedures and guidelines or other operational plans are an effective means of ensuring that a duty of care is adhered to and that risks are minimised as much as possible. Documenting daily work activities and procedures can also provide a means of evaluating work efficiency and effectiveness and help to achieve better business performance. Other statistics, such as work distribution and seasonal loads, response times, number of re-applications and follow-ups needed and number of staff working on ground can provide valuable performance information on which to base management decisions.

The following suggestions may assist in developing an effective operational procedure that minimises risk and fulfils duty of care obligations in an efficient and effective manner.

Operational procedures should consider the two major hazards areas of transport corridor herbicide use:

1. traffic control in close proximity to on-ground workers and potentially hazardous chemicals (eg. flammable, volatile liquids); and
2. herbicide spraying activity in close proximity to native/desired vegetation and fauna, drainage systems (water ways), humans (protected and unprotected) and particularly open or exposed areas.

A procedure should be developed for the two main aspects of spraying activity:

1. A procedure for planning the work to be done; and
2. A procedure for carrying out the on ground work or work methods.

Planning the work to be done attempts to, as far as practical, manage those aspects of the weed control project which can be addressed before crews enter a site, such as equipment, staff and vehicle positioning. Planning creates an awareness of hazards and associated risks before crews are exposed to these hazards. This foresight assists in reducing the:

- number, frequency and length of time of hazards to which work crews and the public might be exposed; and
- likely-hood of the hazards having a significant impact upon workers and the public.

An on-ground work procedure helps to identify and control specific hazards related to work actions on the site. It also helps to:

- ensure that, where possible, methods used in the field are the most efficient, effective and coordinated;
- ensure that methods used take into account legislative and duty of care obligations;
- demonstrate accountability to the public and government;
- provide data on which to base better business decision; and
- consider worker and public needs - creating a positive and pro-active image of those involved with transport corridor spraying.

TRAFFIC CONTROL

Planning aspects to consider include (may vary for night/day activity and transport corridor type):

- traffic control plan or map – diagram which sets out specific sight and clearance distances, position of vehicles, lights and signage, etc.;
- vehicle equipment requirements – spray vehicles, support vehicles and associated vehicle lights, signage and communications, etc.;
- ground equipment requirements - "men at work" and speed signs, barricades, etc (QDMR1, 1999).

An on-ground work procedure should identify potential hazards associated with work activities. It should also identify various actions to control these hazards. A checklist (adapted from QDMR1, 1999) may include those points listed below.

Potential Hazard	Control Measures
Chemical • Transport • Storage	• Correct vehicle transport and storage equipment, also spillage and fire equipment.
Traffic • Public vehicle and pedestrian movement – traffic congestion, flow and control • Staff vehicle movement - stopping, turning, slow movement • Staff vehicle and equipment malfunction • Establishment and disestablishment of signage, barricades and lights – staff being hit or injury through handling of equipment	• Following of traffic control diagram - correct vehicle (including support vehicles), sign and lighting (ground and vehicle)positioning • Adequate staffing, radio communications and safety clothing. • Awareness and adherence to transport regulations and policies - including obeying weight to axle ratios and speed controls. • Dismantling equipment before movement, using correct lifting techniques and dismantling equipment

HERBICIDE USAGE

Planning aspects to consider include:

- alternatives to herbicide use;
- the level of weed control required;
- safe transport and storage of chemicals;
- appropriate staffing numbers, sufficiently skilled and licensed;
- clear and accurate identification of target weeds;
- clearly specified herbicide type, spray rate and application method;
- identify and marking/mapping areas where non-target vegetation exists;
- appropriate equipment, correctly calibrated and in working order
- the keeping of appropriate and up to date spraying records; and
- inspection of area after treatment to determine success (QMDR2, 1999).

A checklist (adapted from QDMR2, 1999) for an on-ground work procedure may include those points listed below.

Potential Hazard	Control Measures
Traffic hazards	• See traffic works procedures
Chemical spills	• Provide spillage clean up equipment • Ensure safe handling and storage of chemicals
UV Radiation	• Provide correct sun protection measures
Hypodermic syringes, other material discarded on the roadside	• Provide correct foot-ware and other safety equipment
Non-target/desired plant fatalities	• ACDC licence and training • Follow label • Clearly mark or identify non-target plants • Avoid water courses or use water-safe herbicides • Inspect area for hidden desired plants and animals • Record areas treated and method of treatment
Public injury or sickness (public liability), operator sickness and injury from weed control activities	• ACDC licence, training, correct application method • Provide operators with correct clothing, eye wear • Have a spotter check for pedestrians • Clear the area of materials (such as fallen debris) in access areas • Ensure all equipment is accounted for and safely stored • Ensure correct record keeping of such things as chemicals and methods used, operator details, date, day and time of treatment
Loss/ theft of equipment	• Keep equipment in the designated area when in use • Keep equipment secured when not in use • Clearly name equipment (engrave or security serial number) • Keep an inventory of equipment and check this at the end of activity

Time and effort needed to record and document (ie. paper work) planning and work activities should be kept to a minimum. Forms involving ticking, crossing or coded explanations and details save time and effort. However, provision should also be made for recording extraordinary or site specific details or significant events. Paper work may need to be kept for a number years, so some type of storage system should also be implemented (eg. saving information to CD-ROM or securing in a filing cabinet).

Legislation that may need to be considered during the formulation and implementation of works procedures includes:

- *Nature Conservation Act 1992* - protection of native fauna, flora, and its habitat. For example, a person must not take a protected plant ("take" includes destroy - Section 89 of the Act);
- *Environmental Protection Act 1994* - Due diligence. For example, establishing a pollution prevention system, exercising all reasonable care to prevent pollution, ensuring the effective operation of the system (QDEH, 1994);
- *Work Place Health and Safety Act 1995* – ensuring a safe work place. For example, employers are required to ensure the health and safety of all persons at the workplace, employees have an obligation to maintain healthy and safe work conduct (LPB, 1996);

- *Agricultural Chemicals Distribution Control Act 1966* – control the distribution of herbicides from air and ground. For example, those involved with commercial herbicide spraying activities are required to obtain an Agricultural Chemicals Distribution and Control licence and ensure no spray drift to neighbours, (QDPI, no date); and
- various traffic and transport control Acts and service utility provision Acts (telecommunications, water and power).

Other state and federal policies such as biodiversity and sustainability policies may also need to be taken into account. If possible, operating procedures and objectives of weed control programs should attempt to coordinate with adjacent or larger regional, state or national weed control strategies. This reduces the possibility of future conflict and overlap with the objectives and ideals of other weed control strategies.

EVALUATION

Having a works procedure can assist in the collection and analysis of information that is necessary to evaluate the efficacy of herbicide spraying activities. Through this evaluation process, works procedures can help identify issues that are commonly viewed as peripheral concerns to weed control management on transport corridors, but may in fact have a significant impact upon weed control activities. Such issues include the;

- design of roads, gardens and landscaping with regard to safe and easy access of weed control equipment and crews;
- species of plants, types and quality of materials used in re-vegetation projects with regard to ease and effectiveness of maintenance weed control and potential of the planted species to become a weed;
- materials used in, and design of, the road pavement or transport surface with regard to its susceptibility to damage from weed growth, or its ability to provide weed favouring environments;
- coordination of weed control efforts with other environmental management activities within and without the department or business;
- other maintenance activities and equipment that may be contributing to weed infestations; and
- appropriateness and effectiveness of timing, amount and distribution of weed control funding.

THE ECONOMICS OF HERBICIDE USE IN TRANSPORT CORRIDORS

There are many methods of weed control apart from herbicide use – mechanical (eg. hand pulling), physical (eg. fire), cultural (eg. prohibition of the sale of declared weeds) and biological (eg. bugs, beetles and rusts). Each method has certain benefits and disadvantages and their usefulness will depend upon the situation and the expectations of weed controllers. Herbicides, like other control methods, will give varying results depending upon how well the herbicide accounts for the conditions surrounding the situation.

As a result of this, it is difficult to give a generalised comparison of the value of herbicides against other weed control methods. Comparisons against herbicide efficacy can only be determined accurately for a particular situation, for a given period of time and/or at a certain point of time. Determining the cost effectiveness of herbicides will involve weighing up how well the herbicide achieves the objectives of the weed control program given the situation - and whether other methods are better suited given the circumstances.

The nature of transport corridors – the special hazards and problems they present – are likely to render weed control efforts within transport corridors more expensive than those elsewhere. Special costs that may significantly increase herbicide weed control (and also other vegetation management) expenses include traffic control equipment, hire of support vehicles and expenses associated with developing works procedures that minimise hazards and associated risks. Transport corridors are frequently drainage areas. They may also contain highly sensitive and limited numbers of desired species within a relatively small target area. Works crews may need to under take specialised training and use special herbicides (eg. highly selective, low residuality) and application methods or use custom-made equipment (such as retractable booms to avoid

roadside furniture, signage, etc) which can be easily manoeuvred in the confined spaces of transport corridors. These special requirements may also add to the cost of weed control.

The risks associated with operating in transport corridors (and that fact that transport corridors are usually high profile areas under constant scrutiny from the public eye), means that spraying activity must be carried out with great accuracy and precision in order to ensure efficacy and environmental, worker and public safety. The benefits of increased efficacy and safety and minimised hazards and risks far outweigh the initial expenses associated with ensuring efficacy of treatment and environmental, worker and public safety.

CONCLUSION

Herbicides are precision tools. They must be used correctly in order to gain the greatest efficacy while avoiding safety hazards. The use of herbicides within transport corridors poses special problems not likely to be encountered elsewhere – such as traffic hazards, water drainage areas, confined spaces and restricted access. By taking into account these important factors:

- knowing the weeds ecological, social and economic importance, its classification and growth habits;
- knowing what herbicides are available for use and selecting the best herbicides to use given the situation;
- knowing the qualifications and capabilities of staff and contractors and legal obligations; and
- developing a comprehensive and practical planning and works procedure; and
- the hazards associated with using herbicides and working within transport corridors, can be significantly reduced or avoided, the efficacy of weed control can be increased and the amount of time, money and resources spent, reduced. Used correctly, herbicides can play an important role in improved corridor vegetation management.

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ROAD VERGES AND THEIR VEGETATION – OUR ROLE IN ITS NATURE AND CONDITION

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ABSTRACT

Roads, regardless of their nature, have plants along their verges. These plants range from deliberate plantings for road verge stability and amenity to plants within abutting copses of remnant native vegetation. These latter areas can be of local, regional, national or international significance depending upon the location and alignment of the particular road. Roads are recognised as an important medium for the presentation of World Heritage Values and access to some our best recognised environmental assets such as National Parks and major recreation areas. As such, roads require appropriate management for the presentation of those values. The instatement of roads adjacent to, or within, remnant native vegetation produces both opportunities and constraints on construction and operational works. Maintenance of road verges has traditionally followed standard (prescription-based) models. Increasingly it is being recognised that some of these practices do not conform to changing codes of environmental best practice. In particular, the prerogative for retaining at least some elements of the original flora along the road verge is seen as preferable to techniques that encourage the establishment and proliferation of non-local species (often-exotic weeds). This paper will deal with this issue from a theoretical perspective with case studies utilised to illustrate the more salient points of potential future directions in road verge maintenance that can meet the demands of both environmental best practice and economic efficiency.

***Key words**: road verge vegetation management, weeds, disturbance, soil seed banks.*

INTRODUCTION

Roads pervade the landscape and are the major linear corridors transecting urban, rural and natural areas. As such they play the most substantive role in connecting and interrupting flows within those systems. Their connectivity role is the reason for their very being, as they are utilised as conduits of people and goods from one site to another. In doing so, they interrupt the connectivity of the systems they traverse, be they urban areas, farms or bushland. Whilst we are all aware of the social and economic impacts of the former two factors interacting with roads (either established or proposed road infrastructure), it is the crossing of bushland by roads that will be the focus of this discussion.

The primary impact of roads, in a biological context, is that as a medium of habitat fragmentation, although the larger roads and highways are substantive enough to result in concurrent local habitat loss effects. Fragmentation associated with roads is in the form of linear environmental discontinuities that disturb areas of continuous habitat (Kroodsma 1982; Goosem & Marsh 1997, Goosem 1997). Fragmentation alters the abiotic and biotic processes that are exerted upon that system (Hopkins and Saunders 1987; Hobbs 1993; Murcia 1995). Fragmentation of natural areas often profoundly impacts remnants of native vegetation and the wildlife reliant on its presence (Wilcox & Murphy 1985; Ehrenfeld 1995).

Apart from the direct consequences of initial species loss as a result of habitat clearance, there are a number of less direct yet arguably more insidious external consequences of fragmentation. Specifically, external stresses upon these systems renders them vulnerable to weed invasion and/or altered disturbance regimes, species dynamics and successional sequences (Malanson 1993). Edge effects, in particular, result in irregular, and often site-specific, conditions which intrude upon many of the natural processes occurring within the remnant (Main 1987; Soule & Gilpin 1991). Edge effects have been shown to exist and exert differential pressures within remnant systems. Empirical research on the effects of remnant edges has found that significantly different patterns, species associations and interactions occur at the remnant-mosaic interface and then decrease with distance into the forest (Arnold *et al.* 1993; Andren 1994; Murcia 1995). Indeed, the presence of edges often leaves the remnant perimeter vulnerable to increased disturbance and the invasion by weeds (Banson & Keith 1984; Planty-Tabacchi *et al.* 1996).

The displacement of roads and the bushland they traverse clearly implicates the issue of connectivity via corridors across the landscape. Theoretically, the presence of corridor linkages between larger areas of native habitat provides wildlife both a habitat refuge and an area in which to move between patches (Watson 1991). The importance of corridors as a means of remnant linkages is a subject of considerable debate (Simberloff & Cox 1987; Hobbs & Hopkins 1991; Saunders & Hobbs 1991; Recher 1993;). However, there is evidence suggesting that in many areas, the availability of habitat corridors has lead to their utilisation by wildlife as both a habitat in its own right and as movement corridors (Bennett 1991; Claridge & Lindenmayer 1994; Crome *et al.* 1994; Downes *et al.* 1997).

Corridors in highly fragmented landscapes can exist as either natural remnant riparian strips of vegetation or vegetation, along highways and roadside reserves, or human created hedgerows and wind breaks (Downes *et al.* 1997). Much of the concern with the effectiveness of vegetation corridors is centred on their size, shape and the characteristically high edge-to-area ratio (Downes *et al.* 1997). The study of these areas has also increased interest in the ecological significance of land previously considered degraded. Roadside verges, urban riparian 'ribbons' and small lots of government owned land are a few such examples (Bennett 1990, 1991).

The conservation and rehabilitation now occurring in these areas has provided further insight into the significance of their value as regional linkages of small habitat islands to form corridors (Atchison 1984; Banson & Keith 1984; Breckwoldt & Others 1990; Bennett 1991; Hopkins *et al.* 1990; Saunders & Hobbs 1991). Roads and highways through natural areas have been identified as providing both problems and opportunities to local wildlife populations (Bennett 1990; Breckwoldt *et al.* 1990). Firstly, roads present an immediate danger to wildlife as a direct cause of mortality due to collision with vehicles (Ehmann & Cogger 1985; Bennett 1991; Goosem & Marsh 1997, Goosem 1997). The presence of roads through forests is believed to encourage species such as cats (*Felis catus*), foxes (*Vulpes vulpes*) and dingoes (*Canis familiaris dingo*) to compete with and/or prey upon native wildlife (May & Norton 1996).

Additionally, roads may present a barrier to certain species and thus inhibit dispersal between sub-populations (Bennett 1991). Cleared linear corridors through forests often posses significantly different habitat characteristics from surrounding areas to the extent that different suites of plants and animals are present (Kroodsma 1982; Goosem & Marsh 1997). This has been found to alter the plant associations at the forest edge and fundamentally alter interspecific faunal interactions, foraging patterns and dispersal capabilities (Goosem 1997).

Roads, however, present environmental opportunities in many areas, especially within rural landscapes. The presence of roadside reserves has allowed the retention of a variety of roadside vegetation which, in the case of the Western Australian wheatbelt, has been found to offer both significant habitat opportunities for wildlife, and potential movement corridors between larger areas of extant vegetation (Hobbs *et al.* 1993; Downes *et al.* 1997). The ability of roadside vegetation to act as habitat linkages and habitat in itself is largely dependent upon its management (Bennett 1991). Many authorities conscientiously practise mowing and maintenance regimes that benefit introduced grass and weed species while simultaneously excluding the possibility of native species to establish (Goosem 1997). It is believed that the enhancement of the environmental amenity of already existing areas of native vegetation such as road reserves or windbreaks has been achieved in the past by providing a complexity of structure. This has been supported by studies in eucalypt forests in Victoria where structurally complex and diverse corridors are preferentially used by different species, especially arboreal mammals, than those less diverse (Downes *et al.* 1997).

Another issue relevant to the current study is the issue of runoff from road surfaces (Drapper, Williams & Tomlinson, 1998a and b; Drapper, Tomlinson & Williams, 1999 and submitted). Levels of pollutants such as zinc, copper, lead, nitrogen and phosphorous were found in road runoff at levels in excess of ANZECC standards for aquatic ecosystems. Asbestos and cadmium were also recorded in these studies. The major sources appear to be brake linings and tyres. Given the proximity of many roads to major waterways, this issue requires considered attention. Management of the trapped pollutants (if such works are undertaken) will also require

consideration. This may lead to linkage with other research areas such as the creation of artificial wetlands for water polishing (Greenway & Bolton 1996).

Having set the biological background to this discussion, it is pertinent to consider more pragmatic issues. The roads that society has deemed essential for the maintenance of human values and processes clearly interact with the ability of our native biota to persist and survive in the fragmented landscapes of the Australian continent. The road infrastructure of the Australian landscape requires regular maintenance. Specifically, it is along the road verges where plants require regular maintenance that will be the focus of this discussion.

DISCUSSION

Maintenance of road verge vegetation involves both growth promotion and inhibition, dependant upon the prerogative of the management schemata or the nature of the plants growing along the road verge. Differences between the management scenarios relate mainly to the nature of the flora. Desirous plants such as those actively planted for amenity or pollution control purposes, have intensive (and often costly) efforts expended to ensure their establishment and maintenance in the road verge. In contrast, it is typically post-establishment efforts (also costly) that are directed towards less desirous plants such as weeds and other plants considered by some as threats to public safety. This latter group of the road verge flora will be the focus of interest as the other area is principally horticultural and covered by many others.

The significance of the pre- and post-establishment management chronology should not be dismissed as irrelevant, however, as this primary difference results in substantively altered philosophies regarding the future maintenance of the respective floras. Obviously, with the considerable costs associated with establishment of desirous plants in a road verge and regardless of the techniques employed or the follow-up maintenance schedule, there will be a strong on-going commitment to ensuring that those plants survive. The ultimate intention may be to achieve some level of a self-sustaining plant community, but this always requires some long-term allocation of resources to ensure the maintenance of the desired suite of plants over the inevitable competitive effects of undesirable flora. It is somewhat ironic that this latter group are generally the same plants that are acted upon along the road verges that are discussed below.

Only small proportions of our road verges have been actively planted to maintain a deliberate set of flora within the road verge. The vast majority of road verges are maintained with the suite of flora that are either extant or establish in response to maintenance activities or via unassisted (assistance in this instance as deliberate seeding/planting) dispersal of propagules onto the site. Thus, road verge managers are generally presented with a flora that is less deterministic in nature than the deliberately planted and managed road verges of landscaped areas. This brings with it a series of problems that are actually shared with land managers across the Australian landscape – managing vegetation with an outcome that is directed by a perception of an "idealised" flora for any particular site/situation.

The "ideal" road verge vegetation may be seen by some contractors as low growing vegetation that does not contain declared plants, grow too quickly (but still grows sufficiently to maintain their maintenance related income) and does not pose a threat to public safety. This latter issue is highly vexatious and will not be dealt with herein other than to suggest that there is a clear mandate to consider the relative biological costs of loss of woody vegetation from road verges against the statistical probability of collisions of vehicles with trees etc. as opposed to collisions with other vehicles. This analysis, if available, has not been well documented or presented to the community.

Current technologies applied to road verge vegetation management involve either mechanical or chemical control of growth. There is no conscious effort to pro-actively affect the floristic composition of the vegetation other than to remove declared plants as required under the *Rural Lands Protection Act*. There is no currently analogous legislation at a State level to remove plants that primarily threaten natural landscapes. Primarily community awareness and voluntary participation drive environmental weed management by the appropriate land management agencies/persons. Thus, the principal factor implicated in the composition of the road verge flora

is the present occupancy of the site or enhancement of germination and establishment phenomena via maintenance and other activities within the road verge. It is this latter area that has received little attention such that empirical evidence is available for discussion.

Disturbance of the vegetation and soil along road verges is the principal means whereby seeds stored in the soil seed bank germinate, and recently dispersed propagules are provided with suitable germination sites to enable their germination/establishment on the site. All of the soil seed banks of road verges and remnant vegetation in south east Queensland (and most likely elsewhere on the eastern seaboard and subhumid zones) are utterly dominated by readily-germinable weed species seeds (Olsen unpublished data). With the known impact of edges, road verge soil seed banks are most likely to be flooded with seeds of weed taxa. Any disturbance to the soil surface will trigger the germination of weed species. Thus, current methods of road verge maintenance involving slashing/mowing and chemical control of road verge plants will result in the germination of a flora that will be dominated by weed species.

The dominance of road verge vegetation within the actively maintained fringe is widely evidenced across the region, even where roads traverse some of our largest tracts of remnant bushland eg. roads within State Forest and National Parks across south east Queensland. It is a common sight along roadsides to see swathes of *Panicum maximum, Chloris gayana, Cenchrus ciliaris, Paspalum urvillei, Melinus minutiflora, Melinus repens* and *Brachiaria decumbens*, thickets of *Lantana camara* and *Schinus terebinthifolia*, and smothering masses of *Desmodium intortum* and *Neonotonia wightii* along with other poorly chosen introductions that have escaped cultivation and now fringe our roads. Indeed, many of these weed taxa are at their most prominent in the road verges of routes that traverse the precise areas that are being presented as our most significant natural assets. The ultimate irony is found within World Heritage listed areas such as the Wet Tropics and the Central Eastern Rainforest where weeds dominate the primary face of the forest (the road verge) that is being presented to visitors. Presentation of the listed World Heritage properties is one of the principal charters of the *World Heritage Properties Protection Act*.

Technology exists to control the majority of the weed species within our road verges via mechanical or chemical means. What is lacking is data and understanding of the most effective (economic and ecological) manner in which weed management can be undertaken. We have responsibilities (legislative in some circumstances) to protect our natural assets. It is suggested that current road verge management practices are not fulfilling those responsibilities. Road verges, through their management related proliferations of weed species, threaten the viability and integrity of contiguous or nearby bushland and its component biota. There is an urgent need to address the cost-effectiveness of the presently utilised road verge management practices. It is known, and widely observed, that weed infestations are maintained and enhanced in road verges via these practices.

As an example of the different scenarios that may eventuate with altered road verge management practices, it is worthwhile considering the situation regarding the grass flora within road verges. Slashing/mowing and grading actively enhance the germination and competitive ability of weed grasses such as *Panicum maximum, Melinus minutiflora, Melinus repens,* and *Brachiaria decumbens* over native flora such as *Themeda triandra*, *Imperata cylindrica* and *Cymbopogon refractus*. These latter native taxa can dominate along road verges where maintenance activities are light and infrequent. They are typically displaced by the weed taxa where mechanical and chemical control methods are utilised frequently and intensively within the road verge. Given the dominance of the soil seed banks with seeds of the weed grass taxa, this response to soil disturbance and herbicide-related gap creation is not surprising. It is actually an inevitability that the native species will be displaced by an exotic weed flora under current road verge management schemata.

There have been attempts to modify road verge management practices in the Wet Tropics World Heritage Area (Dr. Steve Goosem, pers. comm.), but there is no uniform policy to alter practices such that the relative abundance of the weed taxa will be diminished. The logic of this biological outcome is clear. Less vigorous native taxa that require less regular maintenance will reduce economic costs and yield substantial environmental benefits. What is urgently required is some

empirical data as to the relative costs and benefits of road verge vegetation dominated by native flora as opposed to the more familiar scene of weed infested margins of our roads. This should consider the full gamut of costs and benefits, environmental, economic and social.

Ultimately, the major factor that is considered essential to the future success of altered road verge management practices is reducing the level and nature of disturbance in the road verge. If the undesirable flora have a lesser availability of resources and niches for their germination, establishment and proliferation, then the desired native flora will have a greater competitive advantage and resilience within the road verge. Finding the mechanism whereby vegetation growth within the road verge can meet current prescriptions whilst contemporaneously fulfilling these other floristic prerogatives will be one of the major challenges to managers. It could be that the prescriptions presently invoked for growth management will require change based on parameters that are biologically based rather than reactionary based as apparent with current practices.

Critical to the implementation of these proposed alterations to road verge maintenance practices is training of the personnel involved. They must be given the understanding of their role in the dynamics of the road verge vegetation composition and growth. Resistance will no doubt be encountered as personnel are informed that their practices are unsound and require alteration in a manner that will be unfamiliar. The educational process in these areas is generally highly successful with machinery operators typically exhibiting a willingness to try new techniques and adapt to changing conditions.

The fundamental underpinning of this discussion is that the present road verge vegetation management practices are resulting in a weed dominated flora that requires a greater commitment to on-going funding for maintenance and control of growth and floristic composition than ecologically based alternatives. It is considered that the long-term environmental costs of such works are unacceptable, particularly where roads traverse significant bushland remnants. This relates to the biological consequences of the flora found along road verges for the immediate environs of the road as well as contiguous areas that will be infested by propagules dispersed into their interiors from these linear nodes of infestation.

It is postulated that a more ecologically based program of road verge management will actually reduce the long-term road verge management costs for the following reasons:

- There will be less germination, establishment and proliferation of undesirable flora. This will result from a lack of environmental cues for their germination etc. being removed viz. regular soil disturbance, creation of exposed soil surfaces (and hence soil seed banks) following herbicide related plant mortality and decomposition. This will reduce the frequency and intensity of practices reducing the economic cost of road verge vegetation management. It will accrue considerable environmental benefits as the native flora increase their relative abundance at the expense of the exotic flora (the corollary of the present situation).
- The growth rates, stature and competitive ability of the native taxa will require less active and regular intervention in their growth management. This will substantially reduce machinery and chemical costs, with these economic benefits accruing with time.
- The presentation of our natural assets will be markedly enhanced bringing a level of recognition amongst the community of the environmentally sound practices that would be developed by road authorities. At present, the role of our road verge maintenance authorities is poorly, if at all, recognised, and, where it is, is generally considered the antithesis of sound environmental practice. This misconception (where unfairly based) should be countered and, where based upon factual evidence, can be reversed via the adoption of more environmentally sound practices.

Even the implementation of all of these practices will not allow for complacency in the future management of road verge vegetation. Discovery in 1998 of a plant of *Parthenium hysterophorous* within the road verge of the Gatton Bypass (Cunningham Highway) highlights the diligence that is required for flora management in these areas.

Roads, by their very nature, provide the ideal dispersal route for weed propagules. Vehicles are acknowledged as a significant factor in the dispersal of weeds such as *Parthenium*

hysterophorous. We therefore must ensure that personnel who regularly patrol our road networks are familiar with problem plants such as *Parthenium hysterophorous*. Only through informed observation are we likely to avoid costly control programs should new infestations of such plants become well established. Intimately linked with this issue is the provision of establishment sites. Minimising the disturbance within road verges will thus serve a multiplicity of environmental management purposes.

CONCLUSIONS AND RECOMMENDATIONS

There is a major difference in philosophy and nature between the expenditure, in terms of time, effort and cost, committed to desirous and non-desirous plants in the road verge landscape. This disparity relates to artificial perceptions of the landscape that results from the respective activities. Within road verges where landscaping activities have been undertaken, the community accepts the cost as being worthwhile for amenity purposes in the first instance. Any environmental benefit is typically seen as a worthy addition, not the primary directive for such works. In contrast, road verge management practices within extant vegetation is seen by the community as a controlling mechanism "keeping the plants in check". The analogous benefits of both situations to the environment need to be communicated to both road managers and the public. The relative cost of sound management of extant road verge vegetation for a positive environmental outcome is orders of magnitude less than that required in landscaped areas. This is a message that is both poorly understood and communicated to land managers and the public.

The main conclusion of the previous discussion is that current road verge management practices are not achieving cost efficiency in either economic or environmental terms. When taken with the social costs of perceptions of road verges as weed infested frontages onto bushland remnants, the costs of these practices are clearly compounded. This matter requires rectification such that the postulated savings in economic terms can be translated into real economic and social gains. This can then provide a forum for more informed debate regarding the impact of the various human activities associated with modern society across the Australian landscape. Too often the economic costs of our western economic dependency are not adequately or comprehensively addressed with respect to social and environmental benefits or losses.

It is recommended that the following analyses be performed across a range of remnant native vegetation landscapes that are traversed by roads:

- Undertake a cash flow analysis of the relative costs of different frequency and road verge management practice scenarios.
- Determine the full environmental costs associated with current practices of mechanical and chemical control of road verge vegetation.
- Determine the efficacy of maintaining a native flora dominated road verge vegetation mosaic with respect to long-term costs.

If the results of these analyses were known, then well founded road verge management practices could be implemented. The declining extent, viability and integrity of our remnant native vegetation mosaic makes it absolutely imperative that we "get it right", particularly at the artificial interface between our activities and infrastructure and the remnant bushland, be that urban, rural or roadsides.

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STOCK ROUTES

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ABSTRACT

Stock routes played a significant role in the settlement of Australia. Yet what does the average Australians know of stock routes? This paper commences with an explanation and definition of stock routes and concludes that they are simply another use of road corridors. Additionally, this paper identifies their past extent and provides an explanation for their decline in usage during the late 1950s and 1960s. It also discusses what use is made of stock routes today as well as providing reasons for a renewed interest.

The issue of impacts and conflicts between the many agencies with legitimate roles in the use and management of road corridors is also discussed briefly. The paper concludes with a call for the formation of a Queensland Road Corridors Management Forum where road corridor managers can meet to inform others of their activities and needs, resolve issues of conflict as well as discuss matters of mutual interest.

Key words: *Stock routes, roads, stock route network, walking stock, stock on hoof, Queensland road, Corridors Management Forum.*

ROADS VERSES STOCK ROUTES

So what are Stock Routes? For some, the term is likely to conjure up images of mobs of sheep or cattle on the road being tended by drovers, of early starts, long days, nights around the campfire and early nights in a swag under the stars broken by having to watch or settle spooked cattle.

Putting aside the romantic notions, what does the average Australian know of stock routes? It is probably fair to say that many in the community probably have little idea, for others they are an anachronism from the past and of little present or future use. Yet for others they are corridors that provide an alternative means of moving stock and over which other uses may occur. And for the wags amongst us the term could refer to an animal husbandry practice.

I have noted in my position that there is considerable confusion between stock routes and roads. I often hear the phrase "In Queensland all stock routes are roads, but not all roads are stock routes" yet it is obvious in many cases that the speaker has little idea of the difference.

What then is the difference between a stock route and a road? Firstly I will start with a definition of a road. A road is an area of state owned land set aside for the present or future use of the travelling public.

Road is defined in the *Land Act 1994* as:

"An area of land, whether surveyed or unsurveyed that is:

- dedicated, notified or declared to be a road for public use; or
- taken under an Act, for the purpose of a road for public use.

The term includes:

- a street, esplanade, reserve for esplanade, highway, pathway, thoroughfare, track, or stock route;
- a bridge, causeway, culvert or other works in, on, over or under a road; and
- any part of a road."

All persons have a general or common law right to use dedicated public roads for all purposes relating to the transport of persons and their goods from one place to another including the driving of animals except to the extent where an Act or statute restricts this right.

A stock route is also defined in the *Land Act* and "means a road or route ordinarily used for travelling stock or declared under an Act to be a stock route". The *Rural Lands Protection Act 1985* provides for the declaration of a stock route.

From this definition it follows therefore that there are two possible means of a road becoming used as a stock route.

- firstly, recognition and acceptance by the community that a particular road is or may be used to travel stock on hoof; and
- secondly, declaration as a stock route under section 15 of the *Rural Lands Protection Act 1985.*

It is worth noting that section 15 has never been used and all stock routes in Queensland are stock routes because of their usage to walk stock. Whether a road that once was used to travel stock but has not been used for some time to walk stock is still a stock route is a moot point and an issue which has never been tested.

From the discussion so far it can be concluded that stock routes are simply another use of the road network as is the use of road corridors for vehicular carriageways, railways, powerlines, communication infrastructure, pipelines and other community uses (Edwards 1998). Stock routes have no separate title, tenure or declaration apart from that of road (Edwards 1998).

STOCK ROUTE NETWORK

Located throughout Queensland is a stock route network established over a long period of usage with the primary objective of providing for the movement of stock on hoof. This network can be thought of as comprising three (3) elements:

- stock routes;
- reserves; and
- infrastructure.

Stock routes are part of the landmass of the network and can be considered as those linear corridors that allow stock to be walked from one point to another.

Reserves are the other part of the landmass of the network and to some extent consist of nodes along stock routes available to walking stock for access to water or to camp overnight.

Infrastructure consists of water points, holding yards, fencing, clearing etc located on stock routes and reserves to facilitate the movement of walking stock.

The stock route network in its prime consisted of over 72 000 kilometres of roads used for the walking of stock. However, since the 1950s there has been a general decline in the use of the network (McKnight) to the point today where approximately 12 000 kilometres is actively used to move stock.

This decline in usage has been caused by a number of factors. Technological change through the introduction and development of motorised stock transport has probably been the most significant. Associated with this has been the development of beef cattle roads by governments, which assisted the adoption of motorised transport.

Additionally, the rapid adoption of new transport technology led to claims that stock routes were no longer required. As a result many of the less used routes were allowed to rundown through the lack of maintenance and disposal of infrastructure, reductions in the width of some routes or the leasing of parts of other routes to adjoining landholders. These actions have over time reduced the attractiveness of much the network to those wishing to walk stock, further reinforcing the claim that stock routes are no longer required.

Finally, social changes associated with technological change and a decline in terms of trade in rural commodities have also contributed to the decline in usage. A drift in labour to larger urban centres as jobs were replaced by technology and a decline in the producer's abilities to pay wages put an end to labour intensive droving.

What Use is made Of the Stock Route Network Today?

Present day usage can be broadly grouped into two categories:

- traditional uses; and
- emerging uses.

Traditional Use

Drought in the early 1990's saw an increase in usage of the network over that of previous years. As with previous droughts the value of the network to the grazing industry was highlighted as graziers increased their use of the "long paddock" for emergency relief grazing. However, this increased pressure revealed the network to be in poor condition and was the primary reason for funding increases from government to enhance and upgrade the stock route network.

Funding has come in the form of two initiatives, approximately $3 million between 1995 and 1998 with a further $4 million to be spent between 1999 and 2002. The initiatives are administered by the Stock Route Management Unit, Land Protection, Department of Natural Resources where funding is prioritised to those actively used parts of the network where enhancement and upgrading will directly benefit walking stock. Usage of the network is increasing as a result of the enhancement and upgrading program.

Despite an overall acceptance of motorised transport by the grazing industry, graziers and pastoral companies continue to move stock by hoof. These movements are for stock and property management purposes and are adopted for convenience, stock education and cost savings.

An unpublished options paper prepared by the Department of Natural Resources, reviewing travelling stock fees found that it is considerably cheaper to walk stock than to move them by road or rail transport.

Table 1 Comparison of Different Transport Types

Transport Type	20 head cattle/km	100 head sheep/km
Queensland Rail #	$1.06	65 cents
Road Transport #	$1.00	63 cents
Drovers costs plus travelling stock fees	59 cents (57 cents + 2 cents)*	31 cents (29 cents + 2 cents)*

The figures for road and rail transport are averages taken from a number different journeys over differing distances.
* The first figure is the drover's costs while the latter represents the fees to travel stock on the SRN.
Source: Adapted from Papping 1999.

An interesting development in recent times has been the increased use of the network during good seasons by pastoral companies to shift large mobs of young cattle from breeding properties to finishing properties. Condon (1998, p.6) writing in the Country Life of 6 July 1998 quotes a pastoral company livestock manager as claiming "droving cattle is now becoming a cost effective part of our overall cattle movement strategy".

Walking cattle not only saves pastoral companies and graziers in transport costs but offers many other benefits. These include:

- continued weight gains for stock when there is plenty of feed on the network;
- reductions in mustering costs due to the education stock receive from close contact with humans and horses. This education is for life and makes subsequent mustering quicker and easier; and
- reduction in injury as educated stock are more easily mustered. This may result in higher prices on sale due to good carcass condition.

The use of the network for property and stock management purposes is expected to increase particularly in good seasons as graziers attempt to save costs and seek a competitive advantage. Increases in fuel prices may also lead to greater utilisation of the network.

Whilst walking stock is cheaper and offers competitive advantages, motorised transport is expected to remain the favoured option, particularly in those situations where graziers need speed to take advantage of favourable market conditions or need to maintain stock condition prior to sale or slaughter

Emerging Uses

Increasingly, it is becoming accepted that many roads in the State network have uses and values beyond those of access and communication. In many cases development of access and communication infrastructure have left parts of road corridors in an undeveloped state and there are many examples of roads that have never been developed. As a result, roads often contain species, ecosystems and habitat not seen on surrounding lands or represented in the State National Park System. For this reason, roads containing areas of remnant vegetation are being seen as important from a conservation point of view.

Because many stock routes are roads that were set aside to facilitate the movement of stock on hoof they were much wider than those roads which were set aside for access only. Thus, due to their larger area, they potentially contain a greater representation of species, ecosystems and habitat than could be expected on a normal road.

Cultural heritage conservation is also an emerging future use of stock routes. Moving stock required water so most stock routes followed early settler's tracks which in turn followed watercourses and or aboriginal trails or pathways. Thus stock routes can be expected to have a greater than average representation of cultural and heritage values. Indeed many stock routes have intrinsic heritage values due to their use by Europeans to settle Australia.

Impacts and Conflicts

There are many agencies who have legitimate roles in the use and management of road corridors. These activities range from construction, operation and maintenance of roads, provision, operation and maintenance of utilities, weed and pest control, natural resources management and conservation.

Given that many of the agencies involved act according to their own needs and interests and at times without consideration of the legitimate interests of other agencies or without recognition of the inherent values contained within road corridors, it is inevitable that conflicts may arise over the development and use of road corridors. For example the greatest impact on travelling stock comes from the construction and operation of vehicular carriageways along a stock route. It would seem that many road engineers are ignorant of the needs of travelling stock and unwittingly cause safety problems by forcing stock into contact with vehicular traffic.

These conflicts over the use of the road corridor occur in the absence of property rights. That is, road corridors are public property over which no one agency owns or has full control. Therefore, it is in no one agencies business to ensure that the road corridor is used or managed efficiently and each agency tends to use the road corridor to its advantage.

Being the recipient of adverse impacts has sharpened the awareness of the Stock Route Management Unit of the need to minimise impacts. This has been proposed to be achieved through the draft State Stock Route Network Management Strategy and local government Stock Route Management Plans where those agencies and values on which walking stock may impact are to be identified. Where necessary procedures or plans will be put into place to manage or minimise the impact on other agencies or values. If other agencies were to adopt similar practices much of the conflict between agencies and adverse impact on the inherent values of road corridors could be reduced.

CONCLUSION

One of the outcomes of this conference hopefully will be a greater awareness of the inherent values of road corridors as well as an understanding of the needs of agencies authorised to carry out activities within road corridors. To take this forward I would like to propose the formation of a Queensland Road Corridors Management forum. This proposed forum would provide a means for all relevant agencies and stakeholders who undertake activities or have management interests and responsibilities within road corridors to meet on a regular basis to inform others of their activities and needs; to resolve issues of conflict as well as discussing matters of mutual interest.

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LEGISLATION

Land Act 1994 (Qld)

Rural Lands Protection Act 1985 (Qld)

VALUE OF TOURISM AND AMENITY

John Courtney
PROBE

ABSTRACT

The most significant global industry in the 21st Century will be that of tourism. 1996 saw some 592 million international trips globally. The World Tourism Organisation predicts that by the end of the year 2000 this figure will have soared to some 702 million and twenty years from now, in 2020, 1.6 billion. Already tourism arguably is the largest industry in Australia and if we are to continue attracting, and indeed increasing, our share of this exponential growth we have to become lateral in our thinking about destination development.

Historically roads have been viewed as transport infrastructure, but another overlay of use is beginning to emerge as that is of an 'experience'. As visitor numbers increase so does the percentage of free and independent travellers and roads not only connect tourism icons to tourism icons, but in their own right become an experience product which the independent traveller utilises to heighten his or her understanding of the destination and its composition. Classic examples of this additional use is the Matilda Highway in western Queensland and the Great Ocean Road in southern Australia, roads which in themselves have become part of the respective States tourism product range. We are, however, only on the cusp of such a concept. Future design of such roads as highway products could be included in the initial engineering and landscape design so that the tourism amenity becomes integrated into the overall plan.

The most significant global industry in the 21st century will be that of tourism. 1996 saw some 592 million international trips globally. The World Tourism Organisation predicts that by the end of the year 2000 this figure will have soared to some 702 million and twenty years from now, in 2020, 1.6 billion. Already tourism arguably is the largest industry in Australia and if we are to continue attracting, and indeed increasing, our share of this exponential growth we have to become lateral in our thinking about destination development.

Historically roads have been viewed as transport infrastructure, but another overlay of use is beginning to emerge, that of an 'experience'. As visitor numbers increase so does the percentage of free and independent travellers and roads not only connect tourism icons to tourism icons, but in their own right become an experience product which the independent traveller utilises to heighten his or her understanding of the destination and its composition. Classic examples of this additional use is the Matilda Highway in western Queensland and the Great Ocean Road in southern Australia, roads which in themselves have become part of the respective States tourism product range. In fact, two weeks ago the Great Ocean Road's marketing organisation won the prestigious Australian Tourism Award.

We are, however, only on the cusp of such a concept. I wish to put forward that the future design of such roads as highway products could be included in the initial engineering and landscape design so that the tourism amenity becomes integrated into the overall plan rather than a bolt on at some future date.

In the mid 1970s when I began, what I now view in hindsight as, the optimistic task of developing an appropriate tourist plant for the vast monsoonal Savannah region, the Gulf Savannah, that lies beneath the Gulf of Carpentaria. Visitors arrested the normal activity of remote and virtually marooned settlements such as Burketown in this State's north west. These service centres were traditionally suppled from the ocean, and later by air. Roads were often nearly impassable or just tracks in the grass and there was little incentive for the visitor, except for the odd hardcore traveller, to bother. Residents of these small, harsh townships found visitors in general an oddity, later an impact, then later still a migration necessary of management and eventually the foundation of another leg of the region's economy.

For most of Australia it was the development of off-road technology and the affordability of the 4WD that gave Australians the freedom to explore those previously inaccessible, and to an urban dweller exotic, icons of the Australian Outback. One of those icons deeply etched into the national psyche is that of Cape York Peninsula, the very tip of the "bayonet of Australia", as the WWII American military called it.

This primitive frontier was established as a new destination in the late 1970s by safari operators with modified 4WD units. I know you will possibly look at me askance at the end of this next statement, but .... If amenity was to be examined with respect to those early journeys, it was the washouts, the boggings, the virtual 45% from horizontal creek crossings when photographs could be taken of the twisted, ungainly vehicle sitting on its nose in a creek bed. These experiences and images allowed the participants to dine out for months after this gruelling, masochistic experience. Basic, but powerful. In fact, so powerful over the past 25 years or so 4WDs have thundered up the main spine road to the tip of Cape York and back to test their technology. They tell their "horror" stories to friends and relatives who then save their money to perpetuate this idiocy.

On abandoned structures such as linesmen's shelters on the bank of Gunshot Creek crossing or the shed at Captain Billy's Landing on the east coast the 1980s graffiti says it all:

> "Saw one go up and two go down. Decided better and went around."
> "The mighty powerful Nissan crossed no problem"
> "We're sooks, we didn't, but we survived."

On examining these seemingly senseless annual migrations over a period of time, however, several patterns become obvious.

- Where ever the road corridor crosses permanent water unserviced and unstructured campsites begin developing, some to a point where health becomes a major concern.
- Because small communities have no skills to arrest this continuous traffic it was dubious as to the value of the passing traffic except for strategically placed roadhouses and the pub.
- Through ignorance and a false romantic perception of their wilderness journey the 4WD units come equipped with all provisions. This perpetuates the country perception that all tourists do is destroy the roads and inject little money into the local economy.

I lead you down this train of thought for it became apparent that the expectations of both the visitors and the Outback community were mismatched and somehow we had to find ways of satisfying those expectations, while capitalising on the regional assets.

In north west Queensland, besides the historical built structures, the tourism assets were a montage of immense regional images - vast Savannah grasslands, accessible flora and fauna and their environment, historical sites, Aboriginal and settlement history uniquely Northern Australia, and a distinct landscape.

In the early 1980s some 80% of visitors to Cairns were free and independent travellers in command of their own vehicles. We theorised that to attract the traveller deeper into the west we had to make the Gulf Savannah experience attractive, exciting and easily accessible. Overlaid on to the political lobbying for improved road infrastructure was an objective to develop the road from 40 Mile Scrub behind the Atherton Tablelands to the Northern Territory border as a single tourism product. The object was to develop the road as a window through which the kaleidoscope of the Gulf environment could be explored.

As the road intersects most of the regional towns – Georgetown, Croydon, Normanton and Burketown, with Karumba on the coast - we set about selling the 'oasis concept' to town administrators. The sales pitch was visitors will not stop in communities if they are as inhospitable as the harsh and arid environment just traversed. Travellers will put up with the flies, the dust and the heat if, when they reach a small town, it is green, shady, moist and attractive.

We also encouraged the harnessing the historic elements of individual communities so as to present each Outback town's specific character. This approach was successful once basic infrastructure problems such as lack of water were overcome.

The end objective, however, was to consider the road as the tourism product, confined to the road easement with thickenings at the town nodes. We set about encouraging local authorities

to create as little damage to road environments as possible during maintenance and construction phases as we found that Main Roads contractors and Council crews generally were often the worst offenders leaving ugly evidence of a construction or maintenance phase.

We sought to develop overnight facilities at chosen water crossings and planting shade trees at these natural campsites as well as designated picnic and good interpretive sites. Included in Councils long term planning these sites, it was agree, would attract funding when there was money available. With the assistance of a landscape architectural firm in Cairns, Site Plan, we identified the elements required to design rest areas, bush campsites and interpretive sites, incorporating the native vegetation. Either side of this interpretive road the private sector was encouraged and assisted to develop such features as the Undara lava tubes, Tallaroo hot springs and Croydon historic precinct.

This project, in fact, commenced and elements of it are in place. In conjunction with the Northern Territory we established the Great Top Road, Cairns to Daly Waters, which has subsequently in latter years become the Savannah Way.

Regional tourism bodies in Queensland, funded by Tourism Queensland, are recipients of an annual grant which in the main was, and no doubt still is, tied to the expectations that it will be spent on marketing.

Until some seven or eight years ago there were three regions responsible for the development of tourism for the bulk of western Queensland - the Outback, centred at Blackall, the Inland region administered from Mt Isa and the Gulf Savannah which at the time I was the CEO. Annually, these three regions and representatives of the then Queensland Tourist and Travel Corporation met to discuss sharing expenses in developing a generic Outback Queensland brochure as well as its distribution. Every year we spent a portion of our budget developing and distributing our brochures, but the expected increase in numbers of visitors never really happened. It was a process we were observing, a function of our required annual marketing expenditure, shotgun technique it's called. I can tell you, I was never very happy with having to spend this money. I was on my way to one such meeting in Mt Isa when the proprietor at Burke and Wills Roadhouse, north of Cloncurry, asked if I would, with the aid of his A-frame towbar, tow a visitor's vehicle to Cloncurry for repair.

During this exercise I discovered the traveller was from Newcastle, NSW and he was on a six-month tour of Queensland with his wife and children. He had come through Outback Queensland via Charleville, Longreach, Winton, etc and on enquiry he said he had left home only 4 days previously. "Four days." I cried, with a realisation of the uselessness of our collective brochure runs crashing in upon me. "Why so fast?" I pressed him. His answer sealed the fate of the Matilda Highway and justified all the previous hours of convincing local authorities' about the benefits of town beautification and extracting whatever plant time we could bludgeon from Council foreman to work up some form of bush camp facilities around waterholes. He said and I remember this vividly, "There is nothing to see out here."

Now, this Outback of Queensland is rich in ancient landscapes, waltzing Matilda, origins of the trade union movement, dinosaur tracks, pitchery trails, Royal Flying Doctor, QANTAS, historic towns and their buildings, bushrangers, cattle, sheep and mining. The list is legion.

This man could find no easy method of accessing this vast region's extraordinary personality given that his passage of exploration was through a narrow road corridor. He had responded to our generic marketing "come to Western Queensland and see the Outback", but on arrival he discovered that it was inhospitable, too difficult to understand and in fact not visitor friendly, but more importantly there was no mechanism to slow him down and fulfil the expectations we had established through our marketing.

Needless to say I carried on to the meeting in Mt Isa and refused to contribute to cost of brochures. Instead I insisted that what we needed was an integrated road system that we could market, an interpretive highway modelled on the Great Top Road.

This concept eventually became the Matilda Highway with a series of east/west byways connecting distant towns and centres either side on suggested loops of the highway. With the assistance of Tourism Queensland and the local authorities we developed a system of roadside interpretive signs and installed them from Cunnamulla to Karumba, developed a logo and created the marketing name "Matilda Highway".

I remember even attempting to secure some funding through the Main Roads Department to landscape interpretive points and develop at appropriate distances Matilda Highway camping and rest facilities similar to the upmarket complexes that were installed along the Bruce Highway, but with an Outback ambience. Unfortunately, the signage was the best we could do from government with an intention that local authorities would continue adding to the sign infrastructure on an annual basis.

This concept has been copied all over Australia and continues to be, but I must say it is a pale shadow of what it was intended to be, although its very existence has created traffic beyond our expectations.

As traffic increased the towns along its length began restoring buildings, their small businesses became more visitor orientated, Matilda Highway publications and merchandising began emerging, glossy books were printed. Sunmap produced the Matilda Highway map and fish shops in Cunnamulla began buying fish in Karumba.

Preceding the decision to establish interpretive infrastructure for tourism the Matilda Highway was a transport corridor along which heavy transport took produce to market and supplied communities along its length. Now this primary function continues, but the Matilda Highway is also, for the hundreds of thousands of travellers that tour its length annually, an experience.

Researching to prepare this paper I was impressed to find that Outback Queensland received over ½ million visitors in the year 1996/7, of which 300,000 were domestic leisure visitors. The total annual visitation had increased by 20,000 over each of the two preceding years.

The fact is that the State is an essential active partner in the creation of tourism products. Is it not the State which ensures the availability of such basic necessities for tourism as education, essential infrastructure such as airports, railways, roads and water supply as well as the peace, order and security so essential to our way of life as well as our visitors wellbeing.

Integrated interpretive roads implemented by government can be designed to slow the visitor traffic down and keep them in a destination longer. This, of course, equates to higher yield per person for the community, but also ensures that visitors learn about the area they are visiting, not just drive through it. If there is any question in anyone's mind regarding the success of such a concept again the Matilda Highway is an excellent case study particularly if it is compared to Cape York Peninsula.

In the 1980s the Gulf Savannah tourist industry considered Cape York a model to aspire to, visitor numbers wise. Today Karumba the northern terminus of the Matilda Highway hosts some 100,000 visitors annually who regularly book out this highly successful coastal village out. Businesses are profitable and tourism is an essential element of that community's economy. Conversely, Cape York Peninsula is still dealing with rapid visits and the numbers are static at about 30,000.

Although interpretive roads appear to be proliferating across Australia, however, I wish to suggest that the concept has not yet been truly realised. I am addressing professionals who can contribute the missing elements. I wish to encourage you to consider the planning and landscaping of such tourism road products and be reassured by the success of the basic infrastructure that is currently in use on the Matilda Highway.

As for me, I have a new project, a new model I would ideally like to see implemented and that is an "Ocean Road" scenario, a section of the Captain Cook Highway between Cairns and Port Douglas. I believe this road, if approached correctly could be established as one of the

exceptional public icons of North Queensland in the same category as Skyrail if it was designed and constructed as an integrated road product. In my opinion, such planning would focus on landscaping, utilisation of lookouts and beach access, interpretive sites, photo points and be deliberately designed to deliver the optimum experience for visitors.

In conclusion, over the years I have worked with many government departments who seem to delight in producing draft plans, management plans and endless strategies. However, because the Department of Transport is a builder, the evidence of its craft is the quality of the roads that are emerging in Queensland. With its increased environmental consciousness and the recognition that roads are not just that area between the guideposts, it would need, but a slight shift in thinking to incorporate the amenity required for tourism in the planning and construction process. Such an outcome would go a long way towards preparing Queensland for the exponential tourism growth that is imminent and equip communities, big and small, with ways of fulfilling visitor expectations and add to regional economies.

VEGETATION MANAGEMENT AND POWERLINES

Mark Casswell
Ergon Energy

ABSTRACT

While vegetation management in the electrical distribution industry is considered primarily a routine maintenance task increasing ecological awareness and environmental concern has seen an increase in the public's expectations regarding the way that we maintain assets.

While the focus is still primarily compliance with regulations, this reactive approach generally does not allow creativity to achieve multiple outcomes demanded by the "triple bottom line" approach to organisational goals.

Utilising multi-disciplinary teams that include ecologists, botanists, horticulturalists and arborists, project managers can use technology and low energy inputs to achieve the multiple objectives of reduced costs, increased biodiversity and biomass while meeting and exceeding customer expectations.

This paper will cover issues that the electrical distribution industry has had to face to start on the road to better vegetation management practices as well as look at specific techniques and their impacts on vegetation and the environment.

A PROVOCATION – "CHEMICALS ARE ENVIRONMENTALLY FRIENDLY"

"And as a further irony, we persist in doing this (non-selective herbicide application) despite the fact that a perfectly sound method of selective spraying is known, which can achieve long term vegetational control and eliminate repeated spraying in most types of vegetation.

…the objective…to eliminate plants ultimately tall enough to …obstruct driver's views or interfere with wires…"

Selective spraying (takes) advantage of the inherent stability of nature, building on the fact that most communities of shrubs are strongly resistant to invasion by trees.

Carson, R. (1962) *Silent Spring,* Lowe & Brydone, London

Key Point: - 37 years of selective herbicide application knowledge

CHALLENGES FOR THE UTILITY INDUSTRY IN VEGETATION MANAGEMENT

Techniques used will be influenced by customers and staff. Some issues for consideration include:

Customer Expectations/ Perceptions

Internal (Ergon Energy – Wide Bay Region)

- 80% percent of management (in our industry) have a analytical, critical, logical thinking style ("left brain approach to life") excellent for engineering and network management;
- General lack of understanding in ecological processes – growth rates, arboriculture, seasonal timing;
- Conservative; and
- Resistance to change.

Key Point -Change Management and communication to non-ecological staff is critical.

MAINTENANCE VS DESIGN

Maintenance effectiveness is measured by:

- system reliability;
- quality of supply;
- safety to public and the environment; and
- customer feedback.

Separation of construction and maintenance attitudes/ behaviours:

- Construction - cheapest initial supply of power to customer regardless of the life cycle analysis view; and
- Maintenance - cheapest ongoing supply of power to customer.

Maintenance is typically carried out on a routine approach to treatment cycles rather than "right on time supply" based on ecological variables.

In a lot of cases the real chance for reducing our maintenance impacts and costs will be done at the design stage.

Shared land uses such as horticulture, agriculture etc implies a management regime in existence that may only need a slight modification to meet utility maintenance needs.

Key point – ownership of project from birth to death is critical

External (Wide Bay Receivers of Grid Power)

- Generally conservative;
- Green awareness increasing;
- Regional Qld has some mistrust of "Big Brother style" utilities;
- Increase of migration from Southern States with increased customer expectations; and
- Increase in alternative agricultural activities (organics, biodynamics etc).

Key point – customers needs affects practices

EVOLUTION OF CORPORATE PERCEPTIONS TOWARDS VEGETATION MANAGEMENT/ ENVIRONMENT

From resistance to compliance to proactive management that uses creative solutions to save money, meet environmental goals and exceed societal expectations.

Other aspects of change in corporate perceptions may include:

- from economic rationalisation to "Triple bottom line" objectives – ie social, environmental and financial;
- best practice - from static techniques to continuous development;
- management by objectives - management and customers define outcomes – practitioners provide best practice techniques rather than management dictating rigid specifications;
- implied or assumed contradiction of business growth and more efficient and lower impact energy use; and
- commitment to Greenhouse Challenge/ Environmental Management Systems - compliance versus opportunities for win-win situations.

Key Point – Continuous development is essential for the whole corporation

Specific Techniques – Costs and Impacts on Vegetation and the Environment

The following tables can be seen as basic models for decisions on what techniques will meet overall objectives. They are definitely vegetation community and land use specific.

Assumptions: After successive five year cycles: land use type – remnant vegetation (buffer, biodiversity conservation, limited ecological harvesting ie beekeeping, seed gathering)on roadsides and grazing, some weed infestation, non riparian, shallow top soil profile; vegetation community – eucalypt woodland 800 mm rainfall, tall species cover 40%, average height 6m (potential 20m); limited access corridor covering various land tenures servicing rural customers – access is typically in and out of properties.

Rural regrowth and urban tree management are different in terms of customer expectations and the type of vegetation managed. For example, while stem injection has low environmental impacts it would be aesthetically unacceptable to the urban customer. Conversely a mega mulcher which can have greater environmental impacts may inflict less fear on the general public than the sight of a spray rig in areas adjacent to urban areas.

Table 1 Vegetation management techniques (maintenance) comparing costs and environmental ratings

Technique	$/hectare	Cycle time (yrs)	$/ha/year	Environmental Rating
Blade ploughing	200	5	40	low
Stick Raking	150	4	37.50	low-medium
Chopper roller	50	4	12.50	medium
Disk ploughing	100	3	33.33	very low
Hand cutting and debris management (Stack, chip, cart away to landfill	500	5	100	high
Boom spraying	150	4	37.50	low
Cut stump	220	5	44	high-very high
hand spray	180	5	36	medium - high
spot spray	150	5	30	medium
stem injection	120	6	20	high - very high
Silveen mower	350	3	116.66	low-medium
Tree grab	1000	0	na	medium
Tree pruning	1000	2	500	very high

Table 2 Possible and assumed environmental impacts of techniques (scores 1 high impact - 10 no impact)

Technique	Visual	Overall impact on ecosystem	Biodiversity (affect on non-target species, risk of spreading weeds)	Life cycle analysis (energy, cycle frequency)	Geophysical (compaction, disturbance, erosion potential)	Greenhouse impacts (carbon debit or credit)	Score
Applied Ecology							
Burn#	3	5	7	6	8	2	31
Direct seeding	9	8	8	8	6	8	47
Chemical							
Selective herbicide	5	6	9	6	8	5	39
non selective herbicide	2	2	2	4	4	5	19
Selective herbicide - residual	3	3	6	7	8	6	33
Mechanical							
hand cutting	8	7	8	4	7	5	39
blade ploughing	3	2	3	3	2	2	15
stick raking	4	3	4	4	4	2	21
slashing	6	6	5	5	6	4	32
Disk ploughing	3	1	2	4	3	1	14
mega mulching	5	4	5	6	5	5	30
tree pruning	9	8	7	5	6	4	39
"Lopping"	4	8	5	3	6	5	31
Debris Management							
None	3	8	7	8	8	8	42
Stack	6	7	8	8	7	6	42
Cart to landfill	9	5.	4	2	4	2	26
Chip	9	7	7	6	6	7	42
Burn#	3	5	5	7	8	2	30
Stump grinding	9	7	7	7	5	5	40

Burning will depend on communities ecology and frequency, risks to adjacent land use will also affect rating

WHERE TO FROM HERE?

- Natural Heritage Trust funding for increased research and development into practices that meet biodiversity and maintenance goals;
- Increased staff and public awareness through promotion;
- Carbon credit research; and
- Renewable fuel research – biomass.

Research and development may include such technologies as:

- Arboriculture;
- applied ecology – specific mulches, micro flora addition to promote desirable species and inoculate stumps to exclude undesirable pathogens (Smith, 1999 pers. Com.), direct seeding, seed treatments – smoke;
- remote sensing;
- Geographic Information Systems; and
- chemicals – selective herbicides, growth inhibitors.

Key Point – Continuous development of best practices needs research and ecological skills

REFERENCES

Carson, R. (1962), *Silent Spring*, Lowe & Brydone, London

Martin, Steve (1997), *Vegetation Management Presentation* Ergon Energy Unpublished

Smith, I. (1999), Tree Management Techniques, personal communication.

TELSTRA

Philip Quelch (presenter) and Patrick Lowik
Telstra

ABSTRACT

Telstra's business relies on installing network infrastructure in transport corridors. Telstra, and other telecommunications carriers, have been granted limited powers and immunities from some State/Territory laws while carrying out certain network construction activities. However, in exercising these powers and immunities, carriers also have responsibilities to consult and notify, as well as to adhere to appropriate environmental and engineering standards.

This paper briefly outlines Telstra's construction methods, and discusses the planning and approval processes required for the installation of Telstra's network. The issues surrounding the identification of environmentally significant sites is also discussed.

INTRODUCTION

Telstra is a growing telecommunications company with an excess of 9.7 million telephone customer lines connected around Australia and a broadband network which passes over 2.5 million homes. The vast majority of these customers are connected by copper, coaxial cables, and/or fibre optic cable installed in conduits located in road corridors.

With customers demanding access to new technologies, and their growing appetite for data, Telstra has a requirement to not only maintain its network, but to expand it to accommodate customer demand for such things as high speed data, Internet access, broadband modems etc. In this rapidly changing and developing communication environment, Telstra is continually updating and installing new telecommunications networks.

Telstra, as the National Universal Service Provider is responsible for meeting the Universal Service Obligation (USO) as efficiently and economically as practicable. The USO ensures all people, regardless of where they live, have access on an equitable basis to a standard telephone service.

In recognition of the importance of the communications network to the Australian economy and the community generally, telecommunications carriers have been given the authority through the Telecommunications Act, with some limitations, to enter public or private land to install network infrastructure with exemption from some State/Territory laws.

This paper will briefly discuss Telstra's construction activities and the processes that are required to fulfil Telstra's legislative and ethical obligations to enter and use land. While Telstra installs network on both private and public land, the main focus in this paper is infrastructure in road corridors.

TELSTRA CONSTRUCTION

Telstra's infrastructure in road corridors includes conduits, cables, pits, manholes, above and below ground equipment, housings and poles. This infrastructure may be installed by Telstra's internal construction groups, by external contractors or by Network Design and Construction Ltd (NDC) – a wholly owned subsidiary of Telstra.

Telstra has several options available when installing conduit and cable infrastructure in the road corridor. Some of these are as follows:

- shared trench (with power utility, other carriers or other parties with which Telstra has a joint use agreement);
- trench by trencher;
- trench by excavator;
- directional bore;
- plough (generally in rural areas); and
- aerial cable on Telstra poles or power authority poles (New aerial construction is used infrequently).

NETWORK INSTALLATION METHODOLOGY

It is Telstra's preferred option to install its cable network underground, and in the road corridor wherever possible.

The method employed to install the network is largely dependent on the location of the construction and the environmental situation.

In metropolitan areas where a large number of formed surfaced driveways exist, Telstra often uses directional boring to install its conduit network. This technique minimises footpath and driveway disruption and minimises reinstatement costs.

In the rural areas, Telstra examines each task on its merit. For example, for open, previously cleared areas, Telstra may use a trencher, or directly plough cable. However where large stands of vegetation or other obstructions exist on the edge of the road corridor, Telstra will often use directional boring to minimise disturbance and reinstatement requirements.

In cases where it is not possible to use road corridors to trench or bore (eg rocky environment, native vegetation, cuttings etc.), Telstra will look at alternative routes such as utilising adjoining cleared land. Telstra has installed much of its direct buried national fibre optic cable on private property to minimise disruption to native vegetation on road reserves.

Using directional boring in order to avoid clearing native vegetation may incur significant cost penalties, often more than doubling the cost of a project.

LEGAL OBLIGATIONS

Powers and Immunities

The Australian Competition and Consumer Commission (ACCC) and the Australian Communications Authority (ACA) oversee the telecommunications regulatory framework in which all carriers operate. In addition, the telecommunications' industry is self-regulatory through a process of industry codes and practices.

The legislative right of carriers to enter and construct infrastructure on property has existed since Federation. With the gradual deregulation of the telecommunications industry, to the point today where there is an unlimited number of carriers, the legislative right of carriers to enter and construct infrastructure on property has also altered and is now limited, under the Powers and Immunities provisions of the Telecommunications Act 1997, to specific types of activities. These limited specific activities are referred to in Telstra as "Below the Line" activities. Installing infrastructure under the "Below the Line" process provides Telstra with secure tenure, providing our obligations to notify and consult with landowners, occupiers and managers are met. Any infrastructure installed prior to 1997 was 'grandfathered' under the act giving carriers tenure over their existing assets.

Where the carrier Powers and Immunities do not apply, Telstra must seek permission to access property, get land tenure and apply for approval by all the relevant authorities (eg, most often the local council). Within Telstra, the term "Above the Line" is used to classify those activities where carrier Powers and Immunities do not apply.

These "Below the Line" and "Above the Line" activities are discussed in the following sections.

"Below The Line" Activities

In limited instances, telecommunications' carriers are exempt from State and Territory planning, environment and building laws in the planning, design, construction, operation and maintenance of networks and network facilities.

These limited exemptions for network-related activities are in relation to:

- inspection of land;
- maintenance of network facilities;
- installation of low impact facilities;
- installation of subscriber connections (customer lead-ins);
- installation of temporary defence facilities; and
- a limited case-by-case appeal process for a Facility Installation Permit issued by the Australian Communications Authority (ACA) to cover installation of facilities in situations of national significance (where the use of land or relevant authority approval has not been obtained).

An inspection activity is the entry and inspection of land to determine if the land is suitable for any proposed purpose. Inspection can include making surveys, taking levels, sinking bores, taking samples, pot holing and examining the soil.

A maintenance activity is defined to include repair or service to existing facilities, and the installation of a new facility inside an existing facility (eg install cable in an existing conduit).

A low impact facility is a facility determined by the Telecommunications (low-impact facilities) determination. A facility or activity cannot be classed as low impact if it is to be in an area of environmental significance.

The Low-impact Facilities Determination contains a list of telecommunications facilities and activities that are essential to telecommunications networks but are unlikely to cause significant community disruption or significant environmental disturbance during their installation, maintenance or operation. The list includes certain:

- radio communications facilities;
- underground and above ground housings;
- underground cable facilities;
- payphones;
- emergency facilities; and
- co-located facilities.

These are all limited by size and the areas in which they can be located.

Examples of low impact facilities are: 1) the installation of a conduit in a trench less than 450 mm wide; and 2) the installation of a telecommunications pit with a surface area less than 2 square metres.

The Telecommunications Code of Practice places requirements on telecommunications carriers to conduct their network-related activities for which they are to exercise their limited powers and immunities in a way that responds to the rights of individual land-holders/managers, affected utility service organisations and road management authorities, and to broader community concerns on environmental issues and possible effects on heritage areas. These requirements and related provisions include:

- notification to owners and occupiers of land including local councils where they are the manager of public land;
- notification to Commonwealth environmental authorities in specific circumstances;
- notification to utilities and road authorities if impacted;
- generally 10 business days notice;
- ability to agree on alternative notification arrangements;
- emergency work can proceed without notification;
- an objection and consultation process in most cases;
- co-operation with utilities as far as is practical;
- co-location of facilities as far as is practical;
- do as little damage as is practical;
- minimise noise as far as is practical;
- act in accordance with good engineering practice;
- comply with recognised industry standards;
- comply with any relevant international agreements;
- restore land;
- keep records of facilities; and
- comply with conditions specified in a facility installation permit if applicable.

There is provision for the process of notification to be negated or altered through an agreement between the carrier and the notifiable body. Telstra has negotiated MOUs with many local councils, which allow for certain work to be carried out without the notification. This has had the effect of saving much administrative work by both the Telstra and the councils, and allows Telstra to respond more rapidly to customer demand.

"Above The Line" (High Impact) Activities

Installation of Telecommunications facilities not on the low-impact list (and which are not otherwise covered under one of the other exceptions of inspection, installation or maintenance), are dealt with in accordance with the relevant State/Territory laws and require approval by the relevant authorities (ie, they are "Above the Line" activities).

These activities include the construction of towers, aerial cable and any new installation that is going to take place in an area of environmental significance.

Identifying Areas of Environmental Significance

Areas of environmental significance include areas:

- identified for conservation as a World Heritage property. eg Wet Tropics of North Queensland;
- protected by a listed International Agreement;
- entered on the Register of the National Estate or the Interim List for that Register of Heritage Conservation;
- reserved for Nature Conservation purposes;
- protected from significant environmental disturbance; and
- of significance to Aboriginal persons or Torres Strait Islanders.

The identification of areas of environmental significance is a critical aspect of Telstra's compliance to its land access obligations. While some areas of environmental significance are well documented and obvious, many areas are not so obvious and to identify them, Telstra relies on consultation with relevant environment authorities and local councils.

ENVIRONMENTAL ASSESSMENT

Where necessary, assessment of environmental impact may include:

- significant land disturbance erosion;
- subsidence and instability;
- displacement of fauna or creation of significant barriers to fauna movement;
- introduction of noxious weeds;
- adverse effects on Aboriginal and Torres Strait Island communities by disturbing sacred sites;
- adversely affect sites or items of historic significance;
- obstruction of views and sunlight;
- degradation of scenic amenity by extensive land disturbance, vegetation clearance or incompatible building form;
- involves disposal of significant or deleterious volumes of spoil, overburden or process wastes;
- involves the emission of electromagnetic or other radiation which may adversely affect nearby electronic equipment or human health; and
- involves increases in noise and vibration from stationary plant and other on-site activities and equipment including construction and operational activities affecting people working and residing nearby.

Depending on the identification and assessment outlined above, before any activity commences it may be necessary to notify and consult with certain authorities responsible for the management or administration of the area, eg, Environment Australia, Australian Heritage Commission, National Parks & Wildlife Service (States), and certain responsible State/Territory or delegated local government authorities. In some instances, Environment Australia and the Heritage Commission may issue directions which must be followed.

TELSTRA'S ENVIRONMENTAL PRACTICES

In carrying out its activities, a carrier must do as little damage is practical and protect the environment and otherwise act in accordance with good engineering practice. It must comply with industry standards, comply with international agreements, protect safety of persons and property, interfere as little as is practical with operations of a public utility and roads and paths, restore land, etc.

Telstra's specifications and work instructions were developed to comply with government regulations and with input from a wide range of consultants. Below is a list of some of the documents detailing work practices undertaken by Telstra constructors.

- vegetation clearance & soil erosion control;
- cable ploughing measures to minimise soil erosion;
- trenching measures to minimise soil erosion;
- cable ploughing measures to minimise vegetation/tree damage;
- trenching - measures to minimise vegetation/tree damage;
- aerial cable vegetation/tree damage;
- prevention of transfer of disease, pests and noxious weeds;
- water pollution prevention & control;
- disposal of storm water from manholes & pits;
- disposal of water from equipment on site;
- washing of vehicles and machinery on site;
- clean up & disposal of contaminants & chemicals;
- state agencies dealing with the transport of hazardous waste;
- contaminants & chemicals storage & labelling;
- chemical & contaminants cleaning up;
- air & noise;
- control of dust emissions;
- control of exhaust emissions;
- control of noise emissions;

- solid waste management;
- solid waste disposal from site;
- solid waste management from cable installation activities; and
- soil management on site.

In accordance with Telstra's operating principles and Telstra's Environmental Management System (TEMS), there is a wide range of environment related process documentation applicable to each Telstra Business Unit.

FUTURE CONSIDERATIONS

Each year, Telstra undertakes a large number of construction projects in both the rural and metropolitan areas. Each of these projects is subject to environmental assessment as previously described. A major component of the assessment of each project is obtaining information relating to the work site.

To identify areas of significance and to ensure that conflicts do not arise when installing infrastructure, Telstra relies upon the various local, state and federal government departments as well as Internet sites, Aboriginal groups & land councils, and environmental consultants.

While Telstra's Environmental Management System covers the protocol issues for undertaking a project (eg environmental management programs, training and awareness, corrective action), there is a fundamental issue of obtaining correct and relevant information required for an accurate assessment. The number of the government, semi government and private sector parties who, by legislation, are required to be consulted, can cause confusion as to whether all appropriate parties have been consulted.

An example of a consultation where the lines of communication were not clear was the Ooline tree incident near Taroom. The Ooline tree is a tree that dates back to prehistoric time and was found in the rainforests of the region. While the region is no longer a rainforest, this remnant area of Ooline trees is significant. Telstra's assessment included a site inspection, and consultation with local landowners and the local council, although appropriate State Government expert groups were not consulted. Therefore the significance of the tees was not detected, and regrettably some trees were damaged.

Identifying significant areas and identifying significant flora and fauna in otherwise insignificant areas is becoming more difficult with more and more special interest groups and new species of flora and fauna being identified.

With Telstra undertaking a large number of projects across Australia each year, a considerable amount of manpower is allocated in ensuring the environmental issues are addressed. Due to the fragmented method in which this data is stored (eg government, indigenous groups, private companies), and with new 'players' entering the arena each day (eg from the deregulation of power, telecommunications and other industries) the threat to the environment is increasing.

To enable more efficient protection of Australia's environment, it would be beneficial if there was a single location for the storage of this type of data. The "Register of the Nation Estate" maintained by the Australian Heritage Commission goes someway towards providing this, in that it stores information on Natural, Historic and Indigenous areas of significance, although it does not contain an exhaustive list of all significant sites.

One possible model for the way this data may be stored and retrieved, is the way it is done in the 'Dial Before You Dig' service. 'Dial Before You Dig' is a service set up and funded by utilities to protect their underground assets. With one call a constructor can obtain information regarding all underground services in that area. It would be beneficial, if a similar (or the same) service could be used to provide all environmental information of the site.

CONCLUSION

It is the very core of Telstra's business to install infrastructure in road corridors. Government Legislation and Regulation grants Telstra, and other telecommunications carriers, various powers and immunities to be able to do this. However along with these powers and immunities are various responsibilities.

Telstra seeks to provide customer service in an efficient manner, while being a good corporate citizen, and respecting Australia's environment, its heritage and sites significant to indigenous communities. We recognise that through better communication with the various parties and interest groups, that a better balance can be made between these sometimes competing values.

RAILWAYS AND VEGETATION

Vanessa Craigie
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ABSTRACT

Many Victorian rail reserves carry intact, botanically diverse strips of native vegetation. These strips most often consist of remnants of lowland temperate grassland and grassy woodland communities - amongst the most threatened in the State, and grossly under-represented in the conservation reserve system. Roadsides and rail reserves are therefore essential to the ongoing survival of threatened species and communities. The challenge is to conserve these communities and species, on land where conservation is not the primary aim.

These strips remain because they have had a history of frequent burning; a management regime which at least partly resembled the pre-European management events. Railway maintenance works and soil disturbance damage and destroy native vegetation and promote weed invasion. Replacement of frequent traditional fuel reduction burning, by herbicide use and ploughing for firebreaks leads to replacement of sparse, open grasslands, that were often green in summer and presented a relatively small fire risk, with dense, exotic spring-growing plants that dried off rapidly to produce highly flammable fuel. So "quick fix", ostensibly cheaper fire reduction practices have led to greater long-term problems and increased management expenses.

Unnecessary damage is also caused by bureaucratic failures – where even though the rail authorities know of the existence of important sites, that information does not filter down to the workers on the ground, or to the engineers who are planning new works. The rail authority then has the concern and expense of making good the resulting damage. An example where a major rail upgrade has lead to real conservation gains is that of the National Rail Corporation, which duplicated and converted the Melbourne-Adelaide line to standard gauge.

INTRODUCTION

Victoria is a small state that has been intensively developed for agriculture and human habitation. It has a good network of national parks and conservation reserves, but these are mostly limited to areas that the early settlers did not initially want – they were too rugged, too densely forested, or not fertile enough. However, the gently undulating lowland plains of rolling grasslands and grassy woodlands were very quickly settled and farmed. Transport routes criss-crossed these plains, linking areas of population and agricultural produce. It was only along these transport routes that the original native vegetation was retained almost unaltered.

Because of the speed of colonisation, the temperate grassland and grassy woodland communities of the plains were very quickly destroyed and altered by clearing and agriculture. Once upon a time, a third of Victoria was covered by these plain's grassy ecosystems (DCE 1992), but no longer. Today, grasslands and grassy woodlands of the Western Volcanic Plains, Northern Plains and Gippsland Plains have declined to about 1% of their original distribution (Kirkpatrick *et al.* 1995) and are amongst the most threatened in the State. They are grossly under-represented in the conservation reserve system. The last remnants occur only on a few paddocks of unploughed, lightly grazed farmland, ungrazed public land such as "town commons" and cemeteries, and the narrow strips of roadsides and rail reserves. These strips are the most botanically intact and diverse. They remain because they have not been severely disturbed and have had a history of frequent burning; a management regime which at least partly resembled the pre-European management events.

As far as we know, the aboriginal owners of the plains landscapes regularly burnt the grasslands and grassy woodlands to promote "green pick" for their favoured food animals, and to maintain the open vegetation that they needed to grow and harvest food plants. With the coming of Europeans, this pattern of regular burning was altered, and grazing by soft-footed native animals was replaced by intensive, selective grazing by hard-hooved stock. Some native vegetation remained on farming properties but was inevitably altered by soil compaction, grazing, introduction of exotic weeds and removal of fire. The best remnants persisted on land which had not been heavily grazed.

MANAGING FOR CONSERVATION

Regular burning for fuel reduction was an essential part of management of rail reserves and many road reserves for over a century. This management regime is described by today's flora managers as "benign neglect", which fortuitously resembled, at least in part, the pre-European management events. Rail reserves that have never been ploughed, graded or sprayed with herbicides provide magnificent "railway gardens" that are the repository of some of the most endangered communities and plant species in the country. Examples are the nationally endangered *Rutidosis leptorrhynchoides* (button wrinklewort), *Diuris fragrantissima* (sunshine diuris), *Swainsona recta* (mountain swainson-pea), *Prasophyllum correctum* (gaping leek-orchid) and the nationally vulnerable *Senecio macrocarpus* (large-fruit groundsel). Communities listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 include the Western (Basalt) Plains Grasslands, Northern Plains Grasslands, Central Gippsland Plains Grasslands, Northern Plains Grasslands, Forest Red Gum Grassy Woodlands and Plains Grasslands (South Gippsland). Some of the best examples of these communities occur on rail reserves Humphries *et al.* 1992, Hills & Boekel 1996, Hoey. & Lunt 1995.

The challenge is to conserve these communities and species, in locations where conservation is not the primary aim. Railway maintenance requires signal upgrading, cable installation, drainage works, sleeper replacement, ballast discharge, weed control and wildfire prevention. Most of these activities have the potential to cause damage to railside vegetation.

MANAGING FOR ECONOMY

Issue 1 – Fire Protection

Sites of high conservation value were maintained for nearly a century, under a management regime of regular burning and relatively low level maintenance works. Then, during the 1980s, burning for fuel reduction began to be replaced by ploughing for firebreaks and using herbicides for weed control. Hundreds of hectares of invaluable native vegetation, mostly threatened grasslands, were destroyed for fire protection, in response to the 1983 Ash Wednesday bushfires. Unfortunately this tactic produced the opposite effect from that which was intended. Intact native vegetation on rail reserves is generally low growing, sparse and open, mostly dominated by fire-tolerant grasses, herbs and low shrubs. Such native grasslands and herbfields are often green in summer and, under a regime of annual or biennial burning, carry a light fuel load and present a relatively small fire risk. When ploughed or graded, the native vegetation is quickly replaced by tall, dense, exotic species, both annuals and perennials. These are without exception spring-growing plants, that dry off rapidly in summer to leave a strip of dry, highly flammable fuel. In Victoria, such plants include wild oats (*Avena* spp.), fescues (*Vulpia* spp.), yorkshire fog (*Holcus lanatus*) and canary grass (*Phalaris aquatica*). Witnesses have reported that the dry seedheads of Phalaris "light up like torches" and take flight on the wind to carry the fire to neighbouring land.

Issue 2 - Weed Control

When rail managers move from regular burning to ploughing, the resulting soil disturbance favours the growth of exotic weeds. In Victoria these are the grasses noted above, and other mostly agricultural weeds (eg. serrated tussock, thistles, Patersons curse, ragwort, horehound) that make unpleasant neighbours for the surrounding landholders. The rail managers are legally required to control noxious and nuisance weeds, and to keep sight lines and drains clear. Regular ploughing and herbicide use become necessary to keep these weeds under control – and once they have a foothold, nothing but concreting the rail reserve will remove them for good. So rail managers have an ongoing commitment and cost.

A hypothetical example of differing management costs between a disturbed, weedy rail reserve and one with intact native vegetation shows that slashing and/or ploughing and weed control can cost as little as $300 p.a or as much as $1400 p.a, depending on rainfall, soil fertility and other site features. Regular burning, on the other hand, may cost between $100 and $900 p.a., again depending on site features (see Appendix). Thus, the perception that retaining and managing

native vegetation creates a serious economic burden, may not be accurate. Obviously burning has its problems – the major impediments being that burning cannot be carried out on any day in any season, and that availability of CFA crews, the traditional workforce, is becoming more limited. Under these circumstances, use of machinery and herbicides may seem the more attractive option in the short term.

Issue 3 – Damage and Reparation

For many years, Victorian rail authorities have been aware that there is important native vegetation on rail reserves, and that they have an obligation under the *Flora and Fauna Guarantee Act* 1988 to "act in accordance with the objectives of the Act" ie.

"to guarantee that all taxa of Victoria's flora and fauna . . . . can survive, flourish and retain their potential for evolutionary development in the wild";
"to conserve Victoria's communities of flora and fauna";
"to manage potentially threatening processes"
"to ensure that any use of flora or fauna by humans is sustainable"; and
"to ensure that the genetic diversity of flora and fauna is maintained" etc.

Although the location of sites has been in the keeping of the rail authorities for a decade, that information does not always filter down to the workers on the ground, and there have been numerous cases of accidental or careless damage. This communication problem may be exacerbated by the use of independent contractors who have no "corporate history" of conservation issues, and may be inadequately briefed about conservation matters.

Many sites are poorly fenced or not fenced at all, and poorly signposted. Unfortunately even if sites are fenced and signposted, contractors sometimes ignore fences and signposts, either through ignorance, lack of concern, or a belief that the job they have been hired to do overrides any other consideration. On occasions, well-meaning tractor drivers have carefully manoeuvred their vehicle to avoid common trees – and cut a swathe through an irreplaceable rare grassland.

These problems lead to situations where no one is happy. The conservation agency has to handle yet another loss of prized biodiversity, local naturalists are outraged, the contractors are aggrieved and the rail authorities are faced with possible prosecution, the cost of reparation and damage to their public image.

The problem of making good the damage is not a small one. Once native vegetation has been eliminated or severely disturbed it is replaced by exotic weeds which are next to impossible to eradicate. Revegetation of native ground flora is an expensive exercise requiring long term maintenance and weed control, and is seldom successful without extraordinary effort.

So what appears to be an economical practice of sending in a bulldozer to do some quick ploughing and "tidying up", may provide only a short-term benefit and be counterbalanced by the long-term costs of constant fire prevention, weed invasion and cleaning up rubbish dumped in a "weedy wasteland".

To prevent loss of conservation values, there are a number of basic steps:

- railway planners and the regional managers of the lines (road managers and road foremen) must hold maps of important sites and have standing instructions to check these maps prior to planning and undertaking works;
- local offices of the Department of Natural Resources and Environment must be informed prior to the undertaking of works;
- contractors must be closely supervised and advised of "no-go" areas; and
- if works are to take place near a significant site, works corridors should be kept to a minimum, and NRE staff consulted on the location of materials stockpiles and vehicle parking areas.

An example of where these steps were followed was during the operations of the National Rail Corporation in 1983/84.

A MANAGEMENT SUCCESS STORY

In 1983 the National Rail Corporation (NRC) began the task of duplicating and altering the Melbourne-Adelaide rail line to standard gauge. The Victorian National Parks Association (VNPA) raised the question of whether this Gauge Standardisation Project required an Environmental Effects Statement from the Commonwealth, and the then Department of Conservation and Natural Resources (CNR) approached the NRC and requested that they be involved in planning works on rail reserves. As a result, a group of representatives from interested organisations (NRC, CNR, Commonwealth EPA, Federal Department of Transport, Victorian Public Transport Corporation, Victorian Ministry of Planning & Development, VNPA, Australian Heritage Commission) met and visited sites along the lines, and agreed upon works locations and fencing requirements.

Among the conditions agreed to were that CNR would:

- provide maps showing the conservation status of the entire line;
- provide work prescriptions to conserve vegetation; and
- provide brief training sessions on grassland flora to works crews.

And NRC agreed that

- a construction corridor would be marked and enforced;
- temporary fences would be established during construction and where necessary, replaced with permanent fences following surveys; and
- sites of vehicle parks and stockpiles would be agreed upon with CNR.

Overall, NRC went to a great deal of effort to identify alternative practices where the planned works would have serious impacts on conservation values. The attitude and actions of National Rail Corporation and their consultants and contractors set an example for other agencies to follow:

- they consulted extensively and made a genuine effort to understand and appreciate the issue, and ensured that all works staff were likewise informed;
- they demonstrated a firm commitment to environmental responsibility from the highest level and were prepared to establish and enforce environmental works guidelines;
- they were willing to be flexible in their construction methods to get around problems; and
- they adhered to the spirit as well as to the legislative requirements of environmental laws, even when it cost a little more. They fenced and signposted sites containing nationally significant vegetation, and also attempted to discover the localities of significant vegetation further along the rail line, well before works took place.

LATE POSTSCRIPT

Following the recent selling off of all Victorian rail lines by the previous Victorian government, several important rail sites, including those with threatened species, have been destroyed by contractors employed by one of the new private rail corporations. Some of the damaged sites were those fenced as part of the National Rail Corporation works.

COMMUNICATION!

This recent situation reinforces the message that we must always maintain communication between the various parties. We can't assume that one briefing, one letter or one map is enough. Communication with rail managers must be regular and often, or our best conservation efforts will be stymied by the problem of short "corporate memory" – when staff leave, agencies get restructured, jobs are passed on to new contractors and organisations get privatised.

SUMMARY

From Victorian experiences, the suggested benefits of maintaining native vegetation on rail are fourfold.

1. **Conservation**
   Biodiversity conservation is essential to our ongoing existence and quality of life. It is also a State and Federal legal requirement.

2. **Everyday Management**
   Conservation of native vegetation need not cost more in terms of everyday management. Weeds management and fire prevention is a never-ending expense, and native vegetation arguably presents a lesser or no greater problem.
3. **Environmental commitments**
   Damage to native vegetation costs, in terms of reparation, possible legal action and a bad reputation. On the other hand, conservation is good PR.

4. **Native vegetation pays!**
   Food for thought - an example of real returns from native plants.

Kangaroo grass (*Themeda triandra*) is in great demand for restoration and revegetation projects. In southern Victoria in spring 1999, pre-harvest orders for woolbales of clean kangaroo grass cut by brush-harvester start at $750 per bale. Bales have been sold this year for as high as $2000. Since one bale will cover only about 160m^2, there is a significant demand.

The scenarios presented in this paper are not intended to apply across the entire country in every circumstance. Nevertheless, it is hoped that the views expressed may go some way to promoting the idea that biodiversity conservation does not exist in isolation within a national park, and is not something that is always a burden on the ordinary taxpayer. On the contrary, conservation is a part of our everyday lives, and is not just an aesthetic and moral asset but often a financial one.

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APPENDIX: HYPOTHETICAL MANAGEMENT COSTS

Example 1: Rail reserve 3km x 30m (9ha), with a history of soil disturbance, now covered with exotic grasses, thistles, other broadleaf weeds, patches of woody weeds such as boxthorn, and dotted with gullies and rocky areas.

This example assumes that the site is disturbed, heavily invaded with weeds, in a high rainfall area with plenty of rail traffic. It receives some herbicide weed spraying, at least along the ballast and perhaps elsewhere to keep neighbouring farmers from complaining about weed invasions.

Weed control

For weed control along the ballast:
On average, contract driver and machinery @ $50/hectare = $450
Chemicals (variable) eg. glyphosate @ $17-$20/ha = $144 - $180

Annual cost

	High rainfall and fertility	Low rainfall and fertility
Along ballast	annual - $600 - $650	2 years - $300 - $325
PLUS boundary as needed	every year - $600 - $650	not needed

Slashing/Ploughing

For a 3m strip firebreak:
Machinery @ $50/hectare = $45
(Smaller machines are used for manoeuvrability on roadsides and many rail reserves, so two passes are needed.)

Annual cost

High rainfall and fertility	*Low rainfall and fertility*
2 firebreaks every year - $90	one break every two years - $22

Slashing and/or ploughing and weed control can cost as little as **$300** p.a (on a dry, infertile, open site where works are done every second year) or as much as **$1400** p.a (on a damp, fertile site dotted with rocks, trees and dumped rubbish where both weed control and firebreaks are done annually, and progress is slow).

Example 2: Rail reserve 3km x 30m (9ha), mostly covered with threatened and FFG listed native grassland and grassy woodlands. Patches of trees and shrubs, gullies and rocky areas.

This example assumes that the site has never been disturbed, has a history of regular burning and is essentially weed free. It does not always require annual burning if the fuel load is low. Because it is not weedy, the ballast margin very rarely requires spraying. Because of its conservation significance, the local naturalists watch it very carefully and occasionally seek rail authorities permission to hand pull weeds around the margins.

Burning

1. Burn conducted by government employees (maximum number of crew and vehicles) @ $100/ha = $900 (tanker $250/day, slip-on $50/day, employee $150/day)

2. Burn conducted by Country Fire Authority crew @ $100/km = $300

Annual cost

High rainfall and fertility		Low rainfall and fertility	
Annual	Govt crew: $900	**Two years**	Govt crew: $450
	CFA crew: $300		CFA crew: $150
		Three years	Govt crew: $300
			CFA crew: $100

Burning can cost as little as **$100** p.a in a dry, infertile, unfenced area, where burning is done every three years by a CFA crew; and as much as **$900** p.a. in a fenced, more fertile area where burning is done annually by State Government crews. (Mostly sites are burnt every two years.)

There are several variables to consider. On the one hand, CFA crews often burn rail reserves as part of their regional fire plan so costs may be less. On the other hand, availability of volunteers is becoming a limiting factor and difficulty of getting crews to burn may be an incentive to employ a contractor and bulldozer.

Costs increase on fenced sites and those adjacent to farmland, with the need to protect fences and watering down and slashing firebreaks.

(Figures provided by Roadside Conservation Assistance Committee, Dept of Natural Resources and Environment, Grey Box and Grasslands P/L and Land Management Systems P/L. Extrapolations and interpretations are those of the author.)

MANAGING VEGETATION ON PIPELINE CORRIDORS - A BALANCE OF COMPETING OBJECTIVES

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ABSTRACT

Since the 1950's the network of onshore petroleum pipelines in Australia has undergone significant growth and now exceeds 18,000km in total length. These pipelines transport natural gas and oil from the producing fields to refineries, storage and processing facilities and industrial, commercial and domestic customers in a safe, cost effective and environmentally benign manner.

The successful management of vegetation within this extensive network of pipeline corridors requires a range of competing objectives to be balanced. Preventing the growth of trees and shrubs on pipeline corridors improves public safety, protects the integrity of the pipeline and allows maintenance activities to continue unhindered. However, encouraging vegetation growth improves local ecological and aesthetic values, is expected (if not demanded) by many government and community groups and is often a condition of project approval.

The Australian Pipeline Industry Association Inc (APIA) is addressing the challenges faced in meeting these competing objectives via a Code of Environmental Practice, which is currently in preparation. This Code is being developed by the industry in consultation with key government and stakeholder groups and aims to establish standards for the management of environmental issues associated with the construction, operation and decommissioning of petroleum pipelines.

This paper provides a brief introduction to the pipeline industry and discusses the challenges it faces in managing vegetation on pipeline corridors. Key issues are identified and a range of recommendations are presented.

Key words: *Vegetation management, oil and gas pipelines, petroleum industry, APIA.*

INTRODUCTION

The owners of Australia's oil and gas pipelines must deal with a wide range of management issues every day. Traditionally engineering, technical and commercial matters were their main focus and issues such as pipeline pressure, flow rates, corrosion protection, product quality, market demands and operating costs consumed much of their management time. In recent years, it has become increasingly necessary for pipeline owners and operators to consider broader community matters and deal with issues such as third party use of easements, visual impacts and ecological effects. The pipeline industry has embraced these issues and sought to incorporate appropriate management strategies into the planning, design, construction and operation phases of pipeline developments.

However, one area where this is particularly challenging is in regard to the management of vegetation on pipeline easements. The challenge arises from the fact that the characteristics of vegetation cover required to best achieve technical and operational objectives are different from those required to best achieve environmental objectives. Finding the appropriate balance is the key to success.

This paper provides a brief introduction to the pipeline industry and identifies the challenges it faces in managing vegetation within pipeline corridors. Management difficulties are discussed and the actions being taken by industry to resolve potential areas of conflict are outlined. Finally the paper presents a range of recommendations to improve the means by which both industry and the community can better achieve an acceptable outcome.

A BRIEF HISTORY OF PIPELINES

The earliest known record of pipeline use was for the transportation of natural gas in bamboo stems in China over 7,000 years ago. It is likely that similar devices would have been used to transport water during even earlier times.

The Assyrians, Egyptians, Greeks and Romans used clay pipes and hollowed rock as conduits for water. Perhaps the most famous of ancient pipeline concepts was the aqueduct. Records

exist of a long distance pipeline, made of sewn ox hides, being laid across the desert to supply water to the Persian army during its invasion of Egypt in 525BC (AIP, 1997).

In the USA in the early 1820s simple wooden pipelines, often hollow logs, were used to transport natural gas short distances to provide internal light in buildings. By the 1840s iron pipe was being used and the ensuing 50 years or so, aided by high tariffs in the traditional transport modes of road, rail and ship, saw significant development in the reliance of pipelines for transportation.

In 1892 the first high-pressure long-distance pipeline began operation, transporting natural gas from the Indiana gasfields to Chicago. By the turn of the century pipelines were being built for petroleum developments in countries such as Russia, Mexico and Venezuela.

The development of steel pipe around 1910, followed by the high energy demands and oil tanker shipping losses of WWII, heralded the beginning of modern pipelines. Advances in pipeline engineering, materials manufacture and construction methods permitted transportation, across land and under the sea, of significantly larger volumes of petroleum products directly to refineries, ports and consumers.

The recognition of the efficiency of pipelines as a transport medium led to a post-war boom in the pipeline industry with technological advances continuing in line with rapidly increasing energy demands. As a result the pipelines of today are a far cry from their rudimentary origins. Modern pipeline design, construction and operation applies sophisticated technology such as:

- Geographic Information Systems and satellite navigation to aid route planning;
- remote control internal x-ray units for inspecting pipe-joint welds during construction; and
- internal pipe inspection units (known as 'Intelligent Pigs') capable of determining pipe wall condition without interruption to gas supply during pipeline operation.

PETROLEUM PIPELINES IN AUSTRALIA

Australia's first major pipelines were built to supply water for the newly emerging towns of the colony's arid regions. In 1903 the Western Australian government commissioned the 600km Darling Ranges to Kalgoorlie pipeline to transport water to the Goldfields.

The first petroleum pipeline in Australia was built in the 1950s to transport petroleum products 60km from the new Shell Geelong refinery to Melbourne. The significant oil and gas discoveries of the 1960s and 1970s, accelerated the development of petroleum pipelines in Australia and facilitated the delivery of crude oil and other products to the refineries, and natural gas to industrial and domestic users.

Australia's first crude oil pipeline was constructed in 1964 between Moonie and Brisbane (306km). The first major gas pipeline was constructed in 1969 between Roma and Brisbane (397km). The gas pipeiine between Moomba and Adelaide (781km) was also completed in 1969. An LPG pipeline was also built from Longford to Westernport (185km) in 1968.

Today Australia has over 18,000km of high-pressure petroleum pipelines (refer Figure 1 and Table 1).

Table 1. Pipeline lengths.

Location	Kilometres	
	Gas	Oil
New South Wales	2,639	0
Northern Territory	1,988	270
Queensland	3,483	1,239
South Australia	1,506	934
Victoria	1,372	223
Western Australia	4,614	29
Total	15,602	2,695
Sources: AGA 1998, AGSO 1998.		

Australia's petroleum pipeline network is growing at a rapid pace and with increasing energy demands, technological advances, new natural gas discoveries and the deregulation of the gas industry it will continue to do so for years to come. The concept of a truly national pipeline network through which gas is transported and traded regardless of State and Territory borders is becoming a reality.

Australia presently relies upon its own petroleum resources and those sourced under agreement from the jointly regulated (Australian and Indonesian Governments) Timor Sea region. However, as domestic and regional demand grows the pipeline network is likely to extend beyond our shores to facilitate the transportation of petroleum products both to and from our Asia/Pacific neighbours. The first stage in the creation of a regional petroleum pipeline network has commenced with the proposed Papua New Guinea to Australia gas pipeline in the advanced stages of planning.

The future of the Australian pipeline industry will undoubtedly present many new challenges which, as history has shown, will lead to continued innovation, technological advancement and economic growth.

VEGETATION MANAGEMENT ISSUES

Vegetation is an important consideration in the management of pipeline easements. It is recognised that increased density and diversity provides certain environmental and community benefits, while operational and safety advantages result from a less dense, specific type of vegetation. The challenge is to find the correct balance.

Benefits of Reduced Vegetation Cover

From a pipeline integrity and safety point of view, pipeline easements are best kept clear of trees and shrubs. A low cover of grass, sufficient to prevent erosion, is most preferred. This is because people pose the greatest threat to pipelines. Industry records demonstrate that backhoes, excavators and posthole diggers are far more likely to cause a pipeline failure than corrosion, earthquakes or welding faults. If the result of pipeline failure is an explosion and fire, the consequences for life, property and the environment may be significant. In addition, the supply of gas will be interrupted with potentially serious implications for industrial, commercial and domestic users.

For this reason the pipeline easement and the location of the pipeline within it need to be readily identified. In particular, the easement and the warning signs need to be seen. This cannot be achieved if the easement is overgrown with trees, shrubs and other dense vegetation.

Access for maintenance is also an important issue. While many pipeline easements are inspected by air, there will always be the need for maintenance crews to gain ready access. In particular, cathodic protection systems, valves and other infrastructure need to be maintained. Areas of erosion need to be repaired and weeds need to be controlled. Dense trees and shrubs do not allow this.

Trees in close proximity to the pipeline may cause direct physical damage to the pipeline. The trench in which the pipeline is buried is backfilled and compacted but never reaches the same level of compaction as undisturbed soil. As a result, the root systems of regrowth trees and shrubs preferentially utilise the trench, wrapping themselves around the pipeline. If these roots damage the external coating of the pipeline external corrosion may result, weakening the pipe which eventually may lead to pipeline failure.

Tree roots in drainage lines pose additional risk. In times of flood, sections of pipeline that would otherwise remain undamaged may be exposed as the trees are uprooted bringing the pipeline with them.

As a result, from a safety and operational perspective the ideal vegetation cover for an operating pipeline easement is a low cover of grasses. This will protect against erosion but allow easy

access for maintenance crews and be easily seen and identified by third parties. Trees and larger shrubs are therefore removed from pipeline easements.

Benefits of Increased Vegetation Cover

The focus of this paper is the operation phase of pipeline developments. However, it is valuable to touch on the route selection and construction stages as these present the best opportunities to minimise impacts to vegetation and visual amenity. Measures adopted include:

- avoiding areas of dense vegetation or communities of conservation significance;
- keeping the construction right-of-way as narrow as practicable;
- trimming trees on the edge of the right-of-way rather than removing them; and
- reducing the length of straight easement, particularly adjacent roadways or in undulating terrain.

An increase in environmental awareness by industry has led to improvements in construction techniques. These improvements have made it possible to reduce clearing widths from the traditional 30m corridors, to more acceptable easement widths. For example, the Berri - Mildura Pipeline, constructed by Envestra and Boral Energy earlier this year, kept to a 10m right-of-way through areas of remnant vegetation[26]. In some areas these measures may even allow a pipeline to be constructed leaving the canopy cover unbroken.

There are a range of ecological and amenity benefits related not only to reducing the initial clearing but to encouraging complete revegetation. These include:

- promoting biodiversity;
- reducing habitat fragmentation effects; and
- minimising visual impacts.

An additional benefit of dense regrowth vegetation is that it prevents, or at least deters, use of the operating easement by third parties. This is particularly important in more remote areas where the use of the easement may open up previously inaccessible areas to recreational off-road vehicles.

INDUSTRY REQUIREMENTS

There are a range of industry standards guiding the pipeline industry that incorporate environmental measures. In addition, project specific Environmental Management Plans provide site specific management procedures. The role of these documents in the management of vegetation is discussed below.

The Australian Standard

All new high pressure petroleum pipelines must adhere to the requirements of Australian Standard AS2885 (Standards Australia, 1997). This is largely a technical document dealing with technical engineering and design matters, however, Section 3.2.4.4 requires that:

> "Unless approved, vegetation is to be restricted to allow free passage along the pipeline route. Vegetation in the vicinity of the pipeline whose roots may damage the anti-corrosion coating of the pipeline, is not permitted."

The Australian Standard is the principal document guiding pipeline developments in this country. Whilst brief, the message from the engineering branch of the industry is clear: pipelines and vegetation don't mix.

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[26] Construction easement widths are influenced by pipeline diameter. Larger diameter pipe not only requires larger equipment but an increased number of plant and personnel. This results in the need for a greater right-of-way width.

The APPEA Code

The Australian Petroleum Production and Exploration Association is the principal body representing the upstream petroleum industry. The Association has developed a Code of Environmental Practice to guide the upstream activities from an environmental perspective. The latest version of the Code, released in 1996, provides basic guidelines for the construction of pipelines but does not contain any procedures or management objectives in regard to operating pipelines.

Project EMPs

All recent pipeline developments operate in accordance with project specific Environmental Management Plans. These plans have largely been developed case-by-case, in the absence of a comprehensive set of industry standards. Developing such plans in this manner is not ideal for either the pipeline owner or the regulator and leads to inconsistency, inefficiency and greater uncertainty. As a result, the guidelines applied to vegetation management vary between pipelines, owner companies and States.

The APIA Code

The Australian Pipeline Industry Association was formed in 1968 to represent the interests of pipeline owners, operators, construction companies and service providers. The Association now has over 450 members.

In 1998 APIA commenced preparation of a Code of Environmental Practice with the aim of addressing the problems of inconsistency between projects and to assist its members to develop effective management procedures without returning to the drawing board for each project. The Code is divided into three key parts: construction, operation and decommissioning. The consultative process used to develop the document has involved industry personnel, regulatory authorities, non-government organisations and specialist advisers. The construction element was released in late 1998 and has been well received by both industry and government. The first draft of the operations section of the Code is currently undergoing review by external stakeholders.

The vegetation management objectives as outlined in the Code are:

- to promote and maintain stable vegetation cover;
- to minimise impacts to native flora and fauna;
- to minimise soil erosion and sedimentation;
- to avoid losses to agricultural production;
- to reduce visual impacts; and
- to prevent and control weed invasion.

In order to achieve these objectives the Code requires the following:

- in areas of poor vegetation cover, where further impacts are likely, appropriate corrective actions shall be taken;
- regrowth trees that are within 3m of the trench centreline shall be removed at seedling or sapling stages to ensure tree roots do not create a safety risk to the pipeline;
- the access track should be kept navigable by adequately controlling vegetation growth;
- where possible, areas that have been recently revegetated (eg. following construction or maintenance) should be avoided by vehicular or machinery movement. The period for which these areas should be avoided should be determined by qualified personnel taking into account the area, soil type, climate and method of planting conducted;
- care should be taken not to disturb any areas of native vegetation outside of the access tracks or easement; and
- revegetation success should be monitored in accordance with an approved program. Further restoration works may be required in areas where vegetation establishment has been less than acceptable.

In addition the Code provides guidelines for the management of weeds including:

- weed control programs;
- inspection, monitoring and auditing;
- training of personnel;
- reporting; and
- the movement of soil and equipment, including vehicle washdown.

COMPOUNDING THE PROBLEM OF COMPETING OBJECTIVES.

The differences between the vegetation characteristics of the ideal operating pipeline and the ideal "environmental pipeline" are obvious. Achieving a pragmatic balance is complicated and far too frequently new projects are forced to adopt construction easements that are too restrictive, inflexible management measures and impractical operating conditions. The cause of these problems is often the project approval process.

Petroleum pipelines are constructed and operated under licence from state governments. Prior to the issue of a pipeline licence the relevant Minister must consider the environmental and community issues associated with the proposed development. Generally the development company is required to prepare an assessment of the potential environmental impacts. Depending on the scale of the project and the sensitivity of the environment involved, a public process may be required.

As part of the planning and assessment process, the developer should aim to demonstrate that the impacts to vegetation and wildlife habitat have been minimised and that the easement will result in an acceptable level of environmental impact in the longer term. The most effective means for achieving this objective is to select the most appropriate pipeline route. In particular, vegetated areas should be avoided where feasible alternatives exist.

In addition to the impact avoidance strategy adopted during the design, environmental management plans are required to provide practical guidelines for the construction and operation phases. These plans incorporate quality control systems such as on-site inspection, monitoring and auditing by qualified and experienced personnel. Importantly, the objectives for the standard and extent of revegetation are also set at this time.

The project approval processes often drive these impact mitigation strategies. That is, environmental assessment and approval can be a costly and extensive process - recent examples attest that the process can take up to two years and cost over $3 million. The anticipated schedule for approval means that developers commence the planning and assessment very early in the process - often before any meaningful engineering has been conducted. The work is too often conducted by scientists and academics with input from government officers all of whom have limited practical pipeline experience. As the process continues and the need for project approval looms, the developer is more likely to agree to the less practical demands of government or the community. The result is that developers find themselves making promises that may be at the expense of the operational objectives and a practical balance is not achieved.

Recent developments in Western Australia have incorporated "completion criteria" as a condition of approval. This involves the requirement to return the right-of-way to its previous condition, where species diversity and abundance is comparable to surrounding land. This is obviously not consistent with the need to protect public safety or pipeline integrity.

RESOLVING THE CONFLICT

The pipeline industry recognises that vegetation and wildlife habitat have certain intrinsic values that warrant protection. Industry also recognises that it has certain responsibilities in this regard.

Pipelines transport valuable commodities in a safe and efficient manner. They are an essential part of modern society - but are not without environmental costs. New projects need to be considered on the basis of their actual costs and benefits. If it is considered that the benefits

outweigh the costs then projects should proceed on the basis that the costs have been accepted. As a result, the pipeline developer must select an appropriate route, keep the construction right-of-way as narrow as practicable, avoid unnecessary clearing and adopt suitable rehabilitation practices. However, regulatory authorities and the community must accept a standard of easement that protects public safety and pipeline integrity and allows operators to conduct an efficient maintenance program. This will not always be a fully revegetated easement with the same species diversity and abundance as adjacent land.

If an appropriate balance is to be achieved, APIA must take the lead role and must act not only on behalf of its members but the wider community. In this regard, industry must strive to:

- develop and maintain good working relationships with government, non-government organisations (such as Greening Australia) and the broader community;
- work with governments to improve the environmental assessment and approval process;
- produce an agreed Code of Environmental Practice that has had adequate input from all stakeholders and sets a framework for pragmatic management of vegetation;
- ensure the adoption and implementation of the Code by member companies; and
- establish a process by which both the guidelines and company performance can continuously improve.

CONCLUSION

Australia has an extensive network of oil and gas pipelines that continues to expand. This network transports valuable community commodities in a safe, effective and environmentally responsible manner. However, the character of vegetation cover required to allow protection of public safety and pipeline integrity does result in a certain level of ecological and amenity impact. Industry is responsible for ensuring that these impacts are kept to a minimum level. The community should only accept, and regulatory authorities should only approve, projects where the benefits outweigh the costs. However, the safety, engineering and technical needs of pipeline owners are not always recognised by government and the community and often unreasonable conditions are placed on pipeline construction and operations.

APIA aims to resolve this issue and has commissioned the development of a Code of Environmental Practice and is committed to a closer working relationship with government and the community. It is anticipated that this approach will result in consistent and pragmatic guidelines for pipeline projects and ultimately assist industry, regulatory authorities and the community to achieve a standard of vegetation management that is closer to the ideal balance between the competing objectives.

ACKNOWLEDGEMENTS

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CONSERVATION ROADS - FAUNA FRIENDLY ROADS IN ENVIRONMENTALLY SENSITIVE AREAS

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Manningham City Council and LA and NJ Moore Pty Ltd

ABSTRACT

Department of Main Roads (Peninsula and Northern regions) has been active in assessing fauna crossing options where roads, passing through critical fauna management areas, are being upgraded. Fauna of particular concern in these areas include the endangered southern cassowary in the Mission Beach and Atherton Tablelands areas, the rare Lumholtz's tree-kangaroo, rare possums and smaller ground dwelling species.

Work undertaken on a number of "cassowary roads" in the Wet Tropics is presented. This work is the first attempt to design an effective road management strategy for an endangered rainforest fauna species along highly trafficked roads. A variety of management options are presented and road crossing issues discussed. We present this targeted approach of using detailed ecological knowledge as appropriate for use with other sensitive species needing to cross roads. We also recommend that a new road use category *ie* Conservation Roads, be recognised to protect environmental values in sensitive areas. Such a road category would require ecological work to define appropriate road speed, pavement widths and retention of canopy connectivity, all of which are both site and fauna responsive.

Assessment was also undertaken of the use made by ground dwelling fauna of existing drainage culverts. There are several factors which appear to determine the likelihood of fauna using culverts. Utilising these factors to slightly modify culverts can encourage fauna to make greater use of culverts to cross roads without compromising hydrological function.

An essential component of this ecological approach is consultation with community groups who use the roads regularly (residents) or intermittently (tourists) and those road engineers whose responsibility it is to construct a safe and practical road. Using this consultative approach should result in a better balance between the legitimate needs of the road users and those of the wildlife using the habitat through which the road traverses.

BACKGROUND

The Queensland Department of Main Roads (DMR) commissioned a study of fauna issues as part of planning for the upgrade of two busy tourist roads in the Mission Beach area of north Queensland (Figure 1). The work was conducted from July to November 1998 and focused on the dangers to the local cassowary population presented by the existing alignments and preferred upgrade options. Mission Beach is recognised as one of several cassowary strongholds in north Queensland. An assessment was also made of the risk these roads presented to other fauna, along with the use such animals made of existing culverts.

Both the El Arish-Mission Beach and Tully-Mission Beach Roads cut through critical cassowary habitat, with these birds occurring in significant numbers either side of the study roads. The area is also home to a number of other fauna of conservation concern including 10 rare species and four endangered species. Large numbers of fauna are killed on both the study roads, the most significant species being the cassowary. Approximately 40 cassowaries have been killed on Mission Beach roads since 1989, and 28 (70%) of these were killed on the study roads. Of these, 16 birds (57%) were killed in an 8.4 kilometre section of El Arish-Mission Beach Road and a further 12 (43%) were killed on the 13.5 kilometre section of the Tully-Mission Beach Road (Figure 2).

INTRODUCTION TO THE CASSOWARY

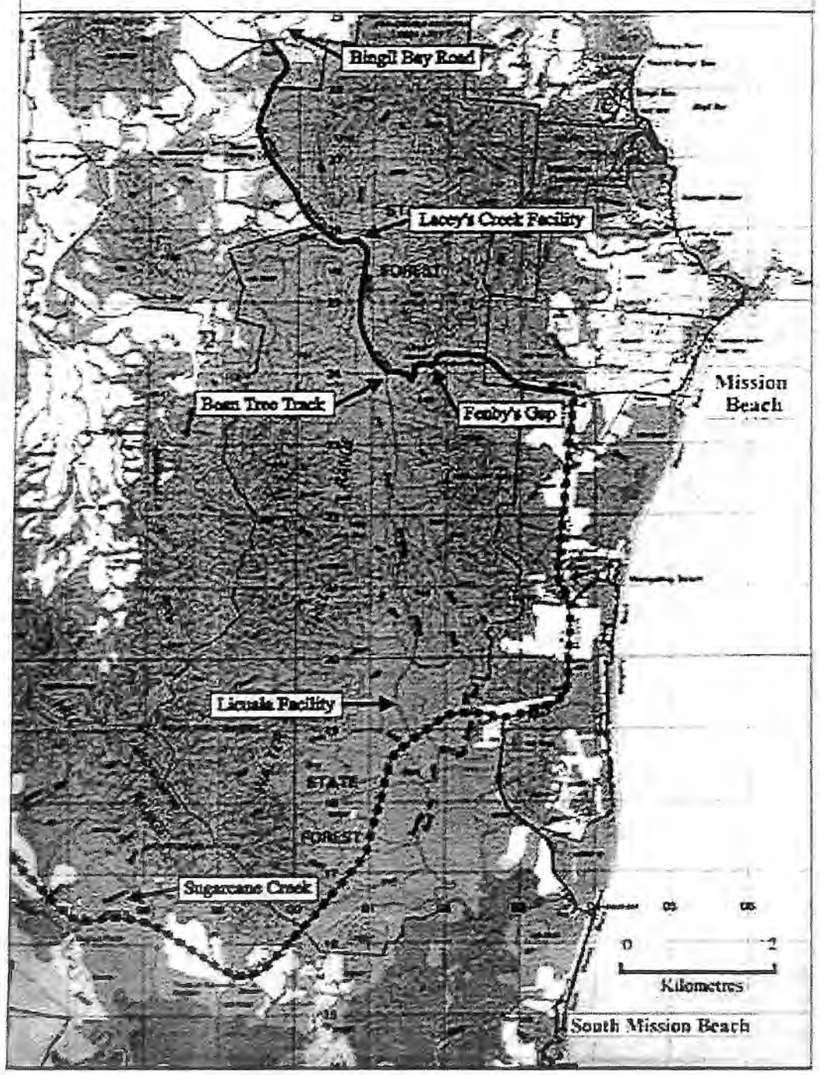
The southern cassowary *(Casuarius johnsonii)* in the Wet Tropics area is classified as Endangered under both the *Queensland Nature Conservation Act 1992* (NCA) and the *Endangered Species Protection Act 1992* (ESPA 1992). Cassowaries also are known to occur in parts of Cape York Peninsula.

Based on a nine-month survey of cassowaries throughout the Wet Tropics (Crome & Moore 1988, 1990), it was tentatively estimated that there were between 2500-4000 adults remaining in the region. As a result of further studies (Moore & Crome 1992, Crome & Moore 1993; Crome & Benntrupperbaumer 1992; Moore 1996a-d) it is now considered that the true number is more likely to be less than 1500 adults. The cassowary is an important keystone species and the only known disperser of over 100 rainforest plant species. As such the loss or decline of this species would have far-reaching impacts on the dynamics of the area's World Heritage rainforests.

Figure 1

Mission Beach Cassowary Study Area

El Arish-Mission Beach and Tully-Mission Beach Roads



Source: Lee Moore 1998

Figure 1. Mission Beach Study Area

Figure 2

Cassowary Road Deaths in Mission Beach District 1986 - 1998

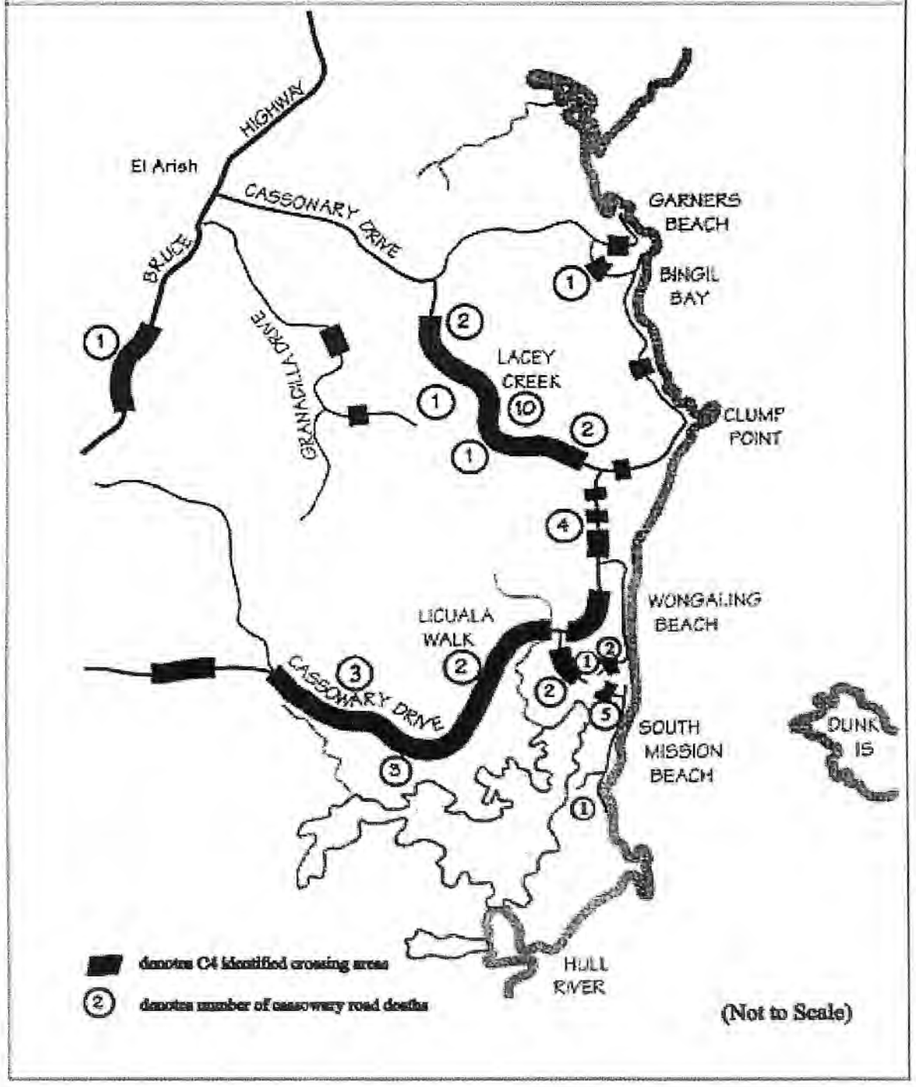


Figure 2. Mission Beach Cassowary Road Deaths

The Field Methodology

The study area is divided into a number of Search Areas, each of which is systematically traversed on foot using compass bearings. All cassowaries are located directly, or indirectly by using signs *eg* droppings or footprints. The survey route is accurately plotted on a field map and a GPS is used when possible to pinpoint trig points. Private land is not accessed unless the landowner's permission has been obtained.

The aim of this surveying technique is to locate individual cassowaries and over time track their use of habitat and likely relationships with neighbouring birds, similarly located. This methodology relies on field expertise and the identification of individual birds from physical characteristics *ie* adult/subadult, male/female, casque shapes, wattle formations, colour and size of individuals and footprint measurements. Any doubt as to an individual's identity is followed up in the field by immediately re-locating neighbouring cassowaries to eliminate them as likely candidates.

Although sightings of individual birds are the most certain evidence of occurrence, footprints and droppings are the most common signs of a cassowary's presence and usage of an area over time. Footprint measurements of an individual bird or family party (male with chicks) are extremely useful in identifying individual cassowaries and to assess their use of an area. It should be noted, however, that footprints are an adjunct to survey information and their visibility is dependent upon soil type and condition. Many birds live in areas where footprints are rarely apparent and thus the bird would be overlooked if an expert survey was not conducted.

As with footprints, droppings are extremely useful in surveying cassowaries. From our knowledge of the species behaviour it is possible to make reasonable interpretations of the habitat usage of the bird based on its droppings. Through a season and from year to year the bird will concentrate activity in those areas of its range that yield adequate food, and fresh droppings are concentrated in such areas. The distribution of old and very old droppings are often spread wider and indicate the past use of the home range.

THE EXISTING SITUATION

Status of Mission Beach Cassowaries

The cassowary population of the Mission Beach area was estimated to be approximately 89 adult cassowaries (Bentrupperbaumer 1992). A total of 34 adult birds were identified as regularly crossing the roads within the study area during this survey (Figure 3). Home range size and density of Mission Beach birds is similar to that found for birds in parts of the Daintree area (*ie* 1-3 kilometres^2/bird). It is probable; therefore, that the Mission Beach area covered in this study currently has a similar total population of adult cassowaries to the Daintree lowlands *ie* 50-60 adult birds.

Status of Other Fauna

There are a number of non-flying fauna species which occur within the Mission Beach study area which are of conservation significance. The construction phase of any road upgrading has the potential to impact on some of these, but it is the barrier affect of the increased road width that is of major concern. Those species known or likely to occur within the Mission Beach survey area are listed in Appendix 1.

Cassowary Crossing Points - El Arish-Mission Beach Road

El Arish-Mission Beach Road has 12 major Cassowary Crossing Points between Bingil Bay Road and its junction with Tully-Mission Beach Road, a distance of 8.4 kilometres. Sixteen birds cross this road (*ca.* 20-21% of the estimated 1992 adult cassowary population of Mission Beach). At least another 20 sub-adults are also known to cross this section of road.

Ten adult birds use multiple crossings within the Tam O' Shanter State Forest section alone. Lacey's Creek area has five Crossing Points within a 400m radius of the carpark area which are used by at least six adults. Only four birds along the El Arish-Mission Beach Road use a single crossing, the other 12 each use up to four different Crossing Points.

Cassowary Crossing Points - Tully-Mission Beach Road

There are nine major Cassowary Crossing Points along the 13.5 kilometres of the Tully-Mission Beach Road study area used by at least 17 adult cassowaries (21-22% of the area's estimated 1992 adult cassowary population). Four of these crossings are in the Licuala State Forest area and are used by 10 adult birds. All Crossing Points are also used by sub-adult cassowaries. Due to the width of the Tully-Mission Beach Road, its verges and the 100-kilometres/hour speed limit, it acts as a severe barrier to cassowaries and other fauna. Any animals that do attempt to cross it are at great risk of being killed by traffic.

Other Fauna Crossing Points

To assess the frequency and success rate of fauna crossing the El Arish-Mission Beach and Tully-Mission Beach Roads would require a long-term research program. That there are constant crossings is illustrated by frequent road kills of species such as pademelons (*Thylogale stigmatica*), northern brown bandicoots (*Isoodon macrourus*) and many species of rodents and amphibians. The examination of culverts along the road during this study indicated that some culverts are currently used by rodents (giant white-tailed rat *Uromys caudimaculatus*, *Rattus sp.* *Melomys sp.*) and reptiles to cross under the road, however the extent of use was not determined.

It is considered that the area with the most potential to encourage animals to cross the road are those sections of the road with significant canopy cover. Sufficient canopy cover can provide protection from predation and often coincides with streams and drainage lines, which are known to be natural fauna corridors within the rainforest.

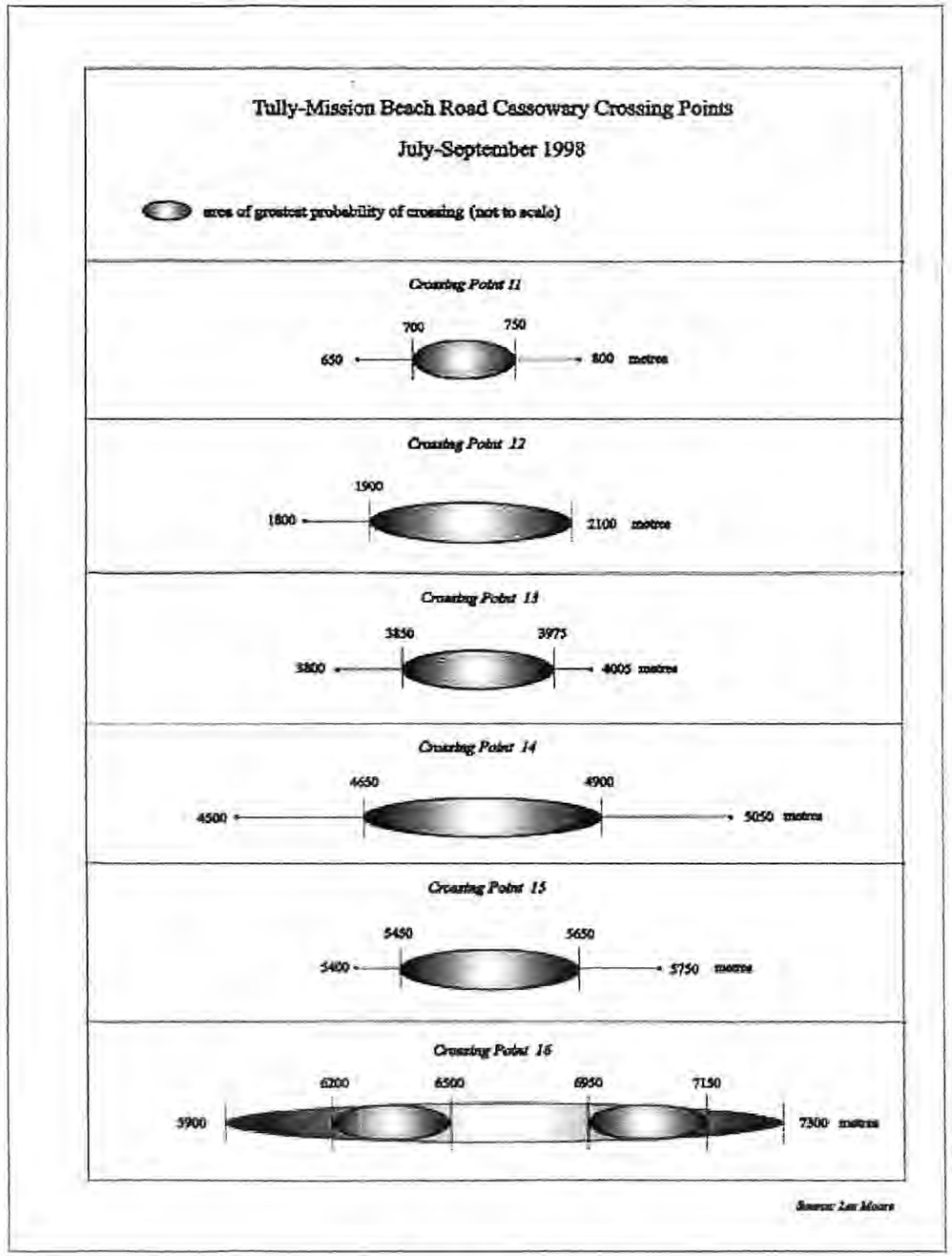


Figure 3. Indicative Home Ranges

MANAGEMENT SOLUTIONS

Risk Reduction Strategies

When designing risk reduction strategies for road crossing cassowaries, it is essential that the Crossing Point be accurately located on the ground. Diagrammatic representations of Cassowary Crossing Points have been developed to assist road designers and planners to understand how birds use these points. Examples of this type of diagram are shown in Figure 4 and apply to Crossing Points along both study roads. The dark ellipse within the diagrams illustrate the area of greatest probability of crossing. The wings or 'standard error' bars either side of the ellipse represent the area where the cassowary(s) may occasionally cross. The combination of the two elements constitutes the Cassowary Crossing Point.

While local government has an opportunity to impose development restrictions or covenants to support the cassowary population in this area, DMR also has the opportunity to contribute to the conservation of the species by implementing innovative best management road design practices, many of which are outlined in *Roads in Wet Tropics* (DMR 1997b).

To safeguard Cassowary Crossing Points there are a number of options for managing vehicle speed and driver awareness along both study roads. The strategies recommended for the study roads use a combination of traffic/driver management options. An example of a generic Cassowary Crossing Point with relevant measurements for rumble strips and signage placement is given in Figure 5. The total road strategy recommended for the El Arish-Mission Beach Road is shown in Figure 6. General crossing treatments that can be used either singly or in combination are outlined below.

Interpretive Entry Sign

To indicate the importance of the major cassowary movement corridors crossing the El Arish-Mission Beach Road, it is recommended that a major entry sign be erected at each end of the Tam O' Shanter State Forest. This sign could be included as part of an interpretive pull-in area which could also indicate other facilities available in the State Forest *ie* walking tracks *etc*. These signs/pavilions would greet visitors as they enter both ends of the Cassowary Conservation Road. An interpretive plan could be formulated by WTMA with the aim of informing visitors and increasing driver awareness of the danger of road crossing cassowaries.

Detailed Standard Cassowary Crossing Point

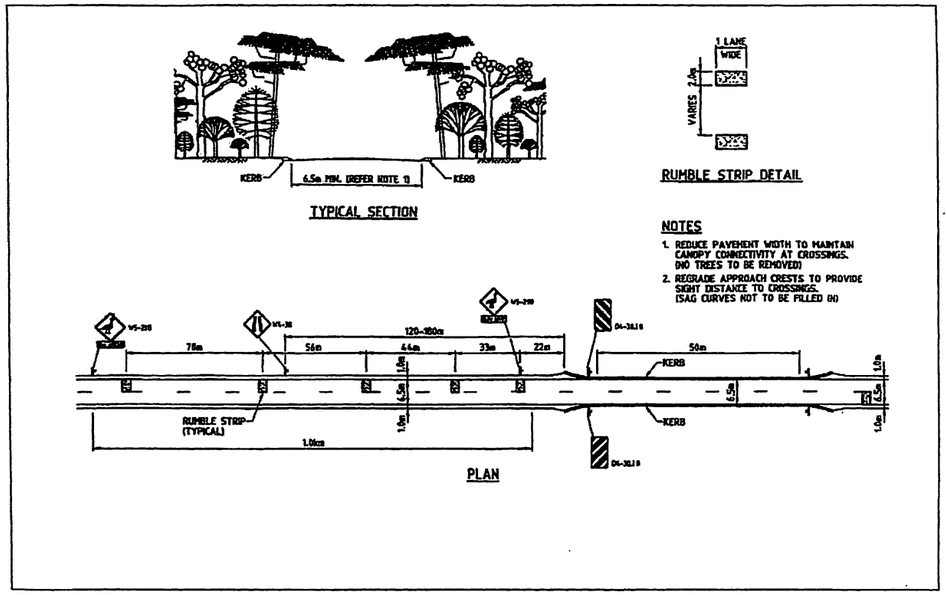


Figure 4. Crossing Point Profiles

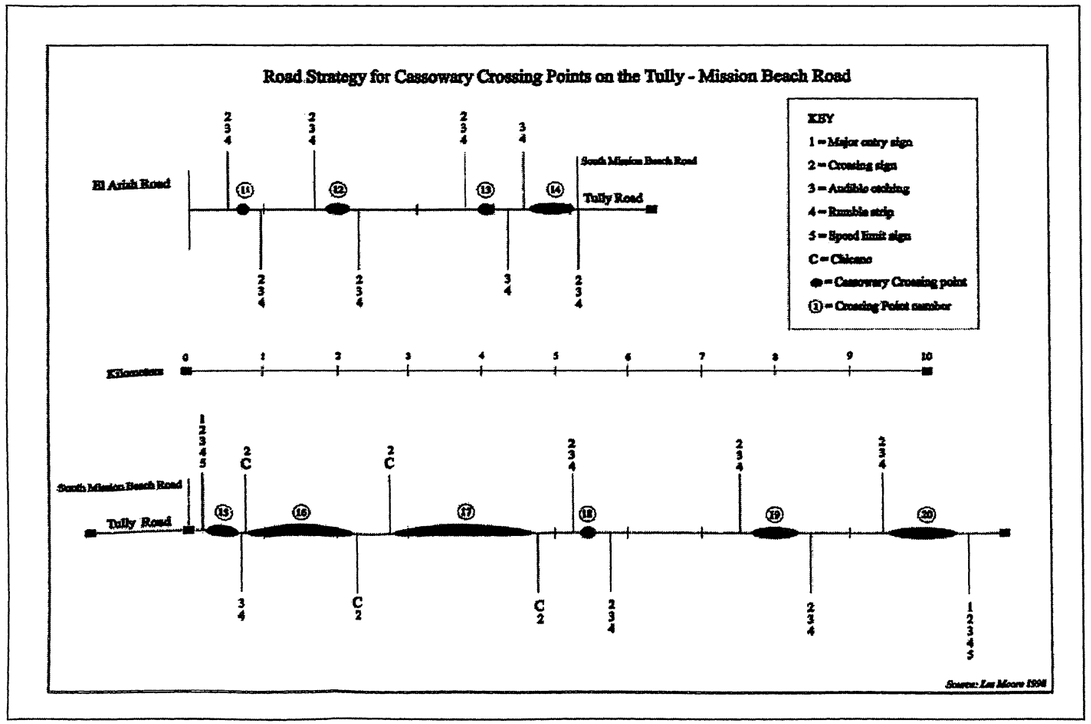


Figure 5. Generic Cassowary Crossing

Cassowary Advisory Signage

Signs within the State Forest, while needing to be sympathetic to limit visual pollution, will still need to convey the cassowary warning message adequately to motorists (as per Section 6.5.17. of DMR 1997b).

Speed Limit Signs

This signage should be in accordance with the *Manual of Uniform Traffic Control Devices* (DMR 1997a). It is critical that vehicle speed does not exceed 60km/hr between cassowary Crossing Points. The reasons for this are:

- road widening resulting from road upgrades reduces the width of verges, thereby reducing the warning time needed for motorists to see a crossing cassowary; and
- this speed limit is appropriate for residential streets where unexpected situations require a short stopping distance. The same circumstances apply here.

Rumble Strips and Audible Road Etching

Rumble strips are recommended in conjunction with audible road etching and signage to alert drivers to a change in road conditions, *ie* there may be fauna present on the road. As cassowaries have excellent hearing, this treatment may also alert crossing birds to approaching traffic.

Road Surface to Be Of Noise-Emitting Material

This may be a substitute for audible road etching and would cover that section of road between Bingil Bay Road and Clump Mountain Camp. It will be necessary to determine whether this option would work as well as audible road etchings prior to applying it to the road.

Painting on the Road

There is potential to increase the visibility of cassowary road crossings through painting the road surface. It may be valuable to highlight the presence of rumble strips with paint, thereby visually defining those crossings. Additionally, C4 proposed that enlarged cassowary footprints be painted on the road at known Crossing Points. Although this latter treatment is considered to be too intrusive for natural areas, it may be appropriate for crossings of smaller width in urban areas *eg* crossings along the Wongaling Road section of the Tully-Mission Beach Road. However, this treatment may be construed by drivers to indicate that cassowaries only cross at the footprints resulting in birds being injured away from the indicated area. As such this treatment could prove to be counter- productive.

Improving Sight Distance to Crossings

An important element to consider in providing safety for crossing cassowaries is to ensure adequate driver visibility. On the El Arish-Mission Beach Road there are two major factors which inhibit driver visibility, crests/dips and roadside vegetation on curves. The modification of these obstacles may be necessary to ensure adequate sighting of road crossing cassowaries.

Chicanes

The Tully-Mission Beach Road is very suitable for chicanes, as they can be used to reduce speed in several critical areas where speed signs and surface treatments are unlikely to be effective. In these particularly sensitive crossing areas the road verges are wide enough to accommodate chicanes without removing existing vegetation.

Fencing or Other Means to Prevent Road Access

The prevention of road crossings by cassowaries is considered to be a last resort. It should only be applied when a bird is found to be at extreme risk due to artificial circumstances ie. being hand fed or opportunistically visiting fruit farms. For example Cassowaries #1 and #2 make use of Crossing Point 1 to access a fruit farm south of the El Arish-Mission Beach Road. The risk to these birds is compounded by the lack of visibility for inbound traffic travelling east towards the Crossing Point.

The Fauna Corridor Role of Existing Culverts

The primary function of drainage culverts is to carry and direct water away from the road. As such many culverts are unsuitable for non-aquatic fauna movement due to constant water flow. Examination of all the culverts along both study roads has shown that a number are currently functioning as excellent movement corridors for aquatic fauna *ie* fish, crayfish, frogs and other aquatic species. Mammal fauna observed within culverts during the study included the giant white-tailed rat *Uromys caudimaculatus*, northern brown bandicoot *Isoodon macrourus*, bush rat *Rattus fuscipes*, fawn-footed melomys *Melomys cervinipes*, and unidentified bats. A number of reptiles were found in smaller diameter pipes and included the amethystine python *Morelia amethistina*, and eastern water-dragon *Psysignathus lesueurii.* It is expected that all these species would use the culverts to cross under the road.

In a three year study conducted along the Kennedy Highway between Smithfield and Kuranda (Goosem 1993), it was found that mammals, reptiles and amphibians comprised the majority of road deaths of vertebrates on the road. Amphibians represented by far the greatest proportion of victims with a startling 3058 individuals killed ie 75% of all vertebrate deaths on the road. It is certain that due to their soft body make-up, many others were killed but did not last long enough on the road to be recorded. In the Mission Beach area, five species of frogs of conservation significance are considered likely to occur along and within the streams that are crossed by the roads (Table 1). These comprise two endangered and three rare species (NCA 1992). The continued protection and enhancement of existing "aquatic" culverts along both the El Arish-Mission Beach and Tully-Mission Beach Roads is, therefore, of great importance.

Some culverts are dry or almost dry outside the wet season and can provide access for terrestrial fauna during this period. Others require separate dedicated fauna pipes positioned away from existing water flows for this to occur (Figure 7a,7b). It should be noted that watercourses function as natural movement corridors for a wide variety of species, and placing dedicated fauna culverts close to them has the greatest potential to encourage their use by animals.

While some culverts are already functioning as fauna corridors, others can be modified to perform this function during the dry-season. To do this, vegetation can be planted along the banks of the drainage channels to funnel animals into the pipes and to provide them with protection from predation. Such revegetation will increase the use of these culverts by fauna and contribute significantly to connectivity across the El Arish and Tully-Mission Beach Roads.

Three types of modifications are suggested for existing drainage culverts along El Arish-Mission Beach Road:

- modification to existing box culverts by the insertion of smaller box culverts within them;
- placement of dedicated fauna pipes at existing unmodified culverts. These dedicated pipes comprise;
- round pipes to 450mm diameter half filled with soil and rocks;
- box culverts with hay, logs, rocks and soil placed along the base for the length of the culvert; and
- revegetation along banks with rocks and low-growing plants to connect the inlet/outlet of all suitable fauna culverts with the forest edge.

There is a role in this work, and the subsequent monitoring of use of these culverts by fauna, for local community/conservation groups. Feedback from community monitoring can then fine-tune the design of fauna culverts.

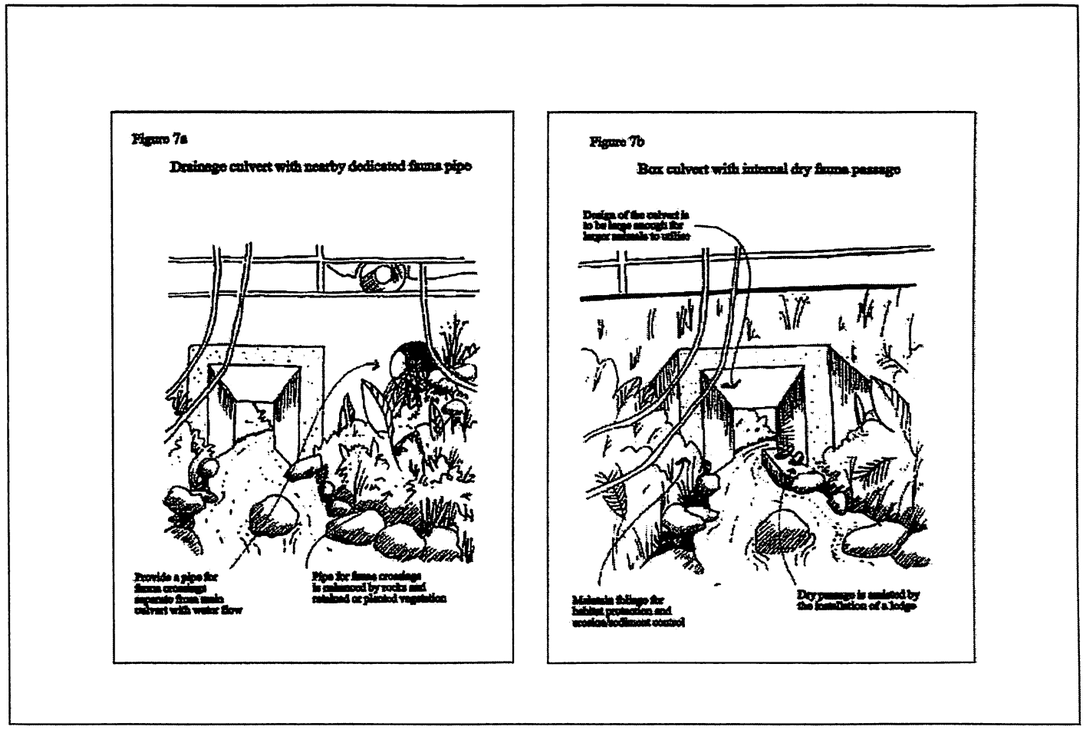


Figure 7a and 7b. Fauna Culverts

CONSERVATION ROAD APPROACH TO SENSITIVE FAUNA AREAS

There are several essential components to the approach advocated in this paper. They are:

- on-ground field assessment and survey;
- good knowledge of the species most likely to be impacted by the road; and
- consultation with the local community and road users.

The general message of this paper is that there is no substitute for expert on-ground assessment of fauna issues in any road construction, design or upgrade in sensitive fauna areas. In the authors' experience too many situations occur where fauna issues are assessed using "walk-throughs" or desktop studies carried out in a remote office. It is considered that such an approach can never address the issues specific to any one road, and is unlikely to lead to an effective fauna conservation strategy. It is a fact of life that environmental consultants rarely get to undertake extended research but instead are asked to assess issues using their own knowledge and published material. Unfortunately, much of this material is outdated and can be easily used out of context. It is common practice, therefore, to see the same material recycled through any number of consultancy reports dealing with widely disparate situations and locations.

Due to either budgetary constraints or corporate research objectives, responsible authorities (EPA, CSIRO *etc*) do not conduct management-oriented field research on non-commercial fauna species. Accordingly, office-based tools such as GIS have become more fashionable. For these tools to be used effectively, however, they require recent and appropriate base-line field data. As this is rarely available, the results obtained are often of limited application to immediate conservation concerns.

As a final point, it must be emphasised that a conservation road strategy is unlikely to work without the willing cooperation of the local community and other road users. To engender

community cooperation requires time and commitment, as some of the measures, such as speed limits through particular areas, may initially be unpopular.

During this project an extensive community consultation process was undertaken. This took the form of newsletters, questionnaires and two intensive workshops, all of which resulted in written submissions. Participants attending the workshops included local business people, residents, tourism groups, police and transport companies. The workshops were designed to gather information on the needs of road users, their attitude to possible upgrade options, the speed limits they felt were appropriate for their needs and those of the fauna, and their general attitudes to conservation. This last element was important as much of the Mission Beach nature-based tourism appeal depends on the ongoing visibility of cassowaries in the area.

While the community consultation aspect of the Mission Beach project is not documented in this paper, it is recommended that a strongly consultative approach be used in areas with a similarly high public profile.

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Appendix 1. Species of significance known or likely to occur around Mission Beach

Species	Conservation Status	Comments
Mammals		
platypus *Ornithorhynchus anatinus*		Widespread but declining in north Queensland
spotted-tailed quoll *Dasyurus maculatus*	Rare	Regional subspecies - scarce and declining.
red-cheeked dunnart *Sminthopsis virginiae*		Status uncertain - restricted to northern wet tropics-eastern Cape York.
mahogany glider *Petaurus gracilis*	Endangered	Most populations outside WTWHA.
striped possum *Dactylopsila trivirgata*		Found in rainforest and associated habitat.
musky rat-kangaroo *Hypsiprymnodon moschatus*		Monotypic species endemic to Wet Tropics - patchy distributions but common in the Tam O' Shanter State Forest.
lumholtz's tree-kangaroo *Dendrolagus lumholtzi*	Rare	Endemic to Wet Tropics but uncommon on coastal lowlands.
prehensile-tailed rat *Pogonomys mollipilosus*	Rare	Patchy distribution but likely to be more common than previously thought .
Birds		
southern cassowary *Casuarius casuarius*	Endangered	Endemic to Wet Tropics and parts of cape York Peninsula - declining
lesser sooty owl *Tyto multipunctata*	Rare	Endemic to Wet Tropics - moderately common in most rainforest patches.
rufous owl *Ninox rufa*	Rare	More common in the ecotones of coastal vegetation mosaics *ie.* melaleuca woodland and rainforest - total breeding population estimated to be *ca* 1000 pairs (Young in Garnett 1992: 115).
Amphibians		
frog *Litoria genimaculata*	Rare	Rainforest and moist woodland habitats - often found on roads after rain.
common mist frog *Litoria rheocola*	Endangered	Found near swift-flowing streams in rainforest.
green-eyed tree frog *Litoria serrata*	Rare	Usually found near creeks but also on and in trees and on forest floor.
Australian lace-lid frog *Nyctimystes dayi*	Endangered	Confined to the rainforests of the coast and ranges from Innisfail to Cooktown.
frog *Cophixalus infacetus*	Rare	Found in low to mid-montane rainforest.
Reptiles		
Boyd's forest dragon *Hypsilurus boydii*		Monotypic - endemic to the Wet Tropics.
skink *Carlia rubigularis*		Recently described - endemic to the Wet Tropics.
four-toed litter skink *Lampropholis tetradactyla*	Rare	Endemic to Wet Tropics.
grey-tailed skink *Glaphyromorphus fuscicaudis*	Rare	Endemic to the Wet Tropics.
amythestine python *Morelia amesthistina*		Australia's largest snake - CYP and New Guinea.

INCREMENTAL PROGRESSION AND TRANSPORT CORRIDORS

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ABSTRACT

This paper argues that it is not lack of goodwill, or lack of scientific knowledge, or lack of money that is the root cause of the relentless loss of natural and cultural features, but the operation of a phenomenon known as "incremental progression". By this process, the main participants in any issue act according to what seems to be best to them at the time, in the light of their main driving motives and their responsibilities, and the flux of events. In a system such as a transport corridor where many different entities have legitimate roles, it is this interaction of motives and events in different forums which determines outcomes, in an incremental manner. To achieve some kind of coherent, unified result is a formidable challenge and, for optimal results, every participant needs to be well informed about the issues and their context.

Unfortunately, various groups of participants tend to communicate within semi-closed networks of their own and their special insights are not shared more widely, so activities are uncoordinated and the corridors incrementally deteriorate.

The process will be illustrated by a hypothetical account of roadside management in the Shire of Black Stump.

***Key words**: incremental, synoptic, coordination, communication*

OVERVIEW

Few people who have attended this conference will doubt that scientific knowledge of how to manage vegetated remnants such as those found in transport corridors is extensive and is growing rapidly. Few would also doubt that most of the public authorities involved are recognising that the land assets under their control have multiple values. Yet still the decline of the reservoirs of natural vegetation and other natural and cultural values on transport corridors continues apace. Why is this so?

This paper argues that it is not lack of goodwill, or lack of scientific knowledge, or lack of money that is the root cause of the relentless loss of natural and cultural features on linear reserves, but rather the operation of a phenomenon known as "incremental progression". By this process, the main participants on any issue act according to what seems to be best to them at the time, in the light of their main driving motives, their legal or other responsibilities, and the flux of events. In a system such as a transport corridor where many different entities have legitimate roles, it is this interaction of motives and events in different forums which determines outcomes, in an incremental manner. To achieve some kind of coherent, unified result is a formidable challenge.

The Land and Water Resources Research and Development Corporation, in a recent project brief, stated that:

"More than ten years' experience in funding natural resource R&D has demonstrated to the Corporation that the most crucial barriers to improved use or management of natural resources are social and institutional factors and not a lack of scientific knowledge."

This conclusion is widely recognised and surfaces regularly at conferences in calls for better "communication" and "coordination" between the numerous public authorities which have responsibilities in the field under discussion. In this paper, I will attempt to show that it is not more "communication" or more "coordination" generally that are wanting, but a quality called "insight-sharing" which embraces elements of both. This paper will deal first with coordination and communication, then turn to an explanation of incremental progression.

IS CENTRAL COORDINATION POSSIBLE OR DESIRABLE?

Coordination involves superimposing a synoptic oversight or control over processes which, however, remain semi-autonomous.

The advantages of coordination are well recognised:

- consistency, so that different public authorities do not contradict each other, to the confusion of the public. The community tends not to understand or care about fine differences in jurisdictions and is impatient with perceived lack of coordination between departments;
- economy, so that duplication is avoided and effort is not wasted; and
- illumination, so that data or conclusions arising out of the exercise of one set of responsibilities may cause another exercise to be more accurate or more complete.

Unfortunately, coordination comes at a cost. The disadvantages can include:

- delay, in that as more angles are covered, the more time it takes to process the information;
- blandness, in that as the aspirations of more participants are addressed, it becomes more difficult to reach consensus on either means or ends without retreating to unhelpful statements of general principle; and
- non-cooperation, in that as more authorities are drawn into the decision-making framework, it becomes more difficult to resolve questions of accountability without confronting jurisdictional boundaries.

I will argue in this paper not for coordination but for insight sharing.

It is possible to have too much coordination. Complete consistency in most multi-lateral systems is mostly not achievable and if it were, would not be desirable. Progress in public affairs often arises out of the constructive friction generated at the edge of overlapping responsibilities. Jurisdictional rivalry between authorities is not always dysfunctionally grounded in egos and empire-building, but can in fact be based constructively upon professionally different perspectives on how business should be conducted.

Moreover, the threat of retribution if an authority intrudes into another authority's sphere of responsibility serves some benefit. It is a brake upon over-zealous pursuit of narrow agendas by authorities. Narrowness of outlook can arise because an authority might be staffed by professionals of largely a single discipline, or because it is under the influence of "regulatory capture" by its clients, or because a single ideological mindset prevails. An authority which enjoys a high level of autonomy might not recognise narrowness. Coordination by a central agent with a broad policy outlook and able to challenge blinkered thinking might moderate narrowness, but coordination by a central agent obsessed with efficiency might worsen it. Further, full integration (such as is common during organisational restructures) might, by elevating the dominant discipline or suppressing dissent, infect the new wider group with an insular view.

In a seminal paper addressing the problems of coordination in the coastal zone, prepared in 1993 for the Resource Assessment Commission, Davis and Weller reached similar conclusions, which bear repeating:

> "Coordination is the hardest task of government."
>
> "Like a unifying theory in physics, am ambitious strategic approach may have to work at such a level of abstraction that all local impact is lost. ...the ideal is a viable strategic process which attains broad goals with meaningful local consequences."
>
> "When government is tempted to impose some rationality upon apparent chaos, decision makers must judge first the limits of their own capacity, and the opportunity price which will be paid in seeking coordination. ...The more comprehensive the synthesis sought, the more unlikely is success. Conversely the more bottom-up the process, the more flexibility in allowing local adaptation of goals, the better the prospects."

Coordination is not only the hardest task of government, it is also a central task and one in which all departments are well experienced. There are well established procedures for ensuring that important matters are not overlooked and that different bureaux know what each other is doing. Not least among these procedures is the process by which matters are brought to the attention of Cabinet. One of the primary responsibilities of middle management — that oft-maligned target of organisational downsizing — is to ensure that activities are coordinated within and between departments. This activity is pursued using procedures which are also much maligned as "red-tape". But red tape is a safeguard against both mistakes and political whim. In our politically attuned democratic system, an objective of the public service must always be to minimise errors and embarrassments, even if at the cost of innovation and speed.

In a provocative book *Uncertainty*, which gives an account of rural development in the Himalayan mountains, Thompson et al argue that coordination can be counter-productive:

> There are three serious objections to a central coordinating position among agencies:
>
> "...integration and coordination inevitably reduce diversity, redundancy, duplication, and overlap — the very system properties that, in a setting characterised by high levels of uncertainty, should be conserved if fragility is to be avoided and resilience husbanded...".

SEMI-CLOSED COMMUNICATION CIRCLES

A common complaint in situations where a number of different authorities have overlapping responsibilities is that there is a "lack of communication" across disciplinary and positional barriers.

How can this be? We are drowning in communication! A recent poll conducted of 1000 office workers in Britain, the US, Canada and Germany found that on average, an officer worker is interrupted every 10 minutes by a telephone call, fax or email. The average day is punctuated with 171 messages, much unwanted (Derbyshire 1999). But much of this "communication" is in fact noise.

Too often the debate about current issues proceeds in several separate forums which do not adequately inform each other. Consequently, the main groups of participants — such as environmentalists, local government, academics, the State public service, the politicians — do not share each other's insights sufficiently intimately to empower them to forge enduring solutions. And within some of these circles, there remains the deeply entrenched myth that environmental protection and economic prosperity are incompatible.

This finding goes beyond a complaint about disciplinary narrowness, to a finding that the main participants in public debate often do not even speak in the same language. This separation is often blamed upon egos and empire building, but that is too simplistic. More often, the attitudes of participants is heavily influenced by the "culture" of the organisations or sectoral groups to which they belong, and this in turn is heavily influenced by the technical disciplines or skills represented in their ranks and by the methods of communication which those groups characteristically employ to disseminate their knowledge.

As the old saying goes, if we are to understand why people act as they do, we must walk a mile in their shoes. The more that one becomes familiar with a person or an organisation, the more that one can come to know what factors motivate that participant and to what motives they are most vulnerable.

Let us examine not just the quantity and quality of communication, but the forums in which it occurs.

Identifiable Communication Forums

The stakeholders involved in transport corridors are many and varied. But they can be classified into various occupational or disciplinary groups and each of these groups tends to communicate within its ranks in a distinctive way. It is the hypothesis of this paper that these groups form semi-closed circles, between which communication is much less satisfactory than communication within them. A few groups typically involved in transport corridors are described.

Communication among scientists is hardly wanting. When one looks at the quite unending outpouring of technical papers in the scientific journals, it is easy to form the conclusion that our understanding of the way ecosystems function is rapidly becoming more comprehensive and that gaps in our knowledge are rapidly being filled. But this by itself doesn't seem to be enough to ensure that management of those ecosystems actually improves.

Scientists tend to share a distaste for the imprecision of policy and political life and prefer to remain stereotypically cloistered in their laboratories and research. Academics gain their self-esteem from recognition within the academic community, a process which requires them to produce papers which are published in refereed journals, these being compiled according to a well-defined set of protocols. The journals are read mostly by other academics and sometimes by the policy community, but almost never by landholders or politicians and "popularisers" within scientific communities are often disparaged by their peers.

There are good connections between science and the environmental literature. But *Habitat*, the magazine of the peak conservation body the Australian Conservation Foundation is posted only to members, and only some 20,000 copies are printed Australia-wide every two months, about 4,000 for Queensland. Contrast this level of exposure with the circulation of Queensland's *Country Life*, 32,850 per week.

Undoubtedly, the level of awareness of and commitment to sustainable land management amongst the rural and landholding sector is growing steadily. The landcare movement has grown from nothing in about 1983 to an Australian-wide network of some 4300 local groups, growing at the rate of 15-20 per cent each year. Surveys of rural opinion repeatedly show that, although farmers have a dislike of city-based "greenie activists" (whatever that might mean), there is a deeply held and growing conviction that they must manage their properties sustainably in order to pass on well managed land to the next generation. Yet landholders generally are not exposed to the voluminous literature on environmental issues and cannot be blamed for under-estimating the severity of the environmental crisis. The typical Queensland pastoralist may receive only one newspaper a week and does not generally absorb information by reading. They learn from their fathers or the neighbours while in town on Friday afternoons. In this way traditional ways are readily reinforced. If it weren't for the tenacious ABC and its rural programs such as *Landline* which attempt to bridge the communication circles, rural Queensland would suffer from a serious information drought.

Policy units in the public service work in an atmosphere of intensive intellectual stimulation from multiple sources. New ideas stream into their offices daily, carried from the four corners of the globe. They daily receive report after report from government departments, think tanks, interest groups, their own subordinates. Reports, submissions, briefing notes, items in newspapers, correspondence, findings of parliamentary committees... — they arrive and depart each day on the desks of senior thinkers by the barrow-load. They are written in a precise English which is suffused with jargon, with terms like globalisation and performance appraisal, which would be misunderstood by rural readers, or which if understood, would fall on philosophically unreceptive soil.

The public service also communicates intensely and continually through its Cabinet procedures and its internal networks of inter-departmental committees and working groups. But public officers don't engage directly in public debate. As Australia's nine public services are built upon a commitment to non-partisan independence, (as their staff deeply wish them to be), most of this activity is, of course, necessarily as invisible to the public as the bottom seven-eighths of an iceberg.

Outdoor staff such as works gangs have distinctive face-to-face methods of communicating, and reading strategic plans is not one of them. The gap between highly paid shiny-bottomed policy officers who write plans and insecurely employed contractors or workers who have to implement them is wide. Purchaser-provider models of service delivery by which the two arms may even lie in separate organisations can only heighten the separation and so the potential for misunderstanding.

Many local governments are leading the way in environmental management. Eleven councils in south east Queensland have co-operated to establish the admirable "Land for Wildlife" scheme, a voluntary network of landholders committed to managing their properties protectively. Many councils have appointed environment officers and green levies and differential rates are in vogue. Local government holds the key to sensitive management of roadsides, not just because of its statutory responsibilities, but because it operates at a scale which makes it practicable to create forums where information from the other sources listed above can be shared, debated and reconciled.

But within local government, there are distinct networks which are semi-self-contained: environmental officers, town planners, councillors, engineers. Much of the communication between them follows structured, formal paths which transfer information but does not necessarily allow insight to be shared.

Circles Explain Why Innovation Is Slow

These are, of course, not the only circles. Nor are they entirely closed. There are people who dedicate their energies to building bridges across the boundaries. I have mentioned the ABC. Another major unifying device is a conference like this. We all receive a buzz from a successful conference attended by people from different backgrounds, because we cross the boundaries of the communication circles. We experience the synergy that comes from sharing insight and discovering how much we have in common with others. However, outdoor people, landholders and professionals tend not to mix in this way because they go to different kinds of conferences and we need to actively create forums where the barriers between them, as well, tumble down.

The existence of semi-closed circles explains why influential participants are often slow to embrace new ideas or to apply the findings that concerned scientists or environmentalists advocate to them. The different responsible participants simply do not share each other's perspectives of reality and act according to their own perspectives, that is, their own motives and their own interpretation of the prevailing circumstances.

SYNOPTIC, CHAOTIC AND INCREMENTAL

Communication and coordination do not operate mechanically between passive participants in hierarchically rigid organisations. Public and private organisations function somewhat organically and are permeable to all kinds of motives and circumstances.

Let us turn to the academic literature on decision-making for some insight into the way that organisations behave. This literature presents three main accepted models by which things happen in public affairs: the synoptic, the chaotic and the incremental. These models are not exclusive formulae but simply analytical tools; and in any given system, elements of each may be observable at different times.

Synoptic Model

The view that affairs should proceed in accordance with a strategic framework can be described as synoptic. It is a holistic view which elevates the value of central coordination and top-down discipline. Pathways for separate component activities are mapped in advance.

The model is built upon assumptions of linearity (that if A happens, B will follow) and rationality (that people can determine what is best for them and then they follow that logical course).

Modern economics, science and the law are structured along linear-rational lines and so, by their intrinsic nature, contribute to the popularity of this model.

I will comment briefly on those three disciplines in turn. Modern economics inadequately reflects reality because it is trapped in assumptions of linearity and rationality — for example, "if we reduce youth wages, we will solve unemployment"; or "the tax system is broken and only a GST will fix it". Competition policy is an example of a linear, rational ideology now being applied synoptically throughout Australia's public sector organisations. In the process, economics seems to have lost its connection with empiricism: the testing of hypotheses and the discarding of theories which don't fit reality.

Second, many scientists in the natural and social sciences are misled by Newtonian linear thinking and would have us believe that if we discover a problem, all we need to do is to throw research money at it and we will discover a cure; then it becomes the government's problem to apply their cure. The government should throw money at it and the problem will go away! Then if we find that the problem hasn't gone away, it must be the government's fault. Half the community says that it didn't get enough government money to fix the problem; the other half says that the government shouldn't have been involved at all.

Third, linear perspectives on cause and effect, guilt and innocence are inherent characteristics of the law. The legalistic approach is a special case of the linear-rational approach and is based upon a sequence of assumptions along these lines:

1. there is a problem;
2. there must be a legislative solution;
3. we must pass laws;
4. once a law has been passed the problem is fixed; and
5. if someone is causing a problem, they should be punished.

The synoptic, linearity-based model leads to a search for simple causes and so fosters a culture of blame: for example, "the deteriorating condition of roadsides is the fault of the shire engineers"; or "conservationists are impractical idealists who are obstacles to progress". You can see how easy it is to fall into this trap: in the preceding paragraphs I myself have identified "economists", "scientists" and "lawyers" as being vulnerable to narrow, linear-rational thinking. Perhaps this was because I was earnestly trying to avoid blaming civil engineers.

It is easy also to blame the media. The media look for simple, linear explanations of complex issues, for winners and losers, villains and heroes. In fact, we know that there is a lot of heroism by quiet, unpublicised local acts of stewardship; and we know that a lot of the villains don't even realise the consequences of their actions and would mend their ways if only they knew how.

The notion that science objectively discovers evidence of a problem, that the media inform then reflect public opinion on the issue, that parliamentarians act to pass legislation in response to pressure from their electorates, that ministers spell out objectives, that policy is changed accordingly and that it is implemented systematically by the public service through strategic plans, procedure and budgets, is synoptic.

A flaw with this synoptic model is that, in reality, people act according to motives which are not necessarily what they seem; and events may intervene. For example, a serious environmental incident may receive no coverage at all in the press because it surfaces just as a major civil war erupts in West Africa, crowding out other news; or a budget allocation to fix it may suffer when the department is reorganised. The synoptic model ignores the usual existence of multiple contributing factors on the causal side, and the multiple consequences on the effect side.

By contrast, ecology teaches us that, overall, the world in fact is not linear, that everything is connected to everything else; that you cannot push one part of a system without causing ripple effects in sometimes unusual places; that some of the people who cause the most environmental damage are victims as well.

Having said all that, the synoptic approach does have some advantages. We can learn from it the value of strategic planning, goal-setting, policy formulation and performance evaluation. Parts of systems do behave linearly and rationally for short periods and we need to take advantage of the predicability which that allows.

The challenge in front of us is to develop a model of decision-making that doesn't look for big bang, dramatic, wide-ranging solutions but one that individuals can apply locally in their own situations in a climate of uncertainty and scarce resources.

Chaotic Model

Modern chaos and complexity theories in the physical sciences have led to claims that socio-economic and political systems behave similarly — in a kind of apparently erratic but ultimately deterministic manner for which equations can be compiled. Theories of cycles in stock market prices arise from these assumptions. But existing expositions have not demonstrated to this writer's satisfaction that there is any causative force or principle which applies to public affairs: they have simply identified similarities by analogy.

"Chaotic" can also be used in its common-language meaning of unpredictable, ad hoc, without purpose or discipline. In this sense also it falls short of being a good model to describe public decision-making. Although the newspapers may sometimes present the affairs of governments in this way, no-one with any knowledge of the operation of public authorities seriously believes that they are incapable of sustained purposeful activity.

Incremental Progression Model

This is an empirical model, drawing on observations of how things actually happen. It claims that decision-makers usually lack enough time and information to develop or implement "grand plans", but rather proceed in a cautious, stepwise manner to minimise the risk of disaster and to make at least some progress in the face of uncertainty and imperfection.

The model of incremental progression varies from the classical Lindblom model of "incrementalism" in the academic literature by drawing inspiration from the science of ecology and by adapting to public affairs concepts such as inter-dependence, iterative feedback, mutation, Kahn's tyranny of small decisions and selection of the fittest. This organic model explains how public policy evolves with circumstances and how it iteratively responds to and affects external forces and events.

By incremental progression, the responsible authority takes only small steps at a time, adjusting direction as feedback and circumstances dictate. An incremental approach does not mean that matters necessarily drift — chaotically — in response to random pressures without apparent direction or purpose. Public authorities may well set long-term objectives, but they change them or ignore them as different motives become ascendant at different times. Sometimes their long-term objectives are somewhat hazy, the authority hoping that things will become clear in time.

Expressed in other words, the effort involved in setting synoptic objectives and then pursuing them in a systematic manner over more than a single electoral cycle is exhausting. The recent application of competition policy would seem to suggest that a synoptic approach is feasible, but the jury is still out on the questions of both the effectiveness and the durability of competition policy.

Textbooks on organisational behaviour usually laud the synoptic approach to management, advocating for example "management by objectives" or "re-engineering processes". Usually, these approaches originate in private companies, accompanied by authors' claims that they surely must also apply to public enterprises because of the universality of the forces which motivate human behaviour. In a public authority, however, a lack of enduring political consensus frequently means that a synoptic sense of direction is simply not achievable. The incremental approach remains a legitimate response by a public authority or its staff to fluidity in its internal and external environment.

EXPLANATION OF INCREMENTAL PROGRESSION

This model will help us to understand how to encourage those involved in management of transport corridors to embrace new concepts of vegetation management. Expressed in concise form:

> Notions progress incrementally through a political system, gaining or losing momentum according to the circumstances and the motives of the key participants at each step.

Those motives amount to much more than pluralist lobbying by self-interested groups and are derived from every inherited and acquired attitude which they possess.

If a given suite of ideas active in a polity is particularly cohesive — as is economic rationalism — it may warrant the description of "synoptic". Yet, even ideas which are synoptic in their scope are usually at least implemented incrementally, now matter how persuasive they may be or how powerful their advocates.

Any new idea progresses in response to the interaction of many forces and events, some apparently fortuitous and not under conscious human control, and some manifestly the result of the motives of the key participants applied to the prevailing circumstances. Those motives and circumstances in turn are the product of previous forces and events, stretching back into history. Forces and events are superimposed incrementally, though from time to time a determined powerful participant may impose a synoptic idea or program on the polity.

Critical to understanding what is happening in a given field of endeavour, and critical to predicting the outcome of events, is an understanding of the motives of the key participants at the time. These motives may not be at all obvious and may not be those professed or even understood by the participants.

Motives

New ideas are likely to be embraced by participants when one or more of six pre-disposing motives is operative. Not all motives are necessary, but the likelihood that a new notion will be accepted or that a decision will turn in a given direction increases as the number of motives which can be harnessed rises. The pre-disposing motives are:

Logic: factual support

People are motivated to embrace notions which confirm their view of reality, which reinforce preconceived convictions, which are perceived to be factually correct, or which promise to solve real-life problems. This acceptance is enhanced if the notion appears to solve more than one problem at the same time.

Every society and individual holds certain values dear. Any new notion which reinforces that value system is likely to be accepted. Further, the more that the new notion accords with that community or individual's self-image, the more readily will it be incorporated. Conversely, an idea which contradicts the established values or self-image cannot readily be accepted, at least until that mind-set changes, a process which may be prolonged.

Community lobby groups sometimes don't look beyond this motive or the next. They amass and present their evidence — then are puzzled as to why the relevant institutions don't immediately accept their views and apply remedies.

Logic: intellectual support

People are motivated to embrace notions which are underpinned by intellectual coherence, by the support of academic experts, or by prevailing orthodoxy in educational institutions.

No policy lasts long unless it rests on an appealing theoretical foundation. Critical to the progression of any new idea is a corpus of intellectual reasoning which is able to be harnessed in support. When a political system is casting around for solutions to its current problems, it will — other things being equal — select the intellectually most convincing paradigm available at the time. Ultimately, if the thinkers in society agree that an idea is worthwhile, it will prosper. However, it has to be said that scientific evidence often filters into the public or political consciousness only very slowly. This is at least partly because scientists often don't look beyond this motive.

Interest: individual interest

People are motivated to further what they perceive to be in their personal interest.

This statement is a long way from coinciding with the assertion of neo-classical economists that individuals behave rationally to maximise their self-interest. Firstly, this is only one criterion of six and in any given case, the others may overwhelm it. Secondly, it is based on what people perceive to be in their interests at the time and this may in reality be contrary to their best interests, short-term or long-term. Third, the neo-classical view struggles to free itself from the temptation to define self-interest in material terms. But in reality, individual interest embraces all relevant personal motives, including the unselfish ones.

Interest: institutional interest

People are motivated to further the interests of the organisations to which they are affiliated.

A person who serves the interests of his or her institution loyally may be doing so simply with an eye to future preferment - that is, to individual interest - but that is not necessarily the case and so this criterion must remain separate from the previous.

The government-bashers often don't look beyond this motive. They ignore the legions of anonymous public servants who are deeply imbued with a commitment to serve the public interest. It is inspiring to those of us who commenced our careers during earlier generations of the old-style public service to observe this idealism still strong among the fresh graduates nowadays presenting themselves for employment.

Influence: patronage by community leaders

People are motivated to embrace notions which enjoy the patronage of leaders of public opinion, of prominent people whom they admire, or of political decision-makers.

Prima facie, this motive would seem to be essential, but innovation without the active support of — and even in the teeth of opposition from — community leaders or of the elected government is possible.

Influence: patronage by the media

People are motivated to embrace notions which receive favourable coverage in the media.

Despite what journalists say, newspapers do "create reality" by reporting selectively and by presenting news in subtly different ways. There is no conspiracy by the proprietors of the press to present ideology, but that is not necessary for the press to be very effective in reinforcing the prevailing orthodoxy. The press reinforces bandwagons.

Propitious circumstances

The operation of the above motives and therefore the existence of motivated participants is not always enough to ensure that a notion is embraced: the external circumstances must be favourable.

"Circumstances" arise as a resultant of events and forces, some under conscious control of the participants in the political system under study and some not.

INCREMENTAL PROGRESSION ON BLACK STUMP ROAD

Let us examine a hypothetical rural road to observe how the semi-closed perspectives of the participants, applied to the prevailing circumstances by a process of incremental progression, explain that the end result might be what none of the responsible parties really would have wished to achieve had they thought more about it or discussed it together.

1. At the beginning of our story Black Stump Road is a country lane fringed both sides by graceful gums and bushland understorey.

What does not happen

2. The Shire of Black Stump, in a fit of bloody-mindedness, sends in machinery on a single occasion to clear and destroy the bush on the road.

What may well happen

3. The owner of the adjoining grazing property wishes to reconstruct the common boundary fence and clears six feet, as best operating practice in the Shire allows. The soil, brush and stumps cleared during that exercise are piled up in the road.

4. That summer was very dry and a bushfire in The Gap, one of the outer suburbs of Brisbane, burnt down three houses. Queensland Disaster Administration (QDA), worried about the possibility of claims for compensation, issues new directives to all fire brigades in Queensland to revise their district fire protection plans and to pay particular attention to preventive fire breaks along vegetated roadsides.

5. The Black Stump Fire Brigade accordingly obtains a grant from QDA for a fire break on the roadward-side of the boundary fence of each side of this road. Again, the spoil is heaped up on the remaining vegetation.

6. In addition to grading this firebreak, a program of selective annual slashing is commenced. Mature trees on the reserve die because of compaction of the soil around their roots by the tractors.

7. In March in one year, the Black Stump Council's Design Engineer resigned suddenly leaving the Shire Engineer without the capacity to spend the year's road construction budget on the intended major projects. He was obliged to therefore advance the priority of such road improvements as could be conducted without detailed design documentation. The Works Foreman was given an allocation to improve secondary roads as best he could without detailed documentation. The end result was in accordance with traditional rural road construction practice but did not align very well with modern environmentally sensitive design specifications advocated by the Department of Country Roads in its recently published Landscape Manual.

8. The Department of Land Protection sent some crews along Black Stump Road to destroy parthenium weed and their spraying operations were conducted rather more enthusiastically than delicately. Some damage to non-target plant species was occasioned. As well, the surfactant used in the herbicide formulation killed a remnant colony of ornate burrowing frogs.

9. During late winter a neighbour lets in a few stock when their own paddocks are short of feed. Eventually, the By-laws Officer herds them out, but not before numerous weeds have been introduced in their droppings.

10. A certain telecommunications authority replaces its existing overhead wires with an underground cable, leaving a trench-wide strip of disturbance. Also a trench-wide strip of giant rat's-tail grass, seeds of which were introduced on the machinery.

11. The local electricity authority cuts a swathe of upper storey vegetation to maintain the prescribed clearance below its cables. Prunings are dumped in heaps over the lower storey.

12. Wood-fired home heaters become common around this time and fallen logs tend to disappear at night on the weekends.

13. The Department of Country Roads (DCR) is concerned about the number of single vehicle accidents on the State's roads and the number of deaths. It commissioned a professional survey which demonstrated quite conclusively that the great majority of serious injuries and deaths were through striking trees and lamp posts within eight metres of the edge of the bitumen. The *Sunday Mail* has been running a campaign lately to reduce road deaths and DCR's Minister has issued instructions to DCR to take appropriate action. DCR initiates a "black tree" program to remove large trees within eight metres of all major and secondary roads in Queensland.

14. About this time, a wandering field naturalist discovers a rare jewel beetle on its rare food plant in the scrub along this roadside. Convinced that the remnant is sufficiently important to warrant some official protection, she inquires of Council. The Council, honestly, claims that it does not have the expertise and writes to the Department of Conservation asking it to specify which parts of the reserve are important enough to be worth saving. However, that Department is being restructured and all the staff with capabilities in that field are away sitting on working parties to write the new corporate plan.

    She appeals to the Department of Country Roads. The Works Foreman, the DCR District Engineer and the field naturalist agree to meet to discuss Black Stump Road. But the scene is set for a confrontation when the field naturalist discovers that on the very day before the on-site meeting, an out-of-town contractor appointed under new tendering arrangements, imposed by the National Competition Policy regime, obliterates the site. The contractor, not being familiar with the district, had misread the map forming part of the contract documentation.

15. Faced with a bare, unappealing length of roadside, the Black Stump Civic Tidy Towns Committee arranges a beautification project at public expense. The end result is that some grevillea "Robyn Gordon" are planted along the shoulder of the road, with the remainder of the reserve being closely mown grass.

Some Contributing Phenomena

A range of factors contribute to incremental attrition. These constitute some of the "motivating forces" which cause things to happen as they do, contrary to the best synoptic intentions of concerned vegetation enthusiasts. Here are some:

1. Under the prevailing climate of ever-squeezed budgets, public departments have no choice but to define tightly their core functions and often cannot afford to be interested in non-core issues such as the appearance of their assets or the environmental effects of their operations. These days most public authorities are not only retreating to "core business", but are continually re-defining core business more narrowly.

2. It is often difficult to obtain budgetary approval for projects not directly related to the economic efficiency of the main operation.

3. Projects such as horticultural treatments for which the expertise lies outside the responsible authority usually require contract documentation. Progress will be slower and more hesitant when staff must enter into unfamiliar territory. The problem is likely to be

more acute in those departments staffed largely by the one discipline or by people unfamiliar with outdoor works operations.

4. In any land management exercise, attention to detail is vital: it is not just whether a road is or is not constructed that matters, but also how wide, what location, what happens to run-off, how is the spoil disposed of, and how the shoulders are treated.

5. Technical knowledge about the management of small and linear reserves is not sufficient; awareness of the procedural and bureaucratic methods of the managing authorities is also vital if action to preserve the natural aspects of those reserves is to be effective.

6. The common assumption that given money any environmental damage can be repaired, eg by planting trees afterwards, is deeply false. That critical in situ topsoil, with its store of indigenous seed, is irreplaceable.

7. "Multiple use" is a popular cliché, popular because it gives the appearance of allowing potentially conflicting activities to be reconciled. But not all activities on transport corridors can be reconciled. For example, trees close to a road pavement are intrinsically incompatible with road safety; grass beside rail tracks is incompatible with adequate traction in wet weather; soil disturbance is incompatible with conservation of natural vegetation; as are slashing and grazing, but less irreversibly. Some compromises are unavoidable.

8. In negotiating compromises, we should try to protect the rare and irreplaceable, if necessary at the expense of the common and cosmopolitan. This principle by itself is a major justification for conserving natural vegetation.

9. A patch of bushland need be destroyed only once, but if it is to be preserved, it has to be protected forever.

CONCLUSIONS: SHAPING THE FUTURE

To look for ways of apportioning blame is to head up a dry gully. It is easy for conservationists to blame shire engineers for what they see as unnecessary destruction in construction works; for engineers to blame their outdoor works gang for lack of sensitivity; for landholders to blame politicians for lack of sustained interest; and for everyone to blame the public service for red tape.

To the extent that those blame mindsets are on occasions partially legitimate, they are all the more misleading and hence wrong. They arise because the participants operate within semi-closed communication circles. We will not make progress on the multi-headed problem of how to effectively manage transport corridors unless we:

- put aside pugnacious or defensive attitudes and adopt a humble, learning approach; and
- set up suitable forums which will facilitate learning and insight-sharing.

Insight-sharing must be directed to realising the multiple potential values of transport corridors, in which not just the main controlling authorities but all Queenslanders have a stake.

And a role to play. Let us not rely on the "powers that be" to establish a single insight-sharing committee such as the Transport Corridors Management group; let us all participate in such forums in our own organisations, and create them if they don't exist.

Every person has a responsibility for stewardship of the State's public land and its natural resources, however indirect that role. We all have some insight to share.

Opinions expressed in this paper are personal and are not necessarily shared by the Queensland Government. Text in the section "Is Central Coordination Possible or Desirable?" has been extracted from an article published in *Queensland Planner* in June 1999 and is reproduced with permission.

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COMMUNITY INVOLVEMENT IN TRANSPORT VEGETATION CORRIDOR MANAGEMENT

Andrew Straker
Roadsides Conservation Advisory Committee, Victoria

THE IMPORTANCE OF FACTS

Much of Victoria has been extensively cleared

- only 30% of the original vegetation coverage remains, the majority located within the higher and inaccessible altitudes or on non arable, depaupurate soils.
- only 5% of the remnants are located on privately managed land, the remainder are managed as part of the state forest, national park or crown land reserve network.

The length of roads and the area occupied by road systems is immense

- in Australia there are approximately 870,000 kilometres of roads, of which by virtue of them being outside towns 780,000 kilometres are defined as rural.
- the area of rural roads in Australia is 3,120,000 square kilometres (ie assuming an average width of 40m).

Victorian roadsides represent an important component of the off-reserve land system

- there is a total of 160,000 kilometres of roads.
- these occupy approximately 500,000 ha., or 2.5% of the land mass, or 7% of public land.
- only a small proportion of Victorian roads (3,000 kilometres of highways and freeways) are managed for state government by the Vic Roads Corporation.
- the remaining 142,000 kilometres are managed by any one of 78 different local governments operating throughout Victoria.

Why value roadsides?

- only 5% of remnant vegetation is located on private property. Roadside remnants are often the only examples of vegetation communities that once existed within lower altitudes or on arable lands now developed for agriculture etc. The vast majority of remnant vegetation is contained within state forests and national parks, which are mostly located at higher altitudes or within non-arable land zones.
- many rare or threatened species are now only found on roadsides; only 0.5% of grassland remain with 45% of the remaining western plains grasslands occurring on roadsides.
- 25% of the plant species listed under the Flora and Fauna Guarantee Act occur on roadsides.
- roadsides offer the possibility of conserving the genetic variation of plants and animals for their potential economic and scientific value and long term evolutionary potential.

Roadsides provide:

- habitat for native fauna.
- corridors for the movement of fauna.
- a scenic landscape for road users.
- windbreaks or shelterbelts.
- feed for stock during times of drought.
- sites for stockpiles, drainage easements.
- stock routes.
- access for pedestrians, cyclists and horse riders.
- appropriate landscaping can accommodate safety clearances, site-lines, rest areas.
- roadsides contain many historic and cultural sites

I always begin discussions with community groups with a recital of the above facts. It seems a good way to introduce the story of roadside conservation and 'tie' local issues into a broader framework. I use these facts to help define exactly what roadside conservation is all about, because many people are unsure how their roadside issue contributes to the bigger picture. I suspect that many of our partners, mothers, siblings and assorted family friends are equally baffled about our unnatural interest in roadsides!

The Victorian Roadside Conservation Advisory Committee has produced a poster containing many of these facts. I have distributed this simple product to groups as diverse as school children to state Ministers of Conservation, and I am constantly surprised at both a lack of awareness of the overall scale of the road network and a strong recognition of roadside values following discussion of the facts listed on the poster. From a funding and promotional point of view this poster has repeatedly proved its worth and I recommend all states become involved in the preparation of a similar product.

MY FIRST THREE QUESTIONS AT AN INITIAL COMMUNITY MEETING

After a recitation of the relevant roadside facts I always take a short time to ask three standard questions. I suspect anyone who takes time out of a busy schedule to attend a community meeting is both curious to hear what others have to say and also at some level wants desperately to contribute their personal story to the general discussion, so I use these questions to:

- stimulate discussion.
- indicate to the audience that I encourage their participation and I am interested in hearing and recording opinions.
- act as an initial ice breaker for discussion.
- give everyone an opportunity of hearing their own voice and not leaving the meeting without having contributed in some way.

To control the potential of 'grandstanding' or people who may take half an hour to reach a point I normally ask for comments to be synthesised into five words or less, and I always attempt to record any comments using the participants own words, and not reinterpret comments using my own 'bureau speak' vocabulary. All comments should immediately be recorded on butcher's paper which is then 'blu-tacked' to a convenient wall. As this is a dynamic process and I don't want any contribution to be lost, I encourage the audience to add any additional comments or thoughts during or immediately after the meeting.

I also like to define the terms roadside reserve, road formation, road verge and roadside. Don't take this for granted, and don't assume everyone is talking about the same thing, I have found that there is constantly misunderstandings about the terms that we commonly use to define what we think of as simple concepts.

Question One: Who uses roadside reserves?

Initially this is role call of the organisations present and should break any trepidation the audience may have to speak out (encourage yelling out). I would normally expect up to 20 or so responses.

Question Two: What activities are occurring on the roadside reserve?

Having determined there is a whole range of different organisations using roadsides I am interested in finding out why each organisation is using the roadside. This question can often bring a whole range of unexpected comments, but record them all. I think my best score for this question has been over 50 different activities. People like answering this question!

After totalling the responses I point out that roadside conservation is about juggling a whole range of different issues and suggest that issues fall out into four broad categories of:

- conservation.
- cultural and recreational.
- functional.

- land management.

I constantly refer to the responses to this question as an example of the complexity of issues to be included when preparing a roadside management plan, and indicate that all of these categories (and not just conservation) need to be addressed if all interactions are to be considered.

Question Three: What particular activities occurring on local roadsides concern you or are important to you?

This is usually the crux of the meeting and highlights the issues that are important in the region. It is usually the reason people have attended the meeting and each participant wants to voice their opinion on a particular issue. Give each group, community representative or individual an opportunity to have their say. This is where the five word comment is important!

After each question I refer to the number and type of response in the previous questions, as I am hoping that throughout this discussion the audience becomes aware of other organisations involved in roadside management and that single concerns do not stand alone, but rather contribute to a complex matrix of roadside management issues.

There is of course one further question that everyone would like to ask; **ie Question Four: What is the solution to these concerns?** I always acknowledge this as a reasonable question, but suggest it usually falls outside the scope of an initial meeting. Having just determined what the major issues or concerns are, the rest of the meeting will determine appropriate processes to find solutions.

ESTABLISH CLEARLY UNDERSTOOD OUTCOMES

I am constantly amazed at how many groups start out on the process of roadside planning without any real understanding of the end product they wish to achieve, or of any clearly defined process they need to follow to achieve outcomes. It seems they have identified a problem and hope that by some vague process of osmosis a solution will be found.

I have attended meetings with groups that were nonplussed when I asked what their final product would look like. I queried if it would be:

- in the form of a council adopted policy? If so what steps were they putting in place to ensure the final draft will have council support?
- an informal set of rules with tacit support from the organisations present?
- only a set of guidelines for contractors to follow?
- a code of practice? If so would it need to be ratified by council, and what steps are in place to enable it to be included in any tender documents?
- produced as a community education document? Was there adequate budget to publish multiple copies and what was the best form for distribution?

Each outcome is quite separate and each requires a slightly different process and adequate resourcing of time, money and people. It should be pointed out that in Victoria a roadside management plan generally consists of four separate sections:

- roadside management strategy.
- roadside conservation assessment and mapping.
- preparation of action plans for individual roads.
- implementation projects (signage, training etc).

Determine what you want to achieve, this may be one, or combination of any of the four sections listed above prior to any community meeting.

Have a firm idea of the sort of document or product you require and prepare some sort of budget and timeline. Someone (and that's usually you) needs to give some thought to the formation of a

steering committee and a technical panel (Community and Agency Reference Group or CARG), although membership of this latter panel may be canvassed at a community meeting.

Be prepared to be flexible at the meeting, you may have misread community sentiments, or have overlooked important products that need to be included.

The Victorian Roadside Conservation Advisory Committee has found after much trial and error the following process is an efficient model for developing a Roadside Management Plan.

Summary Of the Process for Developing A Roadside Management Plan

PROJECT PLANNING	• form the core of the Steering Committee decide to initiate the process • seek approval for project to commence • determine appropriate resources are available • specify objectives • determine project goals and desired outcomes
PREPARE PROJECT BRIEF	• determine roles and outcomes (who will collect background information eg existing legislation, existing local laws, policies, relevant strategic plans, and assessment data?) • decide whether to employ a consultant facilitator or allocate a staff member to the task.
ORGANISE PRELIMINARY PUBLICITY	• publicise intention to develop a management plan (eg in local paper, prepare flier, organise mailout etc.) • conduct preliminary workshops with interest groups to canvass issues of concern, determine conflicting demands
CREATE PLANNING TEAMS	• establish a Community and Agency Reference Committee • determine responsibilities for project management
UNDERTAKE PRELIMINARY CONSULTATION	• advise major players and organisations • invite groups to an introductory meeting to discuss proposal, gather opinions, and seek support • discussion might include what are roadsides used or valued for and any issues; why there is a need for a management plan; what resources, assistance or facilities are needed; what is a suitable implementation process and how long it takes; how to involve the community, and what it might mean in terms of changed planning and works practices
PRODUCE DRAFT PLAN	• develop outcomes • assess conservation values • decide on format • consult community to identify problems/issues • resolve any competing demands on an issue basis by conducting workshops, preparing policies and guidelines, • compile information into draft plan (or as other products eg poster)
SEEK APPROVAL OF PLAN	• seek community comments • make any changes and produce a final plan • present to council for approval or adoption

DETERMINE CONSERVATION STATUS OF ROADSIDES	• appoint botanist or supervisor • co-ordinate field naturalists, LandCare groups etc. to undertake assessments using the RCAC 'Assessment Method' • prepare a map indicating the conservation values
PREPARE SITE PLANS	• prepare overlay maps indicating locations of management issues or concerns (eg. fire management, droving, electrical line clearance) • arrange on site meetings of key stakeholders on roads that have been identified as having competing management demands.
IMPLEMENT PLAN	• distribute plan to all agencies and interest groups for use in planning and works on roadsides • plan training programs for staff and contractors
REVIEW & MONITOR	• appoint a subcommittee of council to review progress and implementation • review plan after five years

APPROVAL PROCESS

- a first draft will be prepared by the Community and Agency Reference Group and approved by the Steering Committee for public comment.
- there will be a one month community review period.
- the Community and Agency Reference Group will include any appropriate comments in a final revision of the draft document.
- the Steering Committee will approve the revised draft and present a final document to council.
- council will either adopt the draft as a roadside planning policy document or return the final draft to the Steering Committee for revision.

FINAL DOCUMENT

The final document will be:

- concise with appendices and any relevant background information available both on disk and in hard copy format.
- economical to reproduce and distribute.
- presented as one bound and one unbound copy.

On completion of the final plan a presentation is to be made to a local council meeting.

TIMELINES

It is expected that the community consultative phase required for the preparation of a final draft RMP will take approx six months. The aim is for the plan to be completed within a calender year.

The facilitator is requested to provide a timetable outlining when the major components of the plan will be completed, including the community consultation phase, and when the final report will be presented to Council. The facilitator is required to allow for at least six meetings with the Community and Agency Reference Group with additional subgroup meetings as required. Hours worked should be flexible to include evening or weekend community meetings/workshops and site visits.

ESTABLISHING A STEERING COMMITTEE

Establish a centralised and small Steering Committee to oversee the preparation of a Roadside Management Plan. Ideally this should be a committee convened by the council and its role will be to approve the final document and advise the council on the appropriateness of adopting any final policy, document or recommendation.

In general, representation of the Steering Committee should consist of a councillor (who will usually chair the meetings), manager of the Technical Services Department (or similar), representative of NRE (usually staff from the Flora Fauna Section) and perhaps a member of a key community group.

Frequency Of Meetings	Membership	Role & Responsibilities
• monthly, prior to reference group meeting • on needs basis	small less than six key project managers	• oversee the project • oversee and control project budget • establish & oversee the reference group • supervise the facilitator & consultants • report to council on progress • ensure that RMP is produced within the time frame • approve the final plan for presentation to council, • collect information, resources or data to assist in the development of the RMP

ESTABLISHING A COMMUNITY AND AGENCY REFERENCE GROUP (CARG)

The formation of a reference group of key stakeholders will provide a forum for technical input into the roadside planning process. When selecting members for a reference group ensure that:

- all interested groups have an opportunity to be represented.
- all groups are contacted directly or via a general notice in a local paper.
- committee members are elected or nominated by their parent organisation.
- members of the reference group have an understanding of their parent organisation's role in roadside management and are willing to provide adequate reporting and feedback on the progress of the RMP from their members to the committee and from the committee to the parent organisation.
- members do not see their role as 'watchdog'; this invariably develops into a defensive stand, may stifle debate or lead to open confrontation and will certainly make it difficult to arrive at consensus.

Frequency Of Meetings	Membership	Role & Responsibilities
monthly	15-20 representatives of all interest groups	• prepare the RMP • discuss and prepare guidelines • group representatives report and discuss recommendations and guidelines to their parent groups to ensure support with the final document • incorporate state legislation, local laws or codes of practice in the final document • provide advice and direction to the project officer • produce press releases and other publicity • produce a draft plan for community comment • review public comments for incorporation into the final plan • present the final RMP to council
on a needs basis	discrete meeting of relevant technical experts	• participate in small working sub-groups • attend on-site meetings to broker solutions for specific site issues

EMPLOYING A FACILITATOR

The co-ordination required to prepare a RMP maybe achieved by:

- employing a consultant facilitator for the project.
- dedicating a council employee to undertake the task.

Either way the person should promote communications between all stakeholders and encourage appropriate levels of participation. The employment of an independent facilitator may be preferable so that the process is seen to be transparent and not representing any individual faction.

Skills Required

A facilitator will need to be able to:

- demonstrate good communication and editing skills.
- liaise with people.
- facilitate meetings.
- synthesise different opinions.
- mediate competing demands.
- understand concepts for the management of natural resources.
- consult with different groups and individuals for technical advice.
- establish and maintain timelines.

Key Selection Criteria

- skills in liaising with community groups, especially with regard to consultation and facilitation of meetings.
- strong interpersonal and negotiating skills, with diverse groups of people and organisations.
- ability to provide effective oral and written communications, write reports.
- an understanding of current roadside management issues and roadside conservation objectives.

- an ability to adopt a multi-disciplinary approach to problem solving.
- ability to prioritise work loads within tight time frames.

Other Relevant Skills, Knowledge and Experience
- a current driver's licence and own transport.
- self sufficiency in computer skills.
- experience in research methodology and development of strategy plans.

Functions Of the Facilitator
- facilitation:
  - of community or inter-agency consultative meetings.
  - of reference group meetings.
  - problem solving with a multi-disciplinary approach.
- provision of technical knowledge:
  - in flora and fauna management.
  - understanding of roadside management practices.
- plan preparation skills in:
  - collation and synthesis of information.
  - writing.
  - editing.
  - word processing.
  - presentation or publishing experience.
- project co-ordination:
  - project management.
  - skills in meeting deadlines.
  - preparing and maintaining budgets.

Terms Of Employment

The length of contract will obviously depend on:
- total area of the council.
- number of community groups to be consulted.
- previous works undertaken (any past history of roadside management planning).
- experience of the facilitator.

A contract between nine-twelve months is adequate for the preparation of RMP. This will enable enough time for the community to synthesise information and review and amend any draft documents as required. A contract period for this period would not rely on a facilitator working full time, rather it is envisaged an average a one day per week is required, with peak periods of activity at the project initiation and the preparation of any draft plans.

INDICATIVE COSTINGS

Roadside Management Strategy

	Budget	Timeline
Prepared by a Steering Committee, employing a facilitator who establishes a Community and Agency Reference Group.	$8-10,000	nine-twelve months
Strategy based on previously adopted RMP policy (eg. City of Greater Bendigo).	$3,000	three-six months

Assessment of Roadside Conservation Values

Based on the method detailed in the RCAC Roadside Assessment Handbook	Budget	Timeline
Using contractors to provide detailed botanical surveys for specific roads (eg. Vic Roads sites).	$ 100+ /km	Time dependant on total kms 1-2 days
Using contractors to undertake all work (as per City of Greater Bendigo).	$ 5-10/km	2 weeks
Using community volunteers and reimbursing travel expenses (eg. Glenelg Shire).	$ 1.50-2/km	2-3 months
Mapping: Purchase of base map Preparation of overlays eg. strategic fire breaks	$20 - $100	
Input of data (usually based on Dynamic Segmentation)	$1,000 - $3,000 depending upon complexity of detail	2-4 weeks depending upon method used

Preparation of Individual Roadside site plans

	Budget	Timeline
Prepare individual plans for all high and medium conservation roads (eg. Mornington Peninsula Shire Council undertaken by facilitator after field studies and using standardised management prescriptions).	price to be determined by successful contractor, variable according to total number of roads, but usually an expensive process	
Prepare plans after identification of priority roads (eg. Cardinia Shire produced plans for roads that were designated as both strategic firebreaks and high conservation value).	most plans prepared by in house staff and cost is small, usually council in-kind support and staff time	Usually prepared following onsite meetings lasting 1-2 hours

PLENARY SESSION

Paul Sattler
Environmental Protection Agency

CONCLUDING REMARKS

This successful conference has brought together a wide range of transport corridor users and managers from Australia-wide as well as our keynote speaker, Bonnie Harper-Lore from the USA.

It has provided a unique opportunity for networking between different disciplines from road engineer to fauna specialist. A common interest has been evident throughout the conference - how better to manage transport corridors and their associated natural and cultural resources.

The extent of this interest by more than 250 participants indicates a new awareness of the need to manage sustainably the valued resources of transport corridors. This interest and networking must be maintained and extended.

Implementation of the new "Significant Environmental Areas" signage system in Queensland with the distinctive maroon bottletree symbol will assist in building this awareness. The signs will identify key sites, particularly those containing rare or threatened species and regional ecosystems, or important vegetation remnants that may provide connectivity across the landscape. These signs signal that no works should be carried out in these sites until specific advice is sought on how to protect these special values.

I would particularly like to thank Greening Australia, Ipswich City Council, the contributing government agencies, our sponsors and all participants who have contributed to the successful outcomes of this conference.



PLENARY

The Plenary session sought to identify some of the key issues presented during the conference with a view to guiding future directions for transport corridor management in Queensland. The rapporteurs for each of the sessions provided a series of key points for each paper presented. Those points were consolidated and presented to the conference participants in plenary. The participants were invited to comment and to provide any additional points which may have been missed. The following key issues and findings are the result of that process.

KEY ISSUES AND FINDINGS

Multiple Values of Transport Corridors

- Transport corridors represent a highly valuable natural resource supporting many multiple uses. These values and uses need to be carefully managed.
- Transport corridors increasingly represent the only opportunity to conserve rare and threatened elements of biodiversity, and important vegetation remnants within the landscape. This includes road reserves, railways and stock routes.
- Transport corridors can be a barrier or a boon for wildlife - barriers may be at both local and regional scales - and transport corridors may provide the only habitat or means of connectivity across the landscape for species.
- Cultural and historical values also need to be considered in corridor management.
- Transport corridors offer the potential to enhance tourism and amenity values - this may be of local and regional benefit and could involve the identification of particular travel routes and experiences.

MANAGEMENT CONSIDERATIONS

General

- Well-defined environmental practice should be a key part of all management activities in transport corridors.
- Meeting community, environmental and road safety needs can occur without entailing excessive costs.
- Local government is responsible for the management of the greatest length and area of transport corridors.
- A number of local governments have developed excellent vegetation management strategies - elements of these include:
    - identification and mapping of key values, often including site-record sheets.
    - codes of practice for construction and maintenance.
    - guidelines and policies, eg. to encourage retention, compensatory habitat, signage.
    - works staff training.
    - effective consultation processes.
- To meet the general duty of environmental care as a defence against causing environmental harm, it is desirable to define a transparent and auditable management system.
- Telecommunications exemption powers in relation to low impact activity cannot be carried out in environmentally sensitive areas without the appropriate assessment process.
- The Australian Pipeline Industry Association (APIA) is developing a code of environmental practice.
- Transport corridor managers are no longer in denial in terms of environmental obligations and there is great opportunity for the networking at this conference to be extended.

Planning & Design

- There is no substitute for good planning to avoid environmental impacts.
- It is preferable to plan for good management rather than rely on prosecution. This includes the development of information packages with contracts so that contractors and others understand their responsibilities.
- Biological processes should be taken into account in planning to achieve desired outcomes.
- Operators should be involved in pre-design and development of projects, particularly to advise on how to take local features into account.
- There is a need for good design for retention of vegetation and for landscaping to ensure safety - "road safety is no accident".
- Planners need a good knowledge of the species being impacted by the road barrier for inputting to the design - "one fauna crossing does not fit all"
- Community consultation is important when developing roadside plans, including for fauna crossing strategies to be effective.
- In-depth ecological studies will become the norm as pressure on remaining fauna habitat increases.
- Native species should form the "backbone" of landscaping though a place does exist for exotic species for specific situations.
- A diversity of species should be included in planting mixes, including species that are fire retardant where appropriate. Direct seeding of native species has the potential to reduce costs. Determination of appropriate seed-treatment is essential for germination. Local provenance seed should be used in plantings wherever possible - including seed collecting from sites prior to disturbance.
- Native seed availability is a key issue when trying to establish local provenance vegetation - there is a need to link producers and users.
- Local species interpretive gardens associated with rest areas is one initiative being pursued in the USA and can assist in creating an identity for different localities.

Implementation

- Protection of what is left is more important than restoration.
- Management of remnants should seek to maintain the *status quo* until ecological requirements are known.
- Extensive legislation exists for the management of transport corridors - there is a growing expectation by society for it to be implemented to protect vegetation and other values - this includes both state agencies and local government and the management of local roads and stock routes.
- Community involvement can assist vegetation management in transport corridors and good leverage is possible through community groups and various government assisted programs.
- Incentives are a valuable component in building community partnerships (eg. weed control rebates).
- There is a greater role for burning as a prescribed management tool - co-operative approaches to fire management are required.
- Erosion should be controlled at the source, with emphasis on minimum disturbance and sound planning.
- A variety of measures are possible to mitigate road kills and overcome roads being barriers for wildlife, including maintenance of canopy cover, rumble strips, reducing speed, awareness signage and possible inexpensive retro-fitting - there is a need to look at what is working already for fauna.
- Consider stock-piling topsoil when bush-sites are disturbed (but note there may be weed issues to consider).

And most importantly ...Don't tidy up!

FUTURE DIRECTIONS

Information

- There is a need for resource surveys and management research to protect key elements of biodiversity as information on key values is often lacking.
- The collation of existing natural resource information is important, but should not replace the need for targeted field assessment.
- There are extensive examples that environmentally friendly actions can save money - there is a need to document those examples of good practice.
- Collated information should be readily available to other transport corridor users, and there is a need to develop protocols to facilitate access to information - this could be linked to agreements to implement best practice.
- Legislation is diverse, and there is a need to clarify responsibilities - including the definition of stock routes and the roles and responsibilities for their management.
- There is a trend in the USA to non-tree plantings due to potential liabilities - this trend may require the further interpretation of duty of care.
- Detailed specifications need to accompany hydro-seeding prescriptions.

Research

- There is a great opportunity to develop new species for transport corridor plantings as a very diverse flora is present in many areas - such as south west Western Australia and south east Queensland - this should be supported by research.
- Weeds will represent a continuing management issue - there is a need to know weed species, their potential and avoid the triggers which enhance infestations.
- There are limited data on native species emergence rates in hydro seeding.
- There is a need for research and monitoring on the impact of roads on fauna and how such impact may be mitigated (the Queensland Department of Main Roads may consider appropriate research proposals).
- Funding key research is a major consideration.

Capacity Building

- Institutional commitment to the overall management of transport corridors in Queensland is needed.
- There is a need to establish a network of transport corridor stakeholders, involving a wide range of agencies, local governments and other stakeholders, to disseminate information and work collectively to resolve issues.
- Management of transport corridors is not someone else's problem. Local governments and other agencies must take the initiative to develop management strategies.
- It is desirable that local governments liaise with each other to build partnerships to develop regional strategies for the management of transport corridors.
- Training programs for environmental management should be developed, including joint programs with bodies such as TAFE for machinery operators.
- There is a need to maintain communication and dialogue between transport corridor managers and conservation agencies regarding key sites.

What Next?

- The Queensland Transport Corridor Management Working Group will review the proceedings with a view to advancing the issues raised during the conference.
- There is a need to explore avenues for disseminating this information - eg. LGAQ, ALGA, ABC Radio and other rural-service providers. This should be targeted so that the message means something to the audience - eg. why local governments can save money by better managing roadside vegetation.

TRANSPORT CORRIDORS MANAGEMENT CONFERENCE
FIELD TRIP FRIDAY 19 NOVEMBER 1999

SITE 1 - HYDROSEEDING SITE CUNNINGHAM HIGHWAY

TRIAL DETAILS

- The hydroseeding site is 15 years old.
- The plot was established as a trial aimed at finding an effective and inexpensive method of breaking seed dormancy before the seeds are hydroseeded. Normally wattle seed dormancy is broken by immersing the seed in boiling water, the trial utilised a microwave to mimick this effect.
- The hydroseeding mix consisted only of 5 wattle species (*Acacia macradenia*, *A. decurrens*, *A. podalyriiflora*, *A. fimbriata* & *A. ixiophylla*).
- The trial was undertaken by 4 final year Gatton College students in cooperation with Main Roads in November 1984. No follow up monitoring is known.
- Recommendations from this trial were inconclusive in regard to utilising microwave seed treatment.



DISCUSSION

- This plot is typical of the long-term results of many hydroseeding projects.
- Many of the trees are either dead or senescing. This has a essentially two problems:
  - The gaps allow for weed invasion.
  - The aesthetics – the removal of dead trees is expensive and dangerous for road workers.
- Is it appropriate to allow fire in to encourage re-growth of wattles? (ie fire is needed to crack seed coats).
- The successful establishment of other longer-lived species and or self-perpetuating species would reduce weed growth. Weed growth is a problem for several reasons:
  - Weeds are a maintenance problem and or a fire hazard.
  - Some of the species invading are declared weeds, by law they should be removed.
  - Some are environmental weeds which will provide seed sources into local bushland areas.
  - Where weeds are this dense they will invade neighbouring properties which may be cropping, residential or set aside for conservation. Is the problem then that landholder's responsibility to manage?

- Essentially there are a couple of points to consider:
  1. Hydromulching is an excellent tool for rapid stabilisation of disturbed areas.
  2. Hydromulching rarely results in a plant community that is long lived and excludes weed species.
  3. Do the cost benefits of gaining rapid stabilisation through hydromulching out way the long-term costs of maintenance? Is this project successful or can we do it better?

- Hydroseeding is most successful with larger seeded species such as wattle.
  - Therefore would it be appropriate to direct seed smaller species before hydroseeding larger species?
  - Is it more appropriate to plant tubestock of larger species and then hydroseed?
  - Should we not hydroseed at all and consider other methods of batter stabilisation that require little or no maintenance at a later date and always suppress future weed growth?

SITE 2 – ROADSIDE DRAINAGE ISSUES - YARROW ROAD, THAGOONA

Description of site

This gravel road is located on a very flat grade with rural residential/large lot holdings. The roadsides are grassed with no other vegetation. This site highlights the multiple uses of road corridors and the often limited width of the road corridor in which to manage these.

Issue

The road was a major maintenance issue with extensive volumes of water coming off what is a considerable catchment upstream. The water used to run down the road and roadside causing regular erosion and maintenance problems and threatening the road asset. Complaints from the local residents were an ongoing issue with their driveway entrances regularly being washed out during regular storm events.

Solution

A consultant was employed by council to assess the situation and come up with some alternatives that involved 'looking outside the box' and extending the management of the drainage onto adjoining private land. As a result a range of approaches were implemented. Extensive consultation occurred with all the private landowners involved.

Bunds were constructed diverting the bulk of the water from the catchment from the road to the back of the properties. A private dam was enlarged and a number of drainage easements were utilised. The grassed bunds were built at a grade that could be easily maintained by the local landholders.

The grassed roadsides are now stable and handle primarily only the water which falls on the road. As a result there has been a dramatic reduction in the number of complaints by residents and the on going maintenance of the road and table drain have been significantly reduced.



SITE 3 – DEPOT REHABILITATION SITE PIONEER ROAD, HAIGSLEA

Background

- As part of the activities of the Freeway Greening Project rehabilitation plans were prepared for 6 expired Main Roads depots in south east Queensland. The emphasis on most of the sites was revegetating the site with the lowest cost method as possible with the local flora.
- On this site the most appropriate method was to utilise both direct seeding and tubestock planting techniques. Ideally the cheapest option would have been to direct seed the entire site, however it was felt, in this instance, we did not want to put all of our eggs in the one basket.
- An emphasis was placed on utilising locally collected seed (otherwise known as local provenance) for direct seeding on all of the depot sites. Greening Australia contract collected over 20kg of local seed specifically for the depot direct seeding projects.

Implementation

- Site was initially sprayed with a Glyphosate product to kill existing weeds on the site.
- Site was ripped on the 1 April 1999 with a 10 tonne drott.
- Rows were mulched with approximately 80 bales of sugar cane mulch.
- $80m^3$ of forest mulch was used on the boundary and parallel to the drain. Mulch was spread with a bobcat.
- Site was planted with 630 tubestock. Each tree was fertilised with a 10gm agriform tree tablet. Each tree was watered with approximately 10L each.
- Planting was undertaken between 6 April and the 9 April 1999.
- The area between the planted tubestock and the remainder of the site was ripped on the 26 May 1999 with a 10 tonne drott with 3 ripping tynes. Direct seeding was undertaken immediately after the site was ripped.



Tubestock species

- *Acacia aulacocarpa* hickory wattle
- *Acacia concurens* black wattle
- *Eucalyptus drepanophylla* narrow leafed iron bark
- *Eucalyptus gumnifera* a bloodwood
- *Eucalyptus tereticornis* forest red gum
- *Lophostemon suaveolens* swamp box
- *Myoporum montanum* water bush

Direct seeding species

- Seed species 14 species (tree and shrub mix).
- Unfortunately 90% (by weight) were wattles as these were the dominant species in the local forests that were seeding.
- However these wattles were largely understorey species of a small stature and should compliment the taller species planted as tubestock.

Seed preparation

- Hard coated species such as wattle and the peas were heat treated with boiling water, allowed to sit in the water for approximately 5 minutes and then removed, cooled (with an electric fan) and allowed to dry overnight.
- Immediately prior to seeding the seeds were mixed together and subsequently mixed with a slurry of pymethrine powder (5gms of powder mixed with enough water to make a slurry was used for 1kg of seed).
- Dry sand was collected from on site and mixed with the seed mix at approximately 1/3 seed and 2/3 sand. This mix has hand sown on the site.

Maintenance

- (29 April) Planting beds were sprayed with glyphosate and plantings watered.
- (8&9 September) Planting beds and seeded areas were sprayed with fusillade and glyphosate.
- (27-29 October) Planting beds and direct seeding areas were sprayed with glyphosate with the surfactant pulse.

Items of note

- The area between the rows of planted trees was sown directly into the rip lines. The area closest to the service road was broadcast across the ripped area. There was a greater rate of establishment between the planted trees because the seed was placed in a specific niche. Although establishment appears to be lower adjacent to the service road the seedling density is adequate to form a canopy.
- A fence was installed to stop people entering the site and dumping. Likewise the mulched planting bed on the service road edge is aimed at ensuring rapid establishment of trees, thereby excluding trespassers.
- *Myoporum montanum* (water bush) has been used in the tubestock plantings. This is the species currently being trialed as a potential median strip plant for the metropolitan district as a native alternative to the Oleander. The plant has flexible stems and branches broadly from the base – that is, it appears to have a high degree of frangibility.

SITE 4 - POWERLINE REALIGNMENT, KHOLO ROAD, KHOLO

Background

It recently came to the attention of the Conservation Resource Officer that an application had been lodged to remove native vegetation from this unmade road reserve for the purpose of allowing utility and vehicular access to a property off Kholo Road at Kholo.

Given the importance of remnant roadside vegetation in the preservation of biological diversity, and the Council's progressive attitude towards it's management, further research and an inspection of the site were undertaken.

A number of matters were revealed for consideration:

1. The unmade road is of high conservation value. It is well timbered with a continuous canopy, good understorey and litter layers and good habitat value. There has been little invasion by exotic weeds, and there are a number of permanent water sources located nearby. In addition it is ideally situated to form a valuable corridor through cleared farmland between an area of significant habitat (as identified in the Catterall report) towards the Brisbane River.

2. A rough vehicular access track has already been bulldozed for approximately half of the length of the unmade road. This track runs through the centre of the road reserve, apparently following an older one used by Queensland Electricity Commission to access their lines which pass by the eastern end of the unmade road.

3. In order to provide power, Energex would be obliged to clear additional vegetation along the left-hand edge of the road reserve at least as far as the closest corner of the property. (In the old Moreton Shire a standard distance of 3.4 metres is set as the distance from the edge of the road reserve to the centre of the line of power poles).



Action taken

In the hope of avoiding any further disturbance to the native vegetation, a meeting was arranged between Mr Andy Hanson, the property owner, officers Ron Scheers and Mal Bothwick from Energex, and the Conservation Resource Officer and the City Landcare Officer from Ipswich City Council.

The discussion centred on the possible avoidance of further environmental damage during the supply of power by Energex whilst at the same time keeping costs to Energex and the property owner to a minimum.

The meeting was very productive, with genuine concern being displayed by all parties.

Two viable alternatives were proposed:

Alternative 1

The route of power supply could be moved to follow the existing track rather than along the edge of the road reserve. This would require a directive from Council allowing deviation from the standard alignment of 3.4 metres.

Because the distance of supply along the access track is less than 250 metres, Energex recommended the use of ABC (Aerial Bundled Cabling), rather than the more conventional cabling in this alternative. The use of ABC would significantly reduce the need for removal of limbs and trees situated close to the actual cable.

It was estimated that this alternative would require the removal of no more than ten (10) trees in excess of that required for the access road itself.

Alternative 2

The route of power supply could be moved off the road reserve altogether. With the consent of the relevant landholders it would be possible to run the power lines through neighbouring paddocks, avoiding the occurrence of trees altogether.

This alternative had already been discussed with landholders on the northern side of the road reserve, with no satisfactory agreement being reached. The possibility still exists however, given the landholder on the southern side is agreeable.

The re-routing of power outside the road reserve on the southern side would result in the necessary removal of one significant tree.

In both alternatives, the cost to Ipswich City Council would be nil.

The City Landcare Officer held discussions with the Area Engineer regarding the alternatives outlined above and determined that the most appropriate course of action is to initiate Alternative 1. Energex were subsequently advised of the suitability of Alternative 1.

ADDITIONAL SITE - SIGNIFICANT CONSERVATION SIGNAGE PINE MOUNTAIN ROAD

Background

- This is an example of a significant site that Ipswich City Council hopes to be permanently sign posted.
- Signs have been erected to show what we are aiming for in the near future.
- There is still some debate of the sign layout within council.
- This site was surveyed by a council conservation officer & local botanist (Lloyd Bird) & was found to contain:
  - *Maytenus cunninghamii* – regionally significant small or large evergreen vine thicket, this site is this plants eastern known limit.
  - *Hibiscus sturtii* – a small prostrate hibiscus that is very uncommon in the Ipswich region, possibly eastern known limit.
  - Water bush (*Myoporum boninense* subsp. *australe*) – a small shrub of the eucalypt vine thicket margins with attractive white flowers and edible fruits, also uncommon in the Ipswich area.
  - Paper daisy was found on this site – regionally significant, now locally extinct.

An example of significant environmental area signage





Roads

NATURAL RESOURCES Queensland

QUEENSLAND GOVERNMENT
Environmental Protection Agency

Ipswich City Council