but corridor movement has only been demonstrated for some species of animals. The dependency on corridor movement appears to be absent for plants and insects but this may be a function of the time scale used to record movement as some species may move very slowly through a habitat. Generally, however, there have been few studies of the role of corridors.

Species which use corridors for movement are more likely to be species with short dispersal distances that are resident in the habitat. Species with special habitat requirements are not likely to use the corridor unless their specific needs are met. Corridors will tend to suit generalist species that are able to adapt or survive in changing conditions. They are likely to be species that can use different types of environments rather than having specific or specialist needs.

Conservation Sites on Stock Routes

There have been very few flora and fauna studies carried out specifically on stock routes. Most of the available information relates to vegetation and this information is very incomplete as the studies tend to focus on a particular species, vegetation type or are at a very large scale (Sattler and Williams 1996). There have been no fauna studies for stock routes and inferences on the presence of animal species are made on the basis of the remaining vegetation and habitat.

The conservation status of regional ecosystems is described in three categories: endangered, of concern and of no concern at present (Sattler and Williams 1996). Many of the regional ecosystems are considered as potentially vulnerable and are threatened by the degree to which they have already been cleared or significantly altered by land management practices.

The Darling Downs area

Fragmentation is not a random process and corridors are a by-product of other land use activities. As a result of bias, many vegetation types are now restricted in their distribution; for example on the Darling Downs, native grasslands have been reduced to little more than 1 per cent of their area, which originally represented about 42 per cent of the Downs (R. Fensham pers. comm.).

Much of the remnant grassland vegetation of the Darling Downs is on stock routes, roadside reserves and highly fragmented patches on private land holdings. In a recent study of the remnant vegetation of the Darling Downs at least five species listed by the Nature Conservation Act were identified (R. Fensham pers. comm.). Grasslands are a high-priority group that are endangered but well preserved on the stock routes of the Darling Downs.

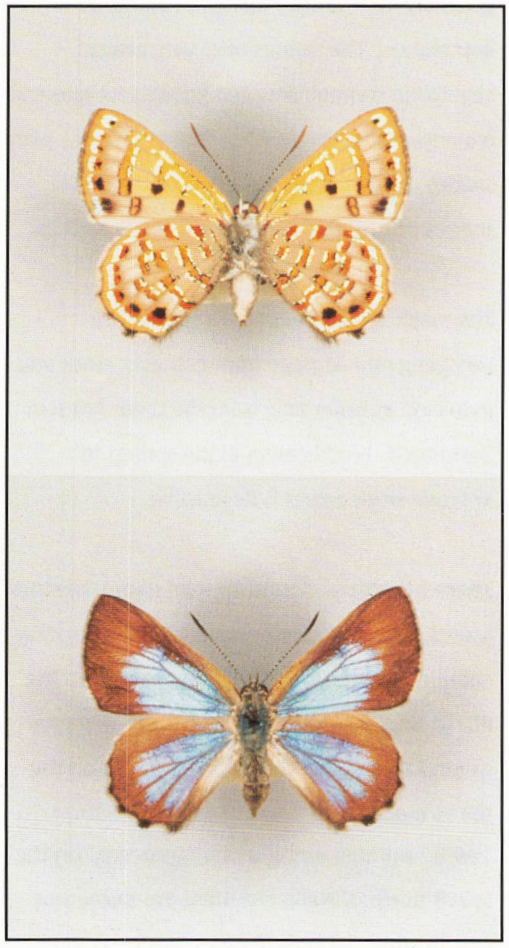


Photo courtesy of CSIRO, Division of Entomology

***Hypochrysops piceatus*, Leyburn jewel butterfly: an endangered butterfly found along roadsides of the eastern Darling Downs**

Other vegetation groups that are considered to be endangered in the Darling Downs include brigalow (*Acacia harpophylla*) open forest, which has been reduced to 5 per cent of its original coverage, poplar box (*Eucalyptus populnea*) shrubby woodlands, which have 7.6 per cent of their original coverage, and poplar box grassy open woodlands, which have been reduced to 6.4 per cent of their original coverage (R. Fensham pers. comm.).

Mound springs

Of particularly high conservation value nationally are the mound springs of the Great Artesian Basin. The rarity of these springs, their disjunct distribution and their associated rare, relict and endemic flora and fauna give them high conservation value.

There are six supergroups in Queensland that generally have unique biological and cultural importance. The springs offer very distinct vegetation communities and habitats for rare and endangered animal species. There are three plant species, at least three species of fish and 12 species of snail that are endemic to the springs.

The major threats to artesian springs are trampling and damage from domestic stock and a reduction in water flow from the Great Artesian Basin itself. Modification of the springs to improve stock access is destructive.

There are many mound springs found on stock routes. Elizabeth Springs is a significant spring complex located on Springvale Station on the P01DI Boulia/Windorah stock route. A major mound spring complex is also located on the M315 stock route north of Aramac (Wilson 1995). Another string of springs occurs on the M013 north of Nelia but there are numerous small springs alongside other stock routes.

A more detailed ground truth survey is required to determine where these springs are in relation to stock routes and the impact stock route management is having on the mound spring function and biota.

Other sites

In preliminary studies of remnant vegetation on stock routes south of the Tropic of Capricorn, at least 152 sites have been identified as containing vegetation types that have not been protected in the National Park or State Reserve system (Roberts 1994). Many of these small, but significant, conservation areas outside of the State reserve system need to be recognised and managed to reduce the impact of other activities on their core conservation value.

The Department of Environment has also identified some sites of significant conservation value on stock routes (Table 1). This list cannot be considered complete as the need remains for a systematic appraisal of stock routes for their intrinsic values.

AREA	VALUES
Stock route from Taroom north to Palm Tree Creek	Contains examples of various vegetation associations once widely distributed throughout Taroom area including brigalow (*Acacia harpophylla*) and ooline (*Cadellia pentastylis*).
Stock route about 10 kilometres east of Mungalalla (near Ooline siding)	Contains remnant vegetation with ooline and *Acacia microsperma*.
Stock route in vicinity of Old Nanango–Goomeri Road	Remnant vegetation, old trees with hollows supporting a range of wildlife including koalas.
Bullamon Plains via Thallon on the Carnarvon Highway stock route	Corridor containing relatively intact remnant vegetation.
Langlo Crossing on the Charleville –Adavale road stock route	Corridor containing relatively intact remnant vegetation.
Stock route along main road west of Talwood	Corridor containing relatively intact remnant vegetation in otherwise cleared country.
Stock route through Diamantina National Park	Contains channels of Diamantina River and associated alluvial ecosystems.
Stock route between Boulia and Winton	Contains habitats of an undescribed Callistemon that grows in saline channels.
Stock routes in Mitchell grass downs regions	Contain major ecosystem types not represented in National Parks.

Table 1. Some significant conservation sites on stock routes as identified by the Department of Environment.

Councils have indicated a knowledge of areas of environmental importance on stock routes such as the stock route immediately north of Taroom, the flora and fauna sanctuary at Mitchell and The Gums reserve west of Tara.

Other sites identified as having conservation value include (Wildlife Preservation Society of Queensland 1987):

- Seventeen kilometres south-west of Mundubbera on Auburn Road is an open forest of forest blue gum (*Eucalyptus tereticornis*) and smooth barked apple (*Angophora costata*) of high conservation value with minimal disturbance and mature vegetation community.
- Seven kilometres south-west of Moonie on the Moonie Highway is an open forest of brigalow and belah (*Casaurina cristata*) which has some disturbance but good regeneration and is of medium conservation value.

Stock routes provide many benefits for biodiversity but there are also many issues for management to deal with

Management Issues for Corridors

If stock routes are to function as corridors for movement of native species and maintenance of habitat, management must be aimed at enhancing these functions. Stock routes provide many benefits for biodiversity but there are also many issues for management to deal with.

Landscape features and areas of high conservation value

Stock routes traverse and pass many different land systems and landscape features. Some of these are fragile to traffic of any sort, for example sandstone

Photo courtesy of Department of Environment, Toowoomba

Mound Springs at Currawinya National Park

escarpments, while others such as natural springs and water holes are sensitive to the impact of grazing and trampling. Many sites on stock routes have high conservation value (both cultural and natural) and are protected under local initiatives and State and Federal legislation. Some stock routes also pass through National Parks.

Off-site benefits

Vegetation corridors provide many off-site benefits for the whole ecosystem, including salinity mitigation, erosion control and refuges for many species useful in the control of agricultural pests.

Availability of flora, fauna and habitat studies

There are very few ecological studies conducted on stock routes and knowledge of their native flora and fauna is limited. The few studies available relate mostly to vegetation and do not consider the fauna, particularly the identification and roles of invertebrates in maintaining ecological balance. Many vegetation communities or ecosystems are not yet mapped because the scale of study has been too large. Consequently our understanding of the role corridors play in conservation needs to be expanded.

Fragmentation

The process of habitat fragmentation and degradation continues. Land is still being cleared which further isolates remnant vegetation, reduces habitat availability and increases the impact of edge effects. Continuity is necessary for corridor function, but depending on the species, connectivity may not be essential.

In cropping areas, especially in the Darling Downs, landholders are cropping the road verges which results in complete destruction of the vegetation. For the grazing regions, corridors are generally less disturbed, and less threatened by destruction and further fragmentation, than in the agricultural and cropping regions.

Roads, communication and service utilities

When roads and the provision of communication and service utilities overlap with stock routes, the major threat to remnant vegetation is the initial mechanical disturbance, which often results in complete destruction of the vegetation. Road realignment, grading of verges and line-of-sight clearing are

Photo courtesy of Elton Miller

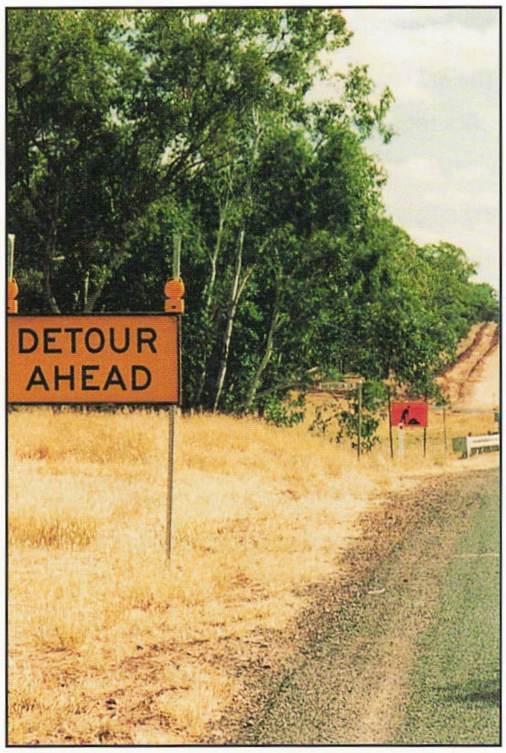
Clearing and fragmentation

all destructive to habitat and considered to be more destructive than fire or grazing. Erosion is a common product of road construction.

Roads create an ongoing problem of disturbance from maintenance, pollution, dust and noise. Road designs often harvest and channel water in ways that create drought for much of the road reserve vegetation.

Roads on stock routes are a major barrier to the movement of wildlife and a major source of wildlife mortalities. Many roads are in the middle of the stock route, or weave across the stock route, increasing the fragmentation and edge effects and increasing the hazards for wildlife.

Many species used for revegetation, including introduced pasture species, become weeds in remnant vegetation.



Grazing

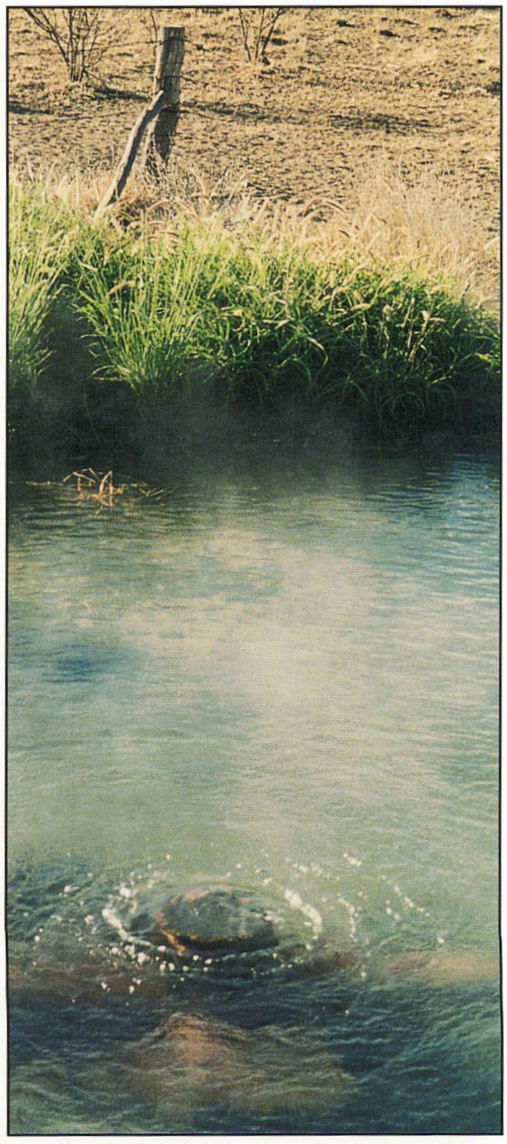
The primary function of stock routes is for the grazing of travelling stock. Sustained long-term grazing is not appropriate for some native vegetation types. Remnant vegetation is comprised of many non-pasture species that are very vulnerable to selective grazing and trampling. The understanding of the long-term impact of grazing on native vegetation needs further study. For the protection of many of the remnant vegetation communities maintaining the status quo is considered to be adequate. Other remnants may need protection from grazing, particularly from the impact of agistment and the permit to occupy system. Overgrazing of stock routes in the Central Highlands has removed competitive pasture species and assisted the spread of parthenium weed.

Droving

The movement of large numbers of hard-hooved animals over remnant vegetation can have considerable impact depending on the degree of movement, timing, and the intensity and frequency of the movement. Soil disturbance can result in soil compaction and structural decline, increased erosion and changes in soil fertility. Increased soil fertility around brakes and night camps increases the potential for the establishment of exotic species, particularly from weed seeds, which can be carried in animal coats and dung.

Water supply

Water on the stock route is generally provided from natural sources such as springs and water holes and from bores which tap the Great Artesian Basin. Some bores are uncapped and free-flowing. Water extraction causes local draw down which can cause nearby artesian springs to cease flowing and/or become extinct. Some bore drains harbour feral animals and declared pest plant populations.



Uncapped bore

Stock routes and adjacent land use

The agricultural and grazing lands adjacent to stock routes are sometimes quite hostile to wildlife. The abrupt habitat change exposes the edges of the remnant vegetation to new and more intense levels of disturbance. These edges develop attributes not found in the interior of habitat.

Edge effects

Physical disturbances such as increased light, wind speeds, erosion, soil fertility and dust can degrade the characteristics of the site and disrupt the relationships and dependencies of the animal and plant communities and favour the development of a different suite of species. Bird species are the most recognisable groups that change in response to fragmentation and edge effects.

The impact of edge effects on wildlife varies from species to species but as the width of the corridor increases the rate of occupancy by wildlife increases and the mortality decreases. Increased predation is considered to be one of the most significant impacts of fragmentation and edges. For some plant communities the impact of edge effects may be felt for several hundred metres into the interior but for animal species the impacts vary considerably and range from metres to hundreds of metres. Stock routes are long and narrow and are subject to edge effects from both sides.

Spread of weeds, feral animals and disease

Corridors are assumed to provide for the movement of native species but the theory equally applies to exotic species. It should also be noted that not all native species like corridor habitat and some will prefer to move in the agricultural landscape.

Feral animals find shelter in corridors and combine with native predator species to increase the general level of predation on smaller animals, birds, reptiles and insects.

Weeds commonly encroach into corridors. They respond to the modified nutrient, light and water regimes created by disturbances and edge effects. Their presence and spread compound the level of disturbance and decrease the integrity of the vegetation.

Movement of animal species and the presence of feral animals on stock routes are implicated in the spread of weeds, diseases and parasites. Isolated populations are vulnerable to diseases and local extinctions are not uncommon. Both feral animals and weeds can act as reservoirs for specific diseases that impact on biodiversity. The control measures used elsewhere may not be applicable in remnant vegetation.

Fire

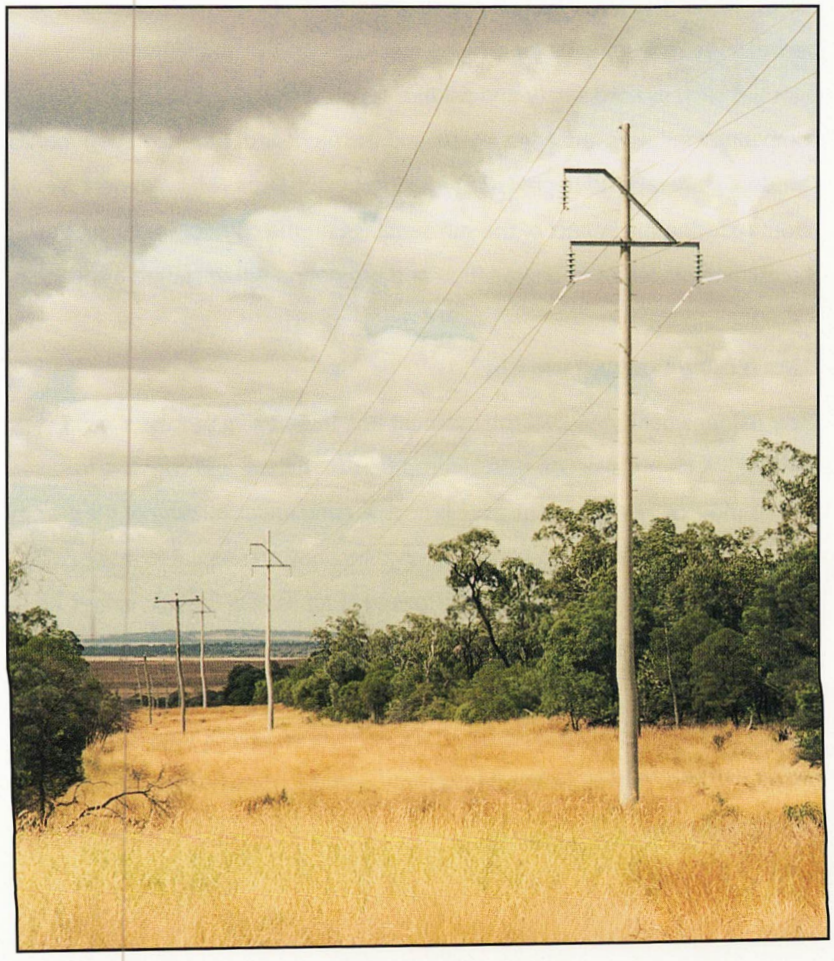
Stock routes are potential conduits for wildfires which can endanger life and property. The construction of firebreaks, particularly within the stock route, reduces the corridor width, increasing the edge effects, and produces an extreme contrast in land uses. Fire is recognised as a natural feature of the landscape and fire management is critical for maintenance of biodiversity. Excessive burning, however, from regular fuel reduction fires, fire breaks or prescribed burns, can lead to biodiversity decline.

Corridor quality

Stock routes vary in their quality as corridors. Good corridor design is important to reduce edge effects and maintain quality habitat.
For the movement of species, corridors need to be continuous if not connected; however, stock routes contain many barriers to movement including open space, roads, and altered vegetation communities. Some species are capable of crossing long-distance barriers while others can be blocked by small impediments of a few metres.

As habitat, the quality of remnant vegetation on stock routes varies from being completely cleared and degraded to patches of relatively undisturbed vegetation. Quality habitat provides for a variety of species and populations. Degraded habitat can still provide for rare and threatened species, as disturbance favours some of these species and not the common species. Quality habitat is as natural as possible, with a good mixture of both adults and juveniles, and provides adequate food, shelter and breeding sites.

Stock route conservation site



Corridor design

The critical features of stock routes that impact on biodiversity are corridor length, edge:area ratio and the quality of the habitat. Stock routes were never designed as vegetation corridors and they are generally not supported by compatible adjacent land use. Their widths vary from metres to more than a kilometre and their lengths vary markedly. They do not necessarily link up with larger patches of remnant vegetation. Their edges need to be as simple as possible and the vegetation should be maintained as undisturbed as possible to provide suitable habitat for native fauna.

Connectivity

Stock routes form only one sort of corridor network and because of land use bias it is often restricted to specific land types. To make full use of the resource, stock routes need to link with other corridor networks and patches of remnant vegetation. An ideal conservation corridor network would have a high level of interconnection, linking across a full range of landscape units, and would provide for the different directions of ecological gradients such as aridity or altitude, migration route or food source.

Management for Biodiversity on Stock Routes

Management principles

Managing stock routes for biodiversity shows an acceptance of the benefits of maintaining habitat and providing for the movement of wildlife. For individuals using the stock route system, a commitment to conservation and sustainable multiple land use is required.

- Corridors have value both as habitat and for movement of species.
- The wider the corridor the more functional it is.
- Corridors do not need to be connected habitat for all species but need to be continuous.
- Ongoing research, monitoring and evaluation are needed to produce flexible management responses to habitat and species requirements.
- The negative impacts of large edge:area ratios need to be managed.
- Corridors are not the solution to biodiversity conservation but form part of a regional integrated landscape-level conservation strategy.
- A precautionary principle is required at all times.

Principles of corridor management adapted from Wilson and Lindenmayer (1996).

Corridors for biodiversity cannot be left to manage themselves. On stock routes, management for habitat and biodiversity is often a compromise between the requirements for droving and other uses or management priorities such as road safety and wildfire suppression. The impact of competing land uses, the edge effects and the process of fragmentation makes corridors vulnerable to degradation and local extinctions. Management is about reducing the impact of the surroundings on the corridor, reducing the threatening processes of degradation and promoting rehabilitation as needed.

What is being managed and why?

Clear management objectives are essential. The threatening processes need defining. A clear distinction between corridors for habitat and corridors for species movement needs to be established. A good understanding of the biology of the individual species, populations and community is essential to make well-informed decisions. Each site must be looked at for its own intrinsic values, its relationship to the whole ecosystem and its function as a stock route.

Tools: vegetation and soil mapping, flora and fauna surveys, land use surveys and inventories, studies on the biology and ecology of individual species and populations.

Minimising edge effects

Stock routes are subject to edge effects from at least two sides. Most edge effects are the result of adjacent land use and are therefore a planning issue. The division of already narrow corridors by roads, rail, fences, grids and communication and service utilities needs to be minimised. Keep all activities that reduce the width or increase exposure of the edges to a minimum.

Tools: establish and maintain buffer zones and compatible adjoining land uses, increase the area (width) of the stock route, keep firebreaks outside the stock route, keep road reserves and utilities to one side, minimise roads meandering across the stock route.

Minimising the process of fragmentation

Tools: restrictions on clearing, re-routing of roads, appropriate adjacent land use, preventing the closure of roads and stock routes.

Maximising connectivity

Tools: link stock routes to other corridor networks, link small patches into the network.

High conservation areas

Tools: identify and provide interpretation, develop specific management guidelines, purchase adjoining land to increase the area, re-route the stock route or roads, restrict access and/or fence as necessary, employ appropriate feral animal and weed control strategies.

Conservation plan

Tools: stock route management plan incorporated into other conservation strategies and regional land management programs, specific management plans for significant conservation areas.

THE OOLINE FOREST

Ooline (*Cadellia pentastylis*) is a tree that was once widespread throughout central Queensland but is now very restricted in distribution and is protected under the *Nature Conservation Act 1992* (Qld). Ooline is threatened by clearing and fire and also appears prone to insect attack when grazing pressure is high. Very little is known about the biology of ooline.

In Booringa Shire a stand of ooline is growing along a stony slope that is traversed by a stock route and the Warrego highway.

The Booringa Shire Council has taken responsibility for the management of the remnant vegetation with advice and support from the National Parks and Wildlife Service.

Travelling stock go around the ooline stand, away from the slope, to water, which is on the other side of the road. A wayside stop has been incorporated into the Park, with toilet and drinking water facilities. Pathways have been designed and constructed to have minimal impact on the site. The Park is well sign-posted, and more interpretive signs and brochures are being developed to raise the profile of the remnant vegetation. An exclosure, that restricts large animal access, has been erected to monitor the impact of grazing on ooline regeneration.

A management plan is needed to link the remnant, which includes adjacent private property, with other conservation strategies. The management options for fire, grazing, and feral animal and weed control still need to be explored and the impact of visitors and grazing animals needs to be monitored.

3.3 Pasture Management

Introduction

Stock routes are not the same as paddocks; they are open - ended; they are not fenced along pasture types or soil types or by carrying capacity; they do not have fragile or sensitive areas fenced out but exist as a route, crossing many types of country. Practices promoted for property planning are therefore not necessarily possible or appropriate for stock routes.

Stock routes are not long paddocks

Stock routes are commonly referred to as the long paddock. This is an unfortunate term because stock route pastures are for the benefit of travelling stock. They do not represent a paddock situation. Some land managers have an unreal expectation that stock route pastures can be managed in the same manner as a paddock and yet the basic aim is to provide, at minimum, a maintenance-level diet during hard times or when travelling from one place to another. The pastures are not for fattening or other husbandry practices; they are for use during droving stock from one place to another.

Pasture management is regularly raised as an issue by Stock Route Supervisors. The demands on the stock route pastures differ from the paddock situation in both the timing of their use and the intensity of their use. While the pasture management principles are the same for both stock routes and paddocks, the actual on-the-ground grazing management practices vary because of the pasture types and the nature and role of stock routes. Pasture management needs to be flexible to balance the demands of the pastoral community and the need for sustainable utilisation of the stock route.

Pastures Types

Stock route pastures are more than just grasslands and include woodlands, shrub lands and even forests. These native pastures form the basis of the grazing industry in western Queensland and are the principal component of the stock routes. Management requires a good understanding of the pasture species, how they function in pasture communities and how they respond to grazing and other land use activities.

Some very good books on native pasture management have been produced by the Queensland Department of Primary Industries and are listed in the recommended reading. Identification of pasture species is made easy using two useful Queensland DPI publications – *Plant Identification in the Arid Zone* and *Pasture Plants of Southern Inland Queensland*.

Staff of the Queensland Herbarium (Department of Environment) are also available to assist with plant identification. The Herbarium is located in Meiers Road, Indooroopilly and botanists can be contacted by telephone on (07) 3896 4326.

The major pasture types found on stock routes and their susceptibility to grazing pressure have been described (Akers 1992):

***Mitchell grass (Astrebla* spp.)**

These pastures are the most highly sought after by both adjoining landholders and travelling stock. Stock routes with Mitchell grass pastures tend to be the most utilised areas in the State because of the quality of the pasture. Mitchell grass pastures can sustain fairly heavy grazing pressure; however, once the tussock system has been destroyed, serious degradation has occurred.

Red mulga soils on river frontage

These pastures are very susceptible to overgrazing. They will not recover pasture bulk as quickly as the downs country and suffer from woody weed invasion by turkey bush and false sandalwood.

Brigalow softwood scrub soils usually supporting buffel grass pasture

This is mainly in cattle raising or grain growing areas. Pastures can generally withstand fairly heavy grazing. The presence of parthenium weed in much of the Brigalow area tends to restrict the movement of travelling stock. Overgrazing in such areas leads to heavy parthenium weed infestations. This has occurred on many water reserves which are leased.

Gidgee scrub soils

Thick gidgee scrub carries little or no grazing pasture in its natural state. Extensive areas on the stock routes in the Blackall–Barcaldine–Isisford area have been cleared and established with buffel grass. They can withstand moderate grazing pressure but some poorly planned clearing has resulted in substantial erosion on lighter or sloping soils.

Black spear grass (Heteropogon contortus)

This is the predominant grass of the south-east quarter of the State. It can withstand heavy grazing pressure but is unsuitable for sheep and there is very little use of it by travelling stock.

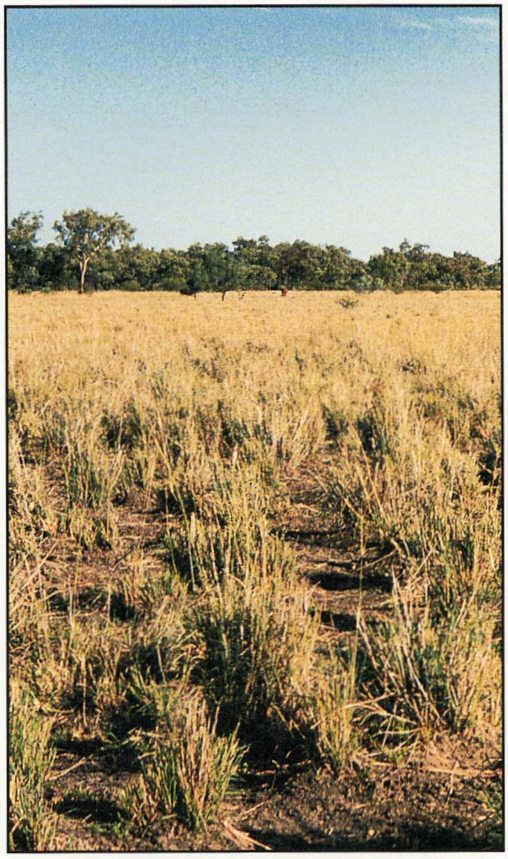


Photo courtesy of Eric Anderson

Mitchell grass pasture, Hughenden

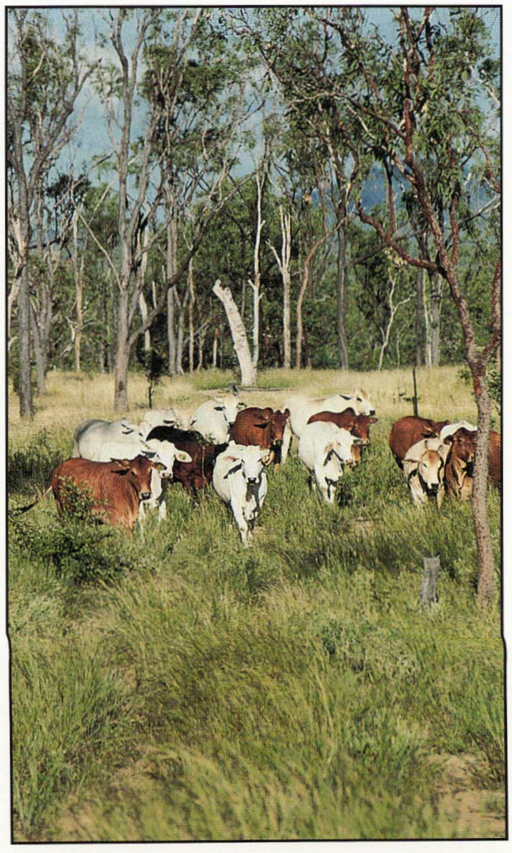


Photo courtesy of Joe Scanlan

Black spear grass pastures

Spear grass–blue grass pastures (Aristida–Bothriochloa)

This is a common pasture of the semi-arid woodlands. The pasture composition is variable. In the north, where grazing is extensive, the pastures are generally in good condition, but in central and southern Queensland grazing has often increased the percentage of spear grass in the pasture. The blue grasses are indicators of good pasture condition.

Sustainable Pasture Management

With the multiple use of stock routes, pasture management is a compromise between fodder conservation and utilisation, road safety, wildfire prevention, aesthetics, and habitat conservation.

With the multiple use of stock routes, pasture management is a compromise between fodder conservation and utilisation, road safety, wildfire prevention, aesthetics, and habitat conservation

Sustainable pasture management is not simply concerned with biomass production. Sustainable management necessitates an understanding of the processes that impact on the quality of the pasture and level of biodiversity. The underlying assumption is that the aim of pasture management is to maintain or improve the productivity of the pasture (as a resource for travelling stock) and to maintain biodiversity (as a national resource).

Guiding Principles for the Ecological and Sustainable Management of Native Pastures on Stock Routes

- Stock route pastures need to be managed.
- Stock movements need to be coordinated between councils.
- Stock routes are spatially different from paddocks and require different management techniques.
- Management must maintain the ecological processes that support the system.
- The negative impacts of the large edge:area ratio need to be managed.
- Perennial pasture species are the basis of the pastoral industry.
- Pasture types and pasture species have multiple uses that reflect their values to the pastoral industry and to biodiversity.
- Utilisation levels must ensure pasture composition and production are maintained in a desirable state.
- Stock route pastures are for short-term grazing.
- Local management guidelines should match local pasture conditions.
- Pasture monitoring is an important tool for making management decisions.
- All management decisions regarding activities on stock routes should not compromise pasture condition.

Managing for drought

The primary function of the stock route network is to provide a reserve of fodder for travelling stock. The issue for pasture management lies in the ability to respond appropriately to drought.

Drought prediction, El Nino and the Southern Oscillation Index

The ability to predict an on-coming drought is improved greatly by studying the Southern Oscillation Index (SOI). The SOI has a strong influence on seasonal rainfall patterns. Drought is often associated with a strongly negative SOI value which is commonly referred to as the El Nino effect.

A typical El Nino event in northern Australia will see the SOI rapidly become strongly negative (lower than −5) in the late autumn and winter, with conditions becoming drier in the spring or summer as the rains fail and/or come late, and conditions persisting at least until the following autumn. A wetter year with greater than average rainfall is probable when the SOI is strongly positive (greater than +5).

Management of pastures involves a level of risk and using the SOI is going to be a personal decision based on attitude to risk. While the SOI is more applicable to the eastern part of the State than the western rangelands, it is a useful indicator for managers to keep an eye on.

The SOI is recorded in the weather reports of most major newspapers and television news broadcasts. Autumn is the time that the SOI and weather patterns usually change, but once the SOI has moved rapidly and strongly in either direction the effect usually persists for about a year.

How to use the SOI for decision making

The SOI can be used to predict pasture production, and to make decisions about the use of the available fodder. This will indirectly assist in the prevention of soil erosion, weed invasion and pasture degradation. When the SOI is greater than +5 there is a good probability for spring and summer pasture growth, but if it is below −5 there is a chance that the season will not be good for pasture growth.

Pasture management and burning

Fire is a major tool in the manipulation of grasslands and woodlands; however, fire management is essential for conservation and pasture production on stock routes. Stock routes needs fire to maintain biodiversity, which includes both native animal and plant species. The frequency of burning, the timing of the burn and the intensity of the fire all impact on the productivity and biodiversity of the pastures. Excessive use of fire in management leads to degradation of the native pastures and remnant vegetation and the destruction of habitat for wildlife.

Native plants in drier parts of the State are well adapted to cycles of burning and will respond to fire, and/or smoke, by producing new growth and increasing germination. Burning clears out dead and dry material, provides ash for the seed bed, stimulates growth of perennial pasture species and promotes a green pick for stock. Conversely it also reduces the vegetative cover and opens the ground up to erosion from both wind and the early summer storms.

Burning pastures at the end of the dry season is a common practice in some pastoral areas; however, recovery depends on the pattern of the follow-up spring/summer rain. Not burning pastures at the end of the dry season when the winter SOI is below −5 will reduce the risk of overgrazing, erosion and pasture degradation later in the year.

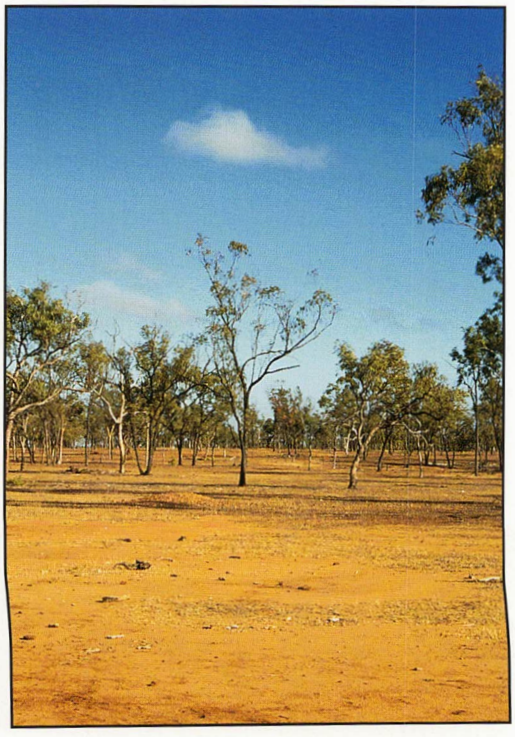


Photo courtesy of Eric Anderson

Drought near Charters Towers

Burning plan

Stock routes and roadside vegetation should not become a safety hazard and a coordinated approach to fire management is required between adjacent landholders, councils and relevant authorities. Each agency will have a different management goal and set of objectives, for example safety and traffic vision, fuel or hazard reduction burns, pasture management burns, weed control burns, firebreaks.

The aim of burning stock route vegetation is different from the paddock situation; what is perceived as important fuel for spreading fire is also valuable for travelling stock and important habitat for fauna. Consequently a joint regional/district management plan, which reflects the needs of all the stakeholders and a common goal, is needed with plenty of lead-in time for consultation, planning and preparation.

Expert advice on the timing of fires to produce either hot or cool burns should be sought from Agronomists of the Department of Primary Industries, Land Protection Officers of Department of Natural Resources, Officers from the Department of Environment and Regional Fire Authorities. The temperature of the fire will dictate its usefulness for woody weed control, pasture production and regeneration of vegetation. It is possible through changed timing and intensity of pasture management burns to encourage different suites of grasses; for example, through certain burning practices (usually in combination with grazing) kangaroo grasslands, *Themeda triandra,* have changed to speargrass pastures, *Heteropogon contortus,* in central Queensland.

The frequency of burning is one of the major issues in management for biodiversity. Annual burns for fuel reduction or firebreaks are too frequent for good pasture management or maintenance of biodiversity. A plan for patch burning at irregular time intervals, using fires of varying intensity, permits the regeneration of species for both pasture production and biodiversity.

Responsible fire management is demonstrated where particular remnant vegetation is considered to be vulnerable to fire damage and the area around it is managed accordingly to protect it from fire. Alternatives can be used such as slashing, grading or ploughing to protect the sensitive areas.

Photo courtesy of Joe Scanlan

Pasture management and spelling

Spelling is a commonly used method of rehabilitation of pastures in the paddock situation. Spelling requires a complete destock for at least one growing season (germination to seeding) on a cycle of 3–4 years. Stock routes should be spelled and access for grazing restricted to maintain the vigour of the pastures. This could be developed as a management strategy for stock routes. A strategic rotation system could be developed to close off some routes, and in some extreme cases of degradation or over-use this may be necessary for several growing seasons.

Pasture monitoring

Monitoring is one of the basic tools for managing a pasture. It encourages you to look more closely at the pasture, and provides a record of management decisions and their results. Monitoring helps to detect gradual changes in condition over the years. Management involves:

- understanding the ecology of the grassland or vegetation community,
- following sound local management guidelines,
- checking (monitoring) the effects of your management on your pastures.

There are several monitoring systems being used by the Queensland Department of Primary Industries including QGRAZE and GRASS Check.

GRASS Check uses photostandard sites to provide estimates of available forage and provides an indication of trends in pasture composition. This tool can readily be incorporated into the monitoring of pastures on stock routes.

QGRAZE is part of the National Rangelands Monitoring Program which is a long-term pasture and soil monitoring research project. This project aims to interpret changes in rangeland pasture condition using data on grazing management, climate, soils, pastures, indicator pasture species and disturbance. This technique is appropriate for regional pasture agronomists.

Monitoring is usually carried out in drier regions at the end of the wet season and again at the end of the dry season. This permits decisions to be made with regard to available forage, utilisation levels and carrying capacity for the coming seasons. Management decisions should reflect the probability of future rain and pasture growth.

Photo courtesy of Eric Anderson

GRASS Check site

Grazing Management

Grazing management aims to maintain pastures in good condition so they have the ability to provide enough fodder for periodic intensive grazing. Native pastures are of most value to grazing animals when the plants are young, green and actively growing. When they begin to flower and seed they quickly become rank and their nutritional value declines rapidly. It is important to understand the characteristics of each pasture type as some make good dry standing feed while others have little value.

Unlike the paddock situation, stock routes are subject to irregular, intensive grazing pressure. The demand for grazing is beyond the control of the Stock Route Supervisor and grazing management requires flexibility in dealing with the unexpected movement of herds/flocks. At times, some stock routes may even need to be closed to prevent overgrazing. Coordination between councils will reduce the number of surprises, the levels of frustration and the degradation of the pastures.

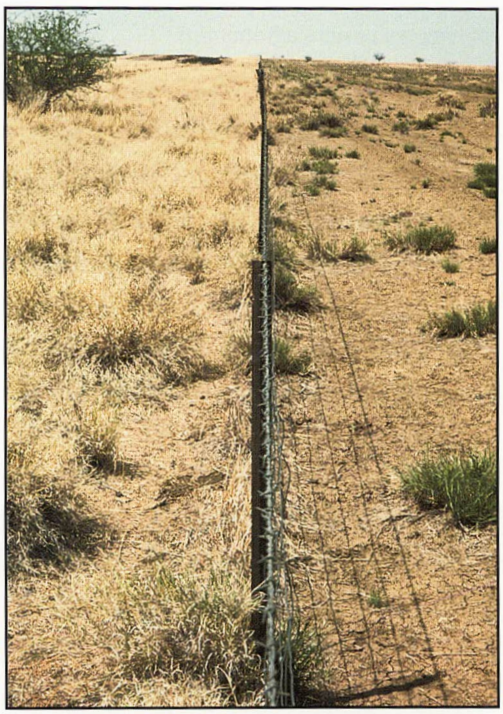


Photo courtesy of Joe Scanlan

Fenceline effect from grazing

Stocking rates and carrying capacity

Stocking rate and carrying capacity are the usual terms used to describe grazing pressure. Carrying capacity is a description of the number of grazing units that an area of a specific pasture type can support over the long term (grazing units are standardised as dry sheep equivalents per hectare or dry 2-year-old cow per hectare). Stocking rate is the pressure applied by the number of animals (head) per unit area and is not specific to a pasture type.

For grazing management on stock routes both concepts are difficult to deal with compared to the paddock situation. Carrying capacities vary along the stock route as the pasture type changes. Stocking rates vary with the type of animal and the age or class of the animal. Carrying capacity is a standard which describes a constant level of pasture utilisation in a continuous grazing system, whereas stocking rates on stock routes are variable and are very high for short periods of time.

Pasture utilisation

A practical tool for stock route managers to use is the level of pasture utilisation. This describes how much of the summer pasture has been eaten, and by subtraction, how much remains. A commonly used guide to sustainable utilisation levels is to use less than 30 per cent of the summer pasture growth. This ensures that most pasture species retain their vigour and reproductive capacity, without compromising their role in other ecological processes, including the ability to carry a fire.

Management Practices Leading to Pasture Degradation

Pasture degradation is intricately linked to other critical processes of land degradation, including soil degradation through fertility loss and increased erosion, and the disruption of hydrological cycles such as through change to ground water table levels, flood patterns and climatic events.

There are four main factors linked to degradation of the stock route resources (Pressland, Mills & Cummins 1988):

- inappropriate vegetation management
- inappropriate stock management
- inappropriate fire management
- inappropriate siting of facilities, developments and encroachments.

Stock route pastures are particularly vulnerable to the activities of the surrounding land uses, to excessive use in their primary role for travelling stock and from intrusion from other land uses on the stock route network itself.

Pasture degradation is not just the loss of the capacity for the pasture to support grazing animals but reflects the change in the ability to support a range of animals and plants, thereby maintaining biodiversity.

Native pastures are made up of many species of annual and perennial grasses, herbs and shrubs

Indicators of Pasture Degradation

- bare soil (poor ground cover, low levels of plant litter and mulch),
- low biomass production compared to potential production (low level of plant vigour, few tillers, small tussocks, few seeds produced, few young plants),
- increased soil erosion as a result of pasture degradation,
- increase in annual and unpalatable plants, increased woody and broad-leaved species,
- decrease or loss of perennial and palatable species.

Grazing and pasture composition

Native pastures are made up of many species of annual and perennial grasses, herbs and shrubs. Depending on the animal species, some plants are more palatable and grazed before other species. Selective grazing of young shrubs and trees can lead to a decline in the pasture condition as successive generations of seedlings are wiped out. Continuous grazing can remove these palatable species from the pasture completely.

Perennial species form the basis of a sustainable pasture. Overgrazing will damage the perennial grass and herb species to the point where they cannot recover. This promotes the invasion of less palatable and weedy species and may change the perennial grassland into an annual grassland.

Total grazing pressure includes feral and native animals.

The degree of grazing pressure also varies between species. A rough and ready guide to the differences in stocking equivalents is:

1 cow = 1 horse = 7 sheep = 7 goats = 10 kangaroos = 100 rabbits.

The preferred diets of these species often overlap, depending on feed availability. Kangaroos eat much the same diet as sheep. Mixed stock can exploit the full range of pasture species but a combination of some grazing species can quickly lead to overgrazing and degradation. Under high grazing pressures, sheep and kangaroos can do more damage than cattle, and goats are worse than sheep. Competition between sheep and rabbits is likely to be most critical in times of drought.

The smaller animals can crop closer to the base of the plant and so survive longer when feed is short and put more pressure on the remaining plants. Rabbits have a similar dietary preference to sheep but can be even more selective. Rabbit grazing is likely to be most significant when the pasture biomass falls below a critical level.

Drought

Most damage to pastures is done when stock numbers have not been reduced early during the drought. The really critical period is immediately after the drought breaks when pastures germinate or regrow. At this stage pastures should not be subject to grazing as utilisation prevents vegetative (leaf) growth and the plant cannot maintain a positive energy balance.

Photo courtesy of Joe Scanlan

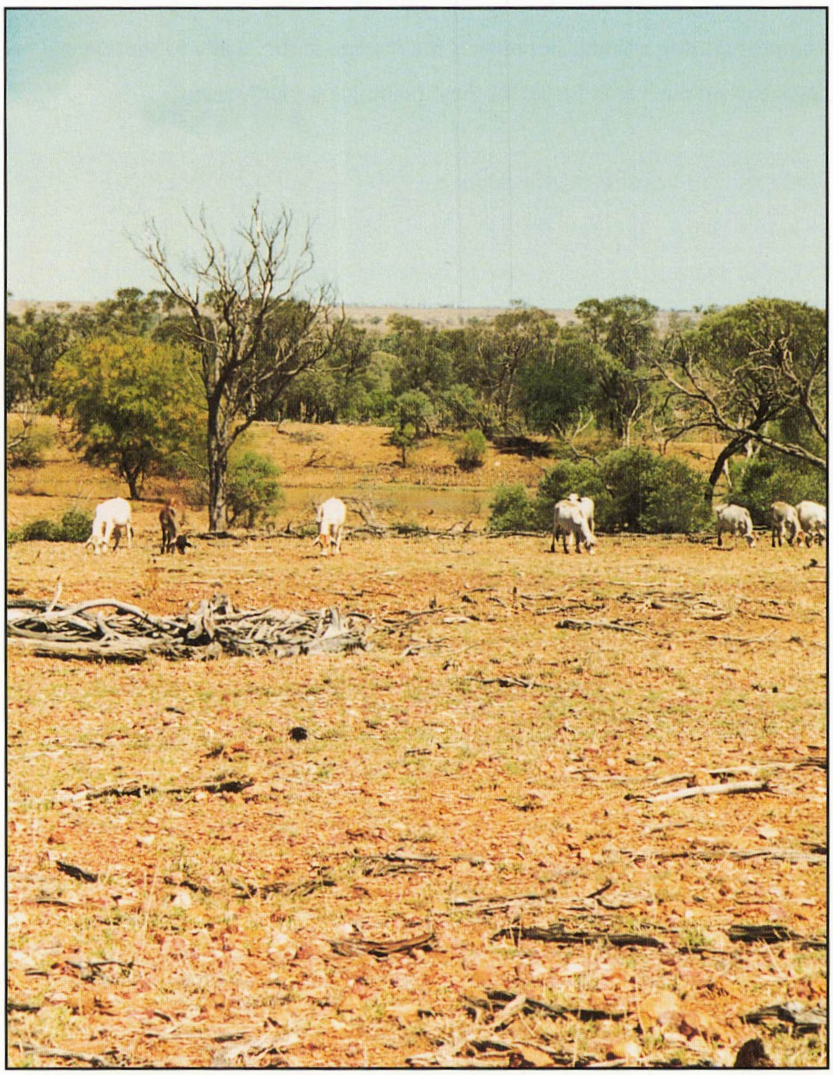


Photo courtesy of Joe Scanlan

Overgrazing

Firebreaks and over use of burning

There is a habit of land managers to put firebreaks in stock routes and road verges. The pasture in the stock routes must be recognised to be as valuable as the pastures in adjoining landholders' paddocks. Firebreaks are burnt very regularly to reduce the fuel load in the vegetation – this is at odds with pasture production on stock routes. Burning should only be done on these narrow corridors with the aim of maintaining productivity of the vegetation.

Firebreaks should be placed outside of the stock routes and not in them as this encroaches on the corridor size and further promotes the degradation of the vegetation by reducing the width.

Fire will generally burn all species but since most native species are well adapted to recovery from fire they are more vulnerable to the lack or indiscriminate use of fire. Too regular burning, burning at the wrong time of the year, or using fires with loads that are too hot or too cool can change the productivity of the pasture and change the pasture species composition. Good advice for particular pasture types are available in the DPI publications by Partridge (see reading list). The reason for the burning needs to be very clear – pasture production, safety etc.

Fire and weed invasions

Weeds often increase in terms of number of species and abundance immediately after a fire, partly at the expense of native flora. The opening up of the canopy and the presence of a seed bank or seed source are important elements of weed invasion.

The invasions are mostly from exotic grasses and woody weeds which continue to change the fire regime (combustibility, timing, intensity) and impact on the conservation value of the corridor.

Pasture management and woody species

The invasion by woody species such as brigalow, gidgee and *Eremophila* spp. is usually a result of degraded pastures and/or poor pasture management. While fire often promotes the growth of woody weeds, often they can also be controlled by burning. Successful burning requires a hot fire with adequate fuel and this may require closing the stock route to build up the fuel load. Woody weeds should not be permitted to grow to a stage where they suppress pasture species or can withstand fire.

Photo courtesy of Eric Anderson

Burnt woodland pastures

Photo courtesy of Joe Scanlan

Pasture regrowth after fire

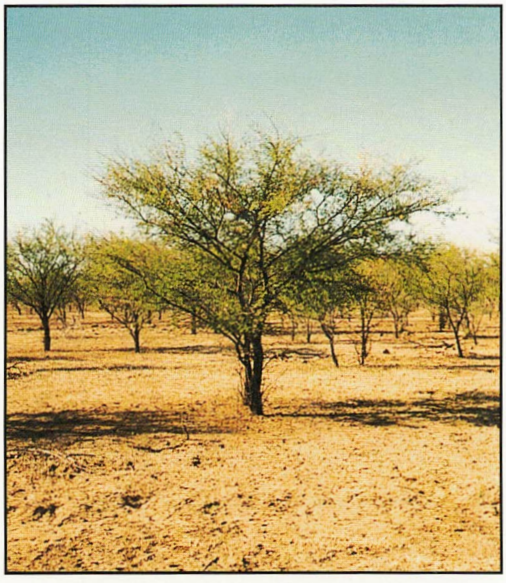


Photo courtesy of Elton Miller

Woody weed invasion (prickly acacia)

Tree clearing

At times it may be necessary to remove woody vegetation from stock routes and reserves in order to improve droving safety, to gain access to facilities, to protect facilities and to minimise the fire risk. Clearing immediately reduces the biodiversity and opens the area up to other land degradation processes including erosion and weed invasion.

All vegetation on stock routes, even if it is fallen or dead, is classified as forest product and covered under the Forestry Act; however, various pieces of legislation apply to tree clearing; the Nature Conservation Act applies to rare and threatened species and habitats; the *Water Resources Act* (Qld) applies to tree clearing in beds and banks of water courses; there are also relevant provisions under the Forestry Act and by provisions under the Land Act.

Clearing on stock routes cannot be authorised under the Rural Lands Protection Act but may be permitted under the Land Act. Applications for tree clearing under the Land Act will be assessed in relation to Local Tree Clearing Guidelines (proposed under Part 6, Chapter 5). For State roads, the Department of Main Roads may clear or remove trees under the Transport Infrastructure Act and local governments may also clear trees for road construction under s. 497 of the Local Government Act.

Road construction activity

The impact of road development on native pastures and other vegetation types ranges from complete irreversible destruction to minor reparable damage. Of particular concern is the widening and upgrading of roads to State-wide safety standards, the realignment of roads and the manner in which these developments take place.

Large and heavy machinery such as bulldozers and graders can disrupt the existing soil profile and destroy surrounding vegetation. Appropriate sized machines should undertake the work to minimise the impact on soil and vegetation. Planning of work programs will enable machinery to operate from the formed road pavement or a cleared area and to turn and park in places which prevent the damage or removal of any vegetation.

Without adequate design considerations, roads and road verges cause considerable erosion, loss of biodiversity and loss of habitat – all significant components of pasture degradation. The channelling of excess runoff and the opposite, water-starvation, are often results of road works. Vegetation responds to the change in water regimes through a change in the species composition and/or their productivity.

The siting of roads in the centre of the stock route creates a safety issue in itself. Roads are best located to the side of a stock route to improve safety and to assist in maintaining the pasture productivity through reducing the edge:area effect discussed in the previous chapter.

Road construction machinery and materials have also been known to introduce weed species to stock routes. Weeds reduce the integrity of the native pasture and can even require quarantine action to restrict their spread further along the stock routes.

Overgrazing of areas held under Permit to Occupy

It is an offence under the Land Act to overgraze areas held under Permit to Occupy. This occurs frequently because the landholder is prepared to sacrifice the stock route to take grazing pressure off his own country. This does not only occur during drought periods and is to the detriment of both the pasture and travelling stock. Monitoring the grazing pressure and level of utilisation by both the permittee and the Stock Route Supervisor is essential before and during the period of the permit.

Areas prone to degradation

Stock routes cross over all types of land systems, land units and pasture types. Some of these are more vulnerable to degradation than others, particularly from the action of grazing (defoliation) and the action of hard hooves (soil compaction and loss of soil structure).

Grazing pressure must not exceed the carrying capacity of the pasture type. Since the carrying capacity varies throughout the length of the stock route, Stock Route Supervisors and drovers must be particularly aware of the timing and movement of stock and the condition of the most vulnerable pasture types.

A good example is where the stock route follows a watercourse; the close

association of the better quality river frontage pastures and permanent or semi-permanent water means these areas will be over-utilised even at low stocking rates.

Best Practice Pasture Management for Stock Routes

- Learn to recognise the pasture types and the value of individual species.
- Learn to understand the characteristics of the pastures and their responses to grazing.
- Burning should be done on a management needs basis rather than as a regular annual event.
- Burning should be done to a regional or district plan that includes and recognises the multiple uses and values of stock routes.
- Prevent or delay stocking/grazing too soon after a fire, flood or drought.
- Be aware of climate predictions and do not burn if a dry season is predicted.
- Be prepared to close and/or spell stock routes to maintain long-term stability and productivity. Regularly allow pasture species to seed and germinate.
- Avoid any activity that results in further fragmentation of the remnant vegetation within the stock route and adjacent to the stock route.
- Do not reduce the width of the stock route with fencelines, roads, firebreaks or other encroachments.
- Place facilities such as wayside stops and camping areas outside of the stock route.
- Do not clear vegetation on stock routes unless essential.
- Avoid complete or partial clearing of vegetation wherever possible.
- Fence out important areas and protect sensitive areas.
- Avoid activities and practices that cause soil erosion.
- Establish a regular and effective monitoring network across pasture types.
- Monitor to assess quality and quantity of pasture.
- Monitor for indicators of change and for degradation.
- Monitor pastures to balance the grazing pressure with the available seasonal forage. Generally, do not graze more than 30 per cent of summer pasture production.
- Monitor and police grazing pressure on Permits to Occupy.
- Account for total grazing pressure, including feral and native animal species.
- Include weed hygiene for users of stock routes in pest management plans.
- Contain/control/eradicate weed species.

Photo courtesy of Joe Scanlan

Soil erosion

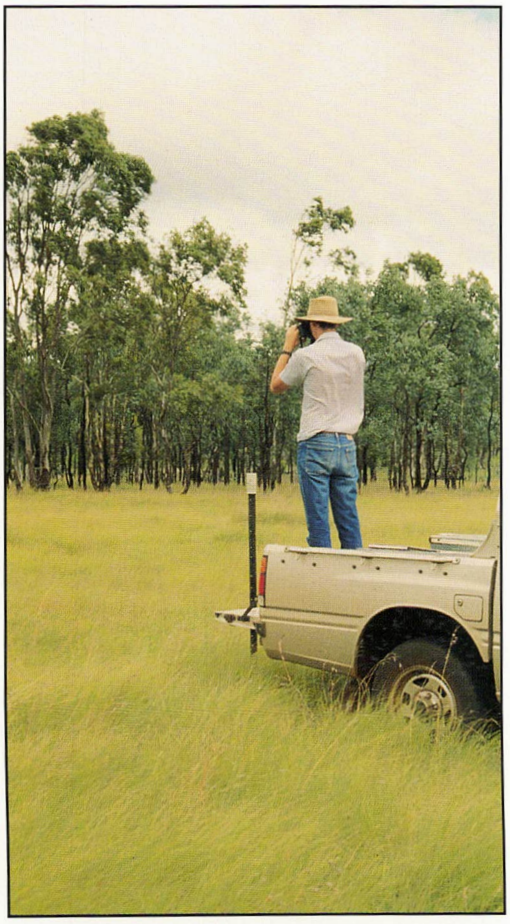
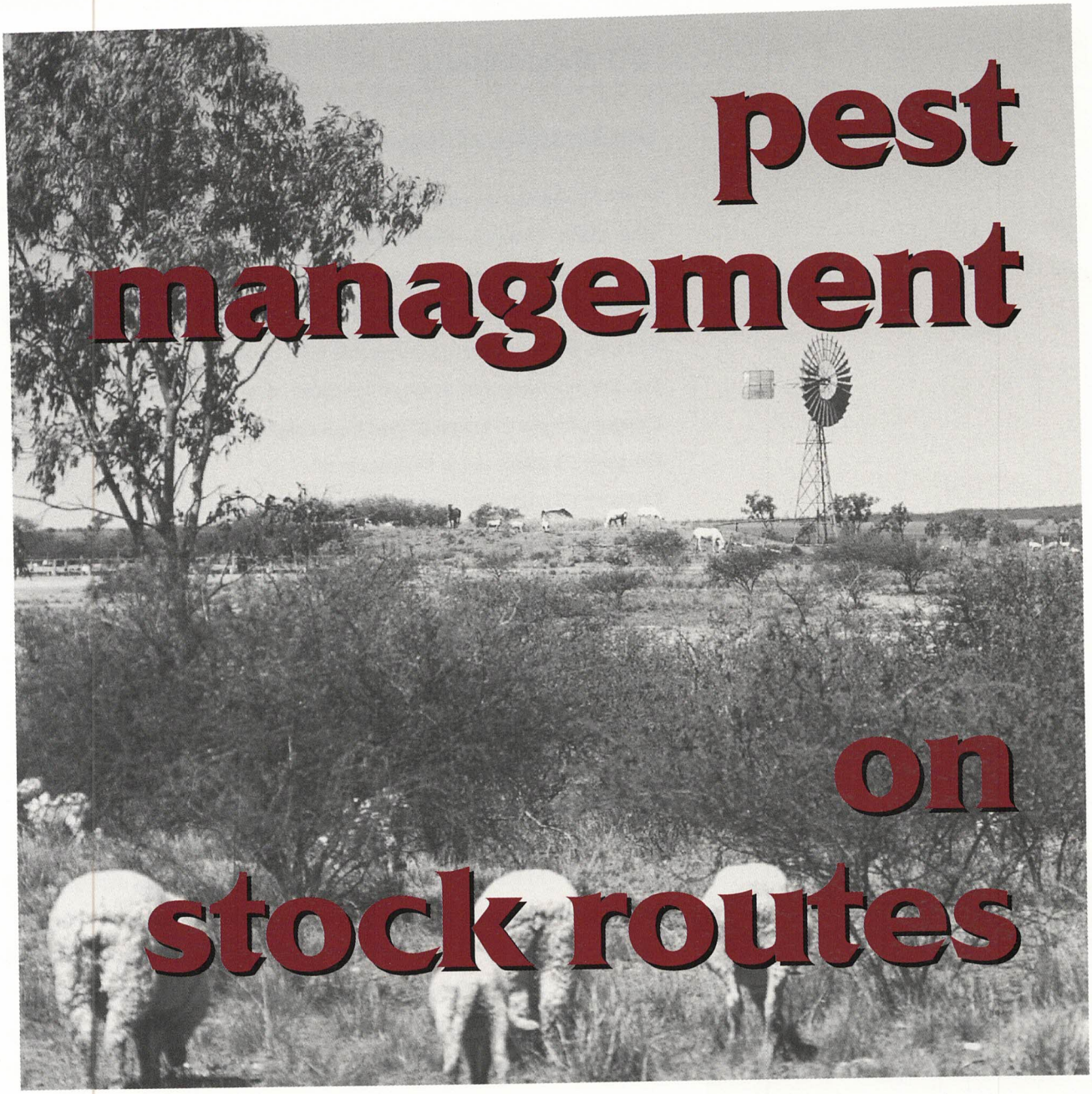


Photo courtesy of Eric Anderson

Pasture monitoring



pest management on stock routes

CHAPTER FOUR

4.1 Pest Plants

Declaration of Weeds

A weed is defined as a plant growing in the wrong place and competing with other plants for water, nutrients and light. A declared pest plant is one which has, or could have, serious economic, environmental or social impacts and is declared in Queensland under the Rural Lands Protection Act. All the current declared plants are species introduced from overseas. They are listed under five different categories which reflect their required level of control:

Category P1 plants are prohibited from entering Queensland.

Category P2 plants are to be destroyed.

Category P3 plants are to have their numbers reduced.

Category P4 plants are to be prevented from spreading.

Category P5 plants should be controlled on land under the control of a Government department or local government.

Local councils also have by-laws for the declaration of individual pest plants that may impact on their shire.

There are also many species of pest plants that are not declared. These include environmental weeds and agricultural weeds. Environmental weeds are important to the stock route network because they are capable of invading native vegetation and are a major threat to the conservation of remnant vegetation. There are also some native plants that may be considered a threat to agriculture; however, on roadsides and other public lands they provide important habitat for wildlife. Conversely, some desirable agricultural species, such as Seca stylo, may be considered environmental weeds on roadsides.

Parthenium weed

Pest Plant Management

Responsibility for control

Control of declared plants is the legal responsibility of the landholder, which includes Federal and State government departments. Local government has been charged with the responsibility of controlling declared pest plants on stock routes.

Control of non-declared environmental and agricultural weeds is a management decision left to individual land managers.

The process of weed invasion begins with activities that create the conditions for weed invasion, followed by the introduction of viable reproductive plant material and the subsequent establishment of a self-sustaining population. Many of the activities that promote weed invasion are active on and around stock routes. Management of the stock routes is about reducing these impacts (see 3.2).

Management goals

The goals for weed management on stock routes are to:

- prevent the introduction of new pest plants,
- prevent the establishment of new pest plants in Queensland,
- prevent the spread of established pest plants into new areas,
- prevent the continuation of the degradation process,
- promote the rehabilitation of degraded vegetation.

The most successful way to achieve weed control is by preventing weed introduction, reducing activities which aid weed establishment and by strategic management of existing infestations.

Strategic management of existing weed infestations

- Treat small outbreaks and isolated patches first.
- Isolate the major infestation and work towards the centre or downstream.
- Spray dense patches to clean them up in one go.
- Undertake a revegetation program with desirable native species to prevent other weeds invading the site (depending on the rate of regeneration, supplementary planting may be required).
- Monitor and use follow-up control and revegetation treatments as required.
- Develop weed-free buffer zones.
- Control frequent burning.
- Control feral animals, particularly rabbits.

Weed identification

Experienced land managers are usually able to identify the declared pest plants and many other weedy species. Drovers are also in an excellent position to report the introduction of new weed species and the spread of existing weeds. Indicators of the arrival of a new weedy species are:

- the appearance of clumps of new or unusual species and species that do not normally grow in the local native pastures,
- species that seem be associated with some sort of human disturbance such as campsites or road works etc.,
- species that have undesirable characteristics such as burrs, toxicity, or are unpalatable to stock,
- species that appear to be spreading along the stock route or from adjacent landholdings.

Photo courtesy of Elton Miller

Rubber vine

Weed species can be presented for identification to Land Protection Officers of the Department of Natural Resources.

Pest plants of the stock routes

The declared weed species of importance on stock routes are: parthenium weed, prickly acacia, parkinsonia, mesquite, rubber vine, saffron thistle and the burrs (noogoora burr, bathurst burr).

Other weeds, such as calotrope, are potential colonisers of stock routes in the north-west areas of the State, while grader grass and the wild sorghums have potential in other areas.

A basic distribution of where major weed species occur on stock routes is as follows (Akers 1992):

Prickly acacia and parkinsonia

Shires of Aramac, Barcaldine, Flinders, Isisford, Longreach, Quilpie, Richmond, Winton.

Mesquite

Shires of Barcoo, Boulia, Cloncurry, Diamantina, Mt Isa, Paroo, Quilpie.

Parthenium weed

Shires in the Central Highlands and Arcadia Valley. Isolated plants occur on roadsides in the Aramac, Balonne, Barcaldine, Booringa, Blackall, Bungil, Murweh, Paroo, Surat and Tambo Shires.

Mother of millions

These toxic plants can be found in almost any area of the State, particularly on reserves and around old settlements.

Rubber vine

This plant is common on water reserves and a problem on stock routes in the central and northern part of the State.

Photo courtesy of Elton Miller

Noogoora burr

Pods of prickly acacia

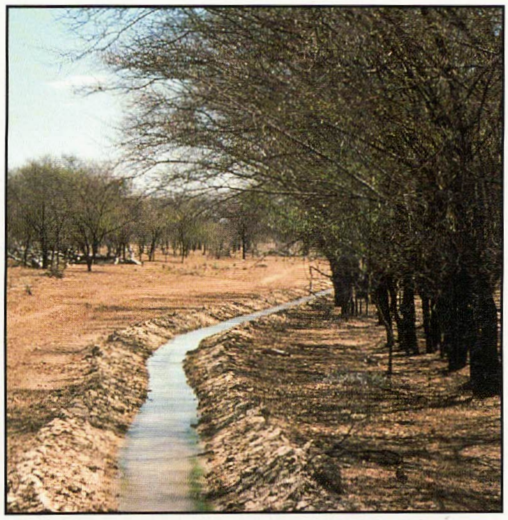
Grader grass

This mainly occurs east of the coastal ranges. Roadsides become heavily colonised and adjoining private land may become affected.

Wild sorghums

These species are not a problem in terms of land degradation, but their presence in the grain growing areas of the Central Highlands, the Dawson and Callide Valleys and the North Burnett is a contentious issue because they act as a refuge for Sorghum Midge.

Weed control programs require accurate weed identification and a good understanding of the biology of the weed and the way it impacts on the local environment. Priority control areas and areas of high conservation can be identified and targeted once the distribution of the weed is known. Specific weed control advice is available from the local Land Protection Officer, Department of Natural Resources.



Prickly acacia along open bore drain

Weed control programs require accurate weed identification and a good understanding of the biology of the weed and the way it impacts on the local environment

Weed Control Techniques

Mechanical Weed Control

When vegetation is removed from roads and stock routes the resulting bare earth will be colonised by:

- the original vegetation if the site is surrounded by bushland, or
- weeds and/or exotic plants.

Physical removal

In sites of massive weed invasion, such as by lantana or rubber vine, bulldozers, graders and other large equipment may need to be used. Machinery should be used with care to ensure that soil disturbance does not promote or encourage further weed invasion.

Burning and fire plans

Fire may be a successful management tool for controlling some weed species. Contact the Department of Natural Resources for advice when considering this method for control of weeds.

Extreme care must be taken using fire on stock routes to ensure adequate protection of life and property on adjoining landholdings. Involving the Rural Fire Brigade when undertaking burning for weed control may provide brigade members with an opportunity to practice fire control procedures.

Mechanical weed control

Strategic and appropriate use of herbicides can assist in the control of weeds and the conservation of remnant vegetation

Investigate the practicality of coordinating weed control and fire management burns to achieve compatible outcomes with all stakeholders as part of a district burning plan.

Careful monitoring and follow-up control may be required to prevent reinfestation.

Chemical Weed Control

Strategic and appropriate use of herbicides can assist in the control of weeds and the conservation of remnant vegetation. Where native vegetation is growing it may be possible to use a selective herbicide which will control larger broad-leafed plants, allowing native grasses to survive.

Reminder

While there is a responsibility to control pests there is also a responsibility to protect the environment, and this includes neighbouring properties and the catchment. The use of chemicals must always be carried out with the knowledge and consent of the landholder in question and the adjacent landholders should be advised. Only trained or qualified personnel should undertake spraying operations.

The spraying of weeds along a stock route, or road side, could affect the status of an adjacent organic crop, or livestock enterprise. Chemical-free agriculture requires other farmers, producers and land managers to be aware of their requirements for a clean production environment.

Principles for use of herbicides

When using herbicides always use best practice techniques:

- Spray when there is no wind to avoid drift.
- Use the correct equipment.
- Avoid overspray of non-target species, especially native vegetation.
- Use equipment in a manner that prevents damage to vegetation and wildlife habitat.
- Employ qualified agents or train staff in the appropriate use and application of herbicides.
- Use the correct herbicide for the job and only use at the recommended rates.
- Train all staff in the health and safety aspects of using chemicals.

Hygiene for Animals and Vehicles Travelling the Stock Route Network

Everything that travels along a stock route is a potential agent for spreading weeds. Practising common sense hygiene principles will reduce that potential and limit the spread of weeds.

Operator hygiene

- Obtain access to vehicle cleaning sites and wash-down bays and use them.
- Ensure that all machinery, implements and equipment entering and leaving the stock route are cleaned and that all seeds, mud and plant particles are removed.
- Begin the day with clean machinery and work from high conservation areas to infected or weedy areas.
- Use only soil, sand, gravel, stone or other material which is free from weed material, or comes from clean areas where there are no declared weeds.
- Locate stock piles and dump sites in weed-free areas.
- Instruct all employees in work practices that will prevent the spread of weeds and minimise disturbance to soils and native vegetation.
- Identify work zones where rigorous hygiene measures may be necessary to control the further spread of weeds.

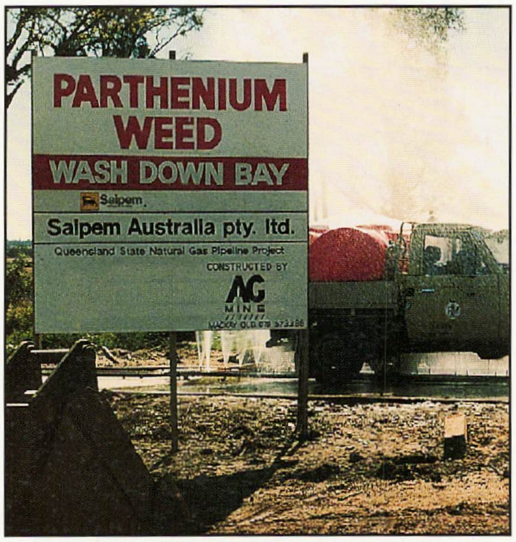


Photo courtesy of David Akers

Vehicles and machinery

- Include a clause in all contracts that all vehicles and machinery arriving on site have been certified as having been cleaned for weed contaminants.
- Clean all vehicles of weed seeds, mud or plant particles before leaving weedy country and entering roads, stock routes or other property.
- Clean vehicles with high pressure water or air hoses. Crop harvesters are particularly difficult to clean and should be cleaned using high pressure air not water.
- Contain the contaminated run-off in the designated cleaning area, such as council wash-down areas, car washes, or other approved wash areas.
- Vehicle wash-down waters are a regulated waste under the *Environmental Protection Act 1994* (Qld). A licence for the disposal of regulated waste is required from the Department of Environment. They also can advise on acceptable designs and guidelines for wash-down facilities and oil and water separators.

Droving stock

- On-property hygiene is particularly important to prevent the spread of weeds from infested areas to clean areas.
- Hold stock in a yard for several days before they leave the property and enter the stock route network and again when they return from the stock route. This is to ensure any hard weed seeds, such as prickly acacia, have passed through the digestive tract, or burrs have dropped off. It is much easier to control the confined infestations which might result.
- Hold stock during wet periods as seeds are readily transported in mud.

4.2 Pest Animals

Declaration of Pest Animals

There are a number of animals that have been deliberately introduced to Australia and are now serious pests. These animals represent a threat to agriculture and the environment and should be controlled.

All non-native Queensland mammal and reptile species are declared pest species under the Rural Lands Protection Act (this does not include most domestic species).

Animals declared as pest species are required to be controlled, but the standard of control varies with the category of declaration:

There are a number of animals that have been deliberately introduced to Australia and are now serious pests

Category of control:

A1 introduction of these animals is prohibited

A2 non-native animals that must be destroyed

A3 keeping and selling is prohibited

A4 introduction subject to prescribed conditions and restrictions

A5 numbers to be reduced and kept under restriction

A6 keeping and selling subject to prescribed conditions and restrictions

A7 native animals that require a management program

A8 plague species (locusts only)

Pest Animals on the Stock Routes

Management of pest animals varies in accordance with the category of declaration, their distribution and their level of impact. The following animals are categorised according to the types of control required:

Dingoes/wild dogs	A1, A3, A5
Rabbits	A1, A2, A3
Feral pig	A1, A2, A6
Fox	A1, A2, A3
Cats and mice	are not declared species

Rabbits

The introduced European rabbit is one of the most widely distributed mammals in Australia. They range from the coastal lowlands to the southern alpine region and arid zone of the interior. In general their range is fragmented north of the Tropic of Capricorn where the food supply is nutritionally inadequate and not synchronised with their breeding cycle.

Rabbits are a major economic and environmental problem Australia-wide. Estimates of the cost of lost production run into hundreds of millions of dollars for the Australian wool industry alone. In Queensland the most significant ecological damage produced by rabbits is in association with the sheep grazing of the semi-arid regions.

Soil erosion

The construction of warrens and associated intensive grazing pressure create large areas of bare and disturbed soil that are prone to erosion. There are considerable historical records of the impact of rabbits on soil, including soil erosion, the siltation of dams and the loss of soil fertility (Williams et al. 1995).

Impact on native plant species

The regeneration of shrublands and woodlands is prevented by rabbits as they eat or ringbark seedlings and juvenile plants. This is of particular concern in the rangelands where many of the long-lived species, such as mulga, are dying from old age without any new recruitment.

Native pastures and carrying capacity

Rabbits have a dramatic effect on the quality and quantity of native pasture. The most nutritious species are selectively grazed and in times of drought the entire pasture may be consumed. Combined soil disturbance, increased soil fertility and increased grazing pressure result in a change from perennial pasture species to weedy unpalatable or annual species. Competition for grazing between stock and rabbits is greatest during and after drought.

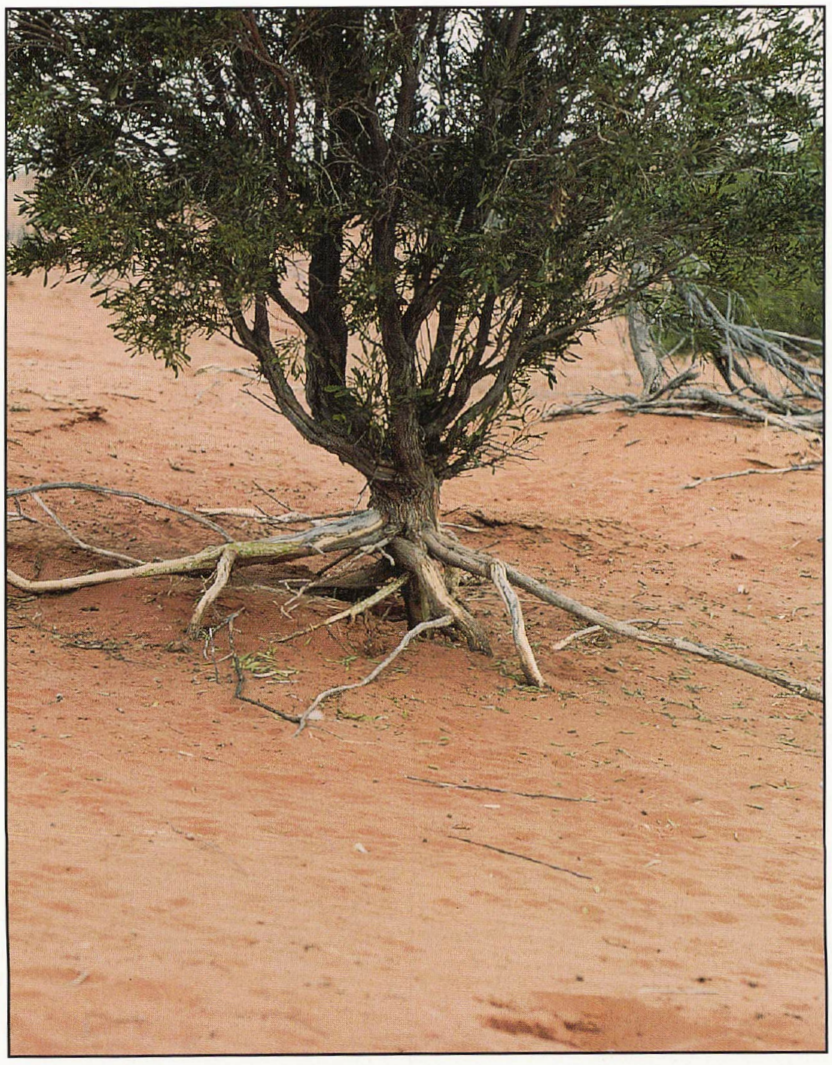
Impact on fauna

While there is considerable documentation of rabbit impacts on whole ecosystems and native flora it is difficult to assess the impact of rabbits on the native fauna. They displace other herbivorous animals through vigorous competition for food and burrow space and form a primary component of the diet of cats, birds of prey and foxes. The activity of rabbits in some drought refuges has been implicated in the decline of some native species.

When rabbit numbers are reduced it is possible that predators will change their food species to include a greater number and range of native species. This is most likely to occur when rabbit populations crash, such as in a disease outbreak or following a drought.

Integrated control

Rabbit control should be accompanied by a complementary program for the control of feral cat, wild dog and fox populations.



Rabbit damage

Feral Pigs

Feral pigs are distributed across a wide range of habitats in Queensland with highest densities found in the larger drainage basins and swamp areas. The criteria for pig habitat are protective cover from environmental extremes and a reliable supply of food and water. The home range of pigs is mostly determined by food supply but also population density. Group sizes vary with season but herds of 400 pigs have been recorded on Cape York (Department of Lands 1996a). A good supply of protein is essential for successful breeding and given the right conditions populations may increase by 500 per cent in a single year.

Habitat degradation

Rooting action is the most obvious sign of pig damage. This can be extensive across grasslands, in forest litter, around swamps and along rivers. It most commonly occurs after rain when the ground is soft, and is generally associated with sites modified by people, such as alongside roads or tracks. Regeneration can be slow and the sites are vulnerable to other pest plant and animal impacts.

Soil erosion

Rooting can lead to erosion, the silting of rivers and the loss of native plants.

Feral pigs

Impact on native flora and fauna

Pigs will eat almost anything. They have a strong preference for succulent green vegetation and a wide variety of animal material. A significant problem is damage caused to rare and endangered flora and fauna species and to particular species such as earthworms, that play important roles in maintaining environmental processes.

Damage to pastures and spread of weeds

Through their rooting habits and dietary preferences, feral pigs can degrade pastures. Rooting decreases green feed and standing dry matter and increases the presence of weed species. Pigs are also vectors for dispersal and distribution of some weed species.

Damage to fences and watering facilities

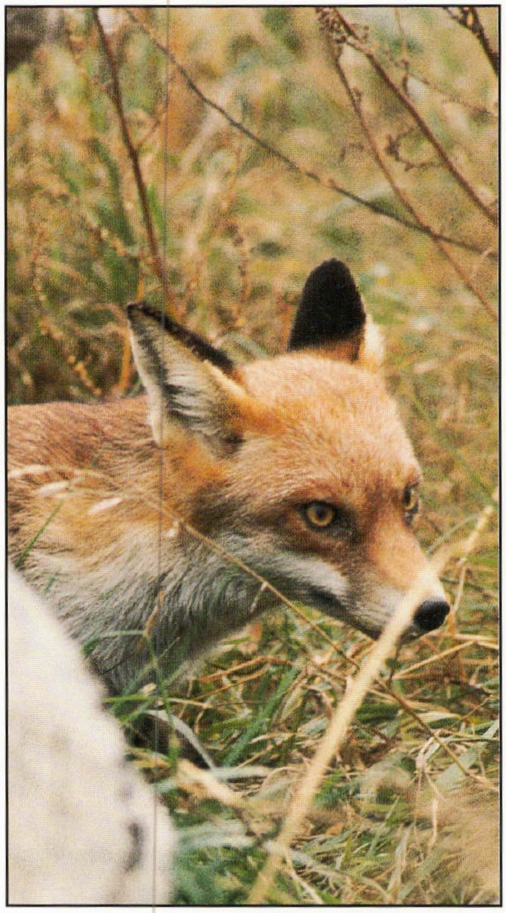
Run-off from overflowing bores or troughs encourages pigs to frequent water facilities. They will wallow in turkey nest dams, foul the water and erode the banks. Fencing of these areas is very difficult as pigs will easily break through most fences. Land Protection Officers will provide advice on regulations governing baiting control programs centred around water facilities.

Health risk

If foot and mouth disease entered Australia, populations of feral pigs are a likely agent for its transmission and spread. They are also carriers of a wide range of parasites and diseases that affect the health of domestic stock.

Control strategies

Broad-scale feral pig eradication is not a feasible goal though control may be possible at the local level. Follow-up monitoring is essential.



Fox

Bilby, prey to fox and feral cat

Photo courtesy of Department of Environment, Brisbane

Foxes

Foxes are the second largest land dwelling, carnivorous mammal in mainland Australia and most native species probably do not have any strategies to avoid fox predation.

Foxes are distributed throughout southern Queensland in a pattern that is similar to that of rabbits. They inhabit a wide range of environments including urban areas and the arid and semi-arid rangelands. They do not inhabit the tropical regions.

Foxes are most common in fragmented landscapes such as in agricultural areas where there is a variety of habitats for them to breed, forage and shelter in. Vegetated stock routes provide ideal habitat for foxes.

Impact on native fauna

Foxes have no particular dietary preferences and are opportunistic predators or scavengers. The most common food items are sheep carrion, house mice and rabbits.

Foxes also eat a wide range of native fauna including invertebrates such as worms, beetles and grasshoppers. They are causing a decline in native animals through impacting on ground-dwelling native animals and the seasonal predation of birds and reptiles. Some native mammals found in Queensland that are vulnerable to fox predation (Saunders et al. 1995) include:

- Bilby, *Macrotis lagotis*
- Black-footed Wallaby, *Petrogale lateralis*
- Kowari, *Dasyuroides byrnei*
- Spectacled hare wallaby, *Lagorchestes conspicillatus*
- Yellow footed rock wallaby, *Petrogale xanthopus*
- Plains rat, *Pseudomys australis*

Spread of weeds

Foxes also eat fruits and berries and may be responsible for the dispersal of some weed species.

Health risk

Rabies is not present in Australia, but if ever it was introduced, foxes would provide a reservoir and vector of the disease that would make it extremely difficult to eradicate.

Control strategies

The impact of a fox-only control program is likely to favour other predators of native animals, so an integrated control program linked to feral cat, wild dog and rabbit management is necessary.

Dingoes/Wild Dogs

The dingo is a declared species and is Australia's largest carnivorous mammal. The dingo population increased with the expansion of the grazing industry but there has always been diverse opinion on the impact of predation by dingoes.

Impact on fauna

Kangaroos and wallabies form a major component of the dingo diet, but dingoes are opportunistic predators and will also attack sheep.

Control strategies

Dingoes/wild dogs exist in all parts of the State except for a few isolated areas. For cattle producers, the level of dingo control is more a matter of personal choice, but for sheep producers, dingo eradication and maintenance of dingo-free areas are the usual control strategies. Coordinated baiting programs by landholders at appropriate times can provide this level of local protection.

Feral Cats

Along with rabbits, feral cats rate as one of the most successful widespread feral introductions to Australia. The classification of whether a cat is feral or domestic is not an issue when it comes to predation on native animals; all cats are hunters and all cats have potential to become feral.

Impact on native fauna

Cats represent a major conservation issue for all regions of Australia. They prey directly on native wildlife, compete with native animals for food resources, displace them from their habitats, spread diseases and parasites and disrupt the functioning of the wildlife community.

Cats hunt and kill animals up to their own size; at least 186 species of birds, 64 species of mammals, 87 species of reptiles, 10 species of

Dingo

frogs and numerous invertebrates are known to be hunted by feral cats (Anon 1994b). In Queensland there are estimated to be 1–1.5 million feral cats and if each conservatively eats 1,000 native animals per year that equates to 1,000–1,500 million animals each year (Endangered Species Unit 1994).

Cats are particularly damaging to animal populations in isolated and remnant vegetation areas, such as stock routes. As with islands, where introduced cats devastate native fauna to the point of extinction, these remnants represent a "captured meal ticket" for cats. Many native animals are restricted to the cover and protection afforded by the remnant vegetation and once this habitat is disturbed or invaded by feral cats the native population tends to decline.

The Endangered Species Program of Environment Australia recognises cats as a significant threat to endangered species and also to programs designed for the reintroduction of native species. In the Diamantina in 1992, a rapidly expanding cat population was threatening the large population of bilbies as the cat's food source declined (Dickman 1996). On a lesser scale, an isolated colony of Allied Rock Wallabies was threatened by a single feral cat in north Queensland (Dickman 1996).

Areas with high conservation value species

The Channel country has been identified as an area with eight species that are at high risk from cat predation (Dickman 1996). The gibber plains and the sand ridges contain the highest numbers of susceptible species. Two of these species are endangered: the Julia Creek dunnart, *Sminthopsis douglasi*, and the kowari, *Dasyuroides byrnei*. All eight of the susceptible species now occupy significantly reduced ranges and have unstable populations.

Photo courtesy of John Cross

Feral cat

Health risks

Feral cats spread sarcosporidiosis which causes cysts in sheep and results in carcass trimming or downgrading. They also spread toxoplasmosis which is a major health risk, causing birth defects in humans and particularly blindness in marsupials.

Control issues

There are no registered pesticides available for feral cat control. The feral cat population is very widespread and there are no feasible control methods yet available.

Mice

The mouse species that causes plagues in Queensland is the house mouse, *Mus domesticus*. This is an exotic species that was introduced with European settlement and has the ability to multiply quickly and to colonise most types of environments. Mice are not a declared animal. The most useful strategy is preventative action, based on monitoring mouse populations to predict plagues and then baiting at appropriate times to pre-empt the plagues.

Habitat

Mice thrive on cracking soils and in light soils where it is easy to burrow. Refuges are provided by sand hills and logs which are not subject to flooding

Photo courtesy of John Cross

Plague locusts

Plague locusts are a unique pest problem because of their high degree of mobility and capacity to cause extensive crop and pasture damage

and from which they can spread out into new territories when conditions are right. Stock routes passing through these areas can act as a refuge.

Factors leading to a plague

Plagues are most likely to occur in grain-growing areas following a set of climatic conditions that support successful breeding. If a wet spring and summer follow good autumn rains then it is likely that a plague will develop in 12–18 months. The early seeding of grasses in late winter can promote the onset of breeding.

The complete cycle of a mouse plague runs for about two years but usually the high numbers persist for about six months before the population crashes. The crashes, which can occur rapidly, are associated with a number of factors including social stress, disease, predation, climate and declining food supply.

On-farm management

For stock routes, control measures are not readily available. No baiting should be conducted in and around bush areas because of risks to other wildlife populations. Grain-growing properties bordering the stock routes need to make their properties less favourable to mice as well as baiting where appropriate.

Plague Locusts

Plague locusts are a unique pest problem because of their high degree of mobility and capacity to cause extensive crop and pasture damage. There are four locust species considered to be economic pests in Australia: the spur-throated locust, the Australian plague locust, the migratory locust and the yellow-winged locust, all of which can swarm hundreds of kilometres in a night.

Plague conditions

Locusts need green grass for the success of each generation and move on weather fronts that are associated with rainfall. Plague conditions develop when rain is widespread and the majority of the population successfully breeds for several successive seasons. Populations can build up very quickly to the point that bands of hoppers (nymphs) up to five kilometres long and dense enough to be seen by low-flying aircraft are not uncommon.

Impact

Crops are vulnerable to severe defoliation and yield reductions from both hopper and adult locusts. High-density swarms (containing greater than 50 adult locusts per square metre) can eat about 30 tonnes of vegetation per day.

Control

Chemical control is undertaken for short-term crop protection and for strategic prevention of breeding and/or migration of swarms.

Control issues

Control of a swarm of adult locusts is particularly difficult for the landholder as they can invade clean areas, lay eggs and move on all in a few days. Crops and pastures can be continually invaded by new swarms from other areas.

There are important control issues for stock routes and adjacent landholders:

- Phytotoxicity – plants vary in their susceptiblity to insecticides.
- Withholding periods – grazing of pastures and harvesting of crops may be restricted for a time period following spraying. For stock routes this may delay or restrict the use of the route for up to a week depending on the chemical used.
- Bees and other insects – bees are susceptible to insecticides as are native insect species and beneficial insect species.
- Poisoning – operators should be aware of the potential for poisoning and use only registered insecticides in the prescribed manner.

High-density swarms can eat about 30 tonnes of vegetation per day

Conservation issues

Many insect species are now only found in the remnant vegetation of stock routes and other road-side reserves. Control techniques aimed at locusts are likely to impact severely on the local populations of these species and on other levels of the food chain within the treated area.

Responsibility for management

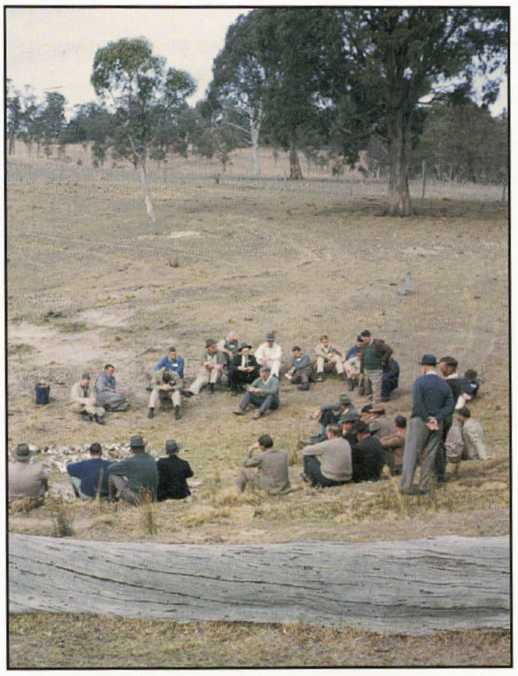
Locust control in Queensland is primarily the responsibility of landholders. Under the Rural Lands Protection Act it is possible for local governments to establish Locust Committees which can enforce control by landholders. The Department of Natural Resources can assist with locust population monitoring, strategic aerial spraying and the provision of machinery and advice on control techniques. A geographic positioning system will make it easier to record the position of swarms for reporting to Land Protection Officers. The Australian Plague Locust Commission will become involved where the locusts represent an interstate threat, but landholders can assist in the coordination by reporting all sightings to their local authorities.

4.3 Pest Control: Management Principles

Stock routes can harbour pest species that will impact on local biodiversity, the function of the stock route or the productive capacity of adjacent land. The most effective way to control pests is through prevention and it is important that the use of the stock route network does not encourage or facilitate the spread of pests onto clean country.

Stock routes, roads and other small, associated reserves are particularly vulnerable to invasion by pest plants and animals. The narrow and accessible shape of the stock routes and their isolation from surrounding land uses increase their exposure to disturbances which encourages the invasion of pest species.

Management is about reducing the impact of the surrounding land use on the stock route and the processes that lead to degradation. It is important to recognise that the impacts of pest species are not confined to stock routes and management cannot be isolated from the regional context in which pests are located.



General Control Principles

- Control programs on stock routes should involve all local land managers with adjacent or contiguous holdings to avoid missing populations that can reinfest clean country.
- Areas of high conservation value should be targeted first. Besides their high biodiversity and conservation value, they may also offer a habitat or refuge for pest animals.
- Techniques used on agricultural land may not be appropriate in conservation areas because of the risk of damage or injury to habitat or native fauna.
- Where populations go through a cycle of boom and bust, it is most effective to undertake control when the population is naturally low.
- Higher levels of control may be needed on and around stock route water points to prevent the destruction of facilities, to minimise the potential for disease transmission and to reduce interference of droving stock.
- Provision of artificial watering points has enabled many populations of feral and pest animal species to be maintained. Animal access to watering facilities should be restricted to times of use only.
- Animals are mobile and individuals will move into and out of the local population. Some will travel long distances, others will move in a smaller home range. Control strategies need to recognise and reflect these movements.

- Integration of several control techniques such as baiting, shooting, on-farm hygiene and trapping are likely to be more effective than relying on any one particular technique.
- For information on specific control techniques, advice and assistance, contact the Department of Natural Resources.

Pest Management Plans

Effective pest management is a combination of prevention and control activities.

Management objectives need to be prioritised based on the size or potential size of the problem and the amount of resources (time, money, labour) that are available.

The Department of Natural Resources has staff to assist in developing Pest Management Plans. A useful brochure titled *Planning Your Pest Management* is available from the Department of Natural Resources. It is a step by step guide to developing a realistic plan appropriate to local conditions and recognising the needs of all parties involved.

Community consultation

Legislation is worthless without community support, and the range of community attitudes needs to be understood and appreciated when it comes to pest control work. The community can become quite divided, especially over issues such as feral animal control or the use of herbicides.

Make sure the community is involved in the development of the pest management plan.

Points to remember

- Many pest species are very widespread and eradication is not a feasible option.
- The management options and control strategy chosen depend on the level of control required.
- A sustained strategic approach is preferred where pest species represent a serious risk to the environment and agricultural production.
- Strategic management targets the areas most sensitive to control.
- For advice on control techniques and pest management plans contact the Department of Natural Resources.

Responsibility for Control

Landowners and leaseholders must take all reasonable steps to control declared pest plants and animals on their own land and on stock routes included in their property.

Government departments are only responsible for declared pests on land under their control.

The Main Roads Department must take steps to control declared pests on roads.

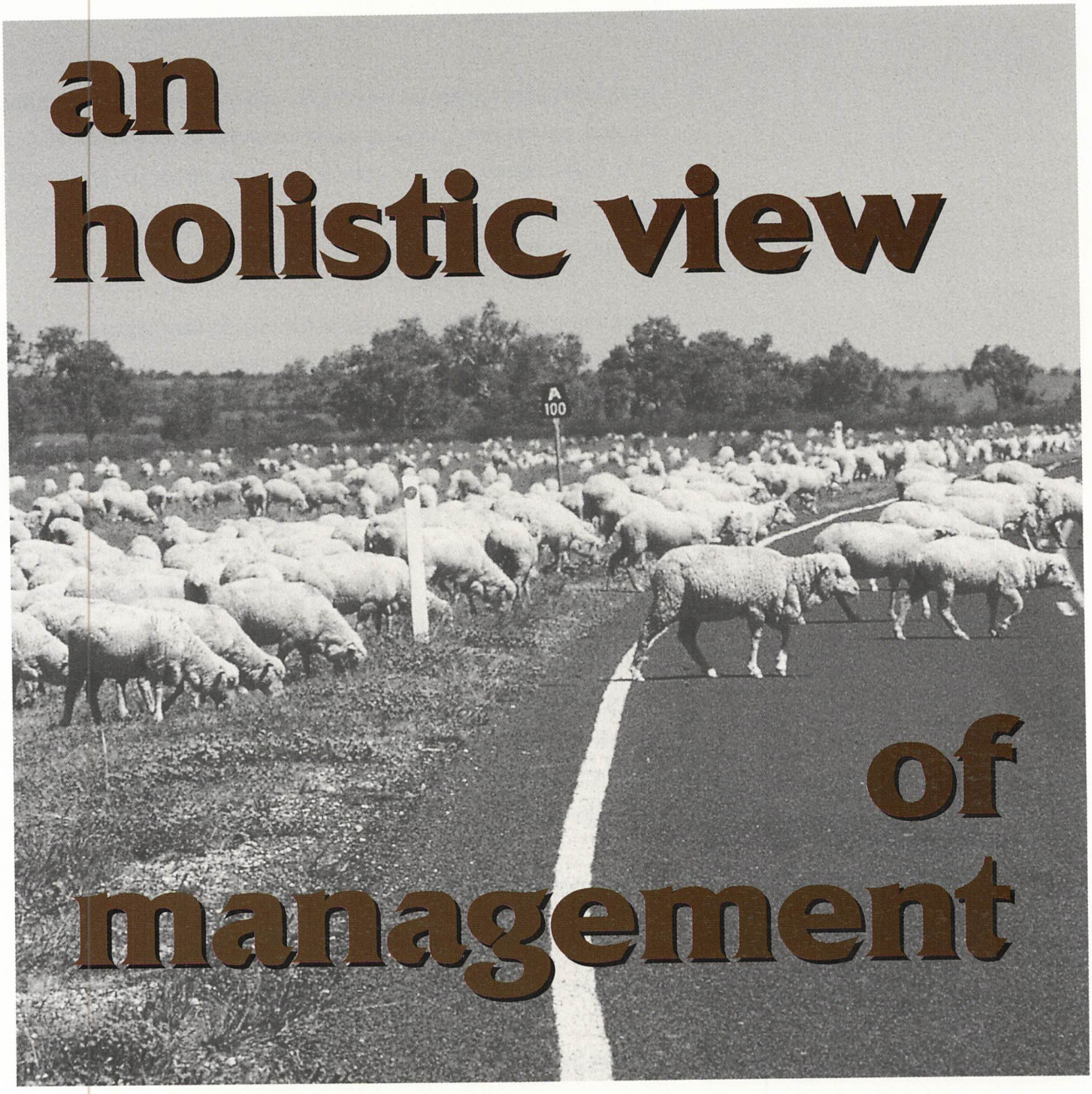
Councils are responsible for roads, road reserves, stock routes and other lands under their control.

Communication and power utilities are encouraged to assist with control programs associated with their easements.

Penalties

The Department of Natural Resources may impose penalties for not controlling declared species under provisions of the Rural Lands Protection Act.

an holistic view of management



CHAPTER FIVE

An Holistic View of Management

'The pressures on stock routes come from outside not from within.'

Previous chapters highlighted the complex web of issues that link the values of the stock routes to the individuals and communities who use them. Many of these issues compete with one another for sole, or priority, use of the stock route resources. Land managers face the daunting task of trying to balance resource conservation with the demands of the community.

Stock routes do not operate in isolation from surrounding land use activities, be that locally within the council, within the catchment or even at the regional level. Likewise, stock route management should not be undertaken in isolation or independent of other land management and planning processes. Stock routes have been traditionally managed as a natural grazing system with minimal development by Local or State Governments. Generally the ecological processes which sustain the stock routes also sustain the surrounding land systems. The threatening processes, however, tend to be a product of the surrounding land uses, external to the stock route.

Management of these issues requires integration of the economics of production and the economics of conservation. An holistic view of management integrates the environment, heritage and production values in the context of the shire, catchment or region and community values.

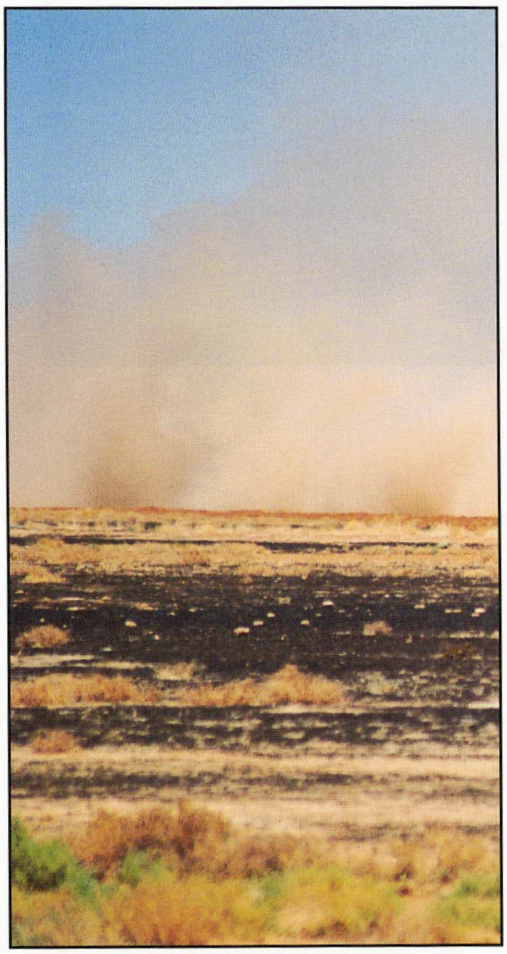


Photo courtesy of Eric Anderson

Management Plans

Management plans generally have a common framework and follow a similar pattern across all disciplines; only the issues are changed.

Planning cycle

Figure 1 shows a typical planning cycle of collecting and collating background information, the identification of goals and objectives, the analysis of options and alternatives, implementation of the plan, monitoring and evaluation of the process and results and then modification of the plan.

Stock route management plans

The development of stock route management plans are considered to be a high priority by Stock Route Supervisors. They are recognised as being a tool for improving coordination of stock movements between councils; a means of linking stock routes into other local and regional plans; a way to raise the profile of stock routes; and a means of capacity building for the local community.

Where do stock route management plans fit?

Stock route management plans should form part of an overall land management and cultural heritage strategy and not be developed independent of their context. Councils have their corporate plan and many community-based land management groups such as Landcare, Rural Fire Services, Catchment Management have their own management plans. Agencies concerned with local and regional tourism or heritage strategies have also developed other management plans. Stock routes traverse the boundaries of all these groups and their recognised values should be integrated into these other management plans to maintain consistency and produce synergistic effects.

Management plans generally have a common framework and follow a similar pattern across all disciplines

Figure 1. Planning cycle for stock route management

The planning scale

The scale at which plans are prepared will depend on the context of the plan.

Property level planning: Many of the processes threatening and supporting stock route biodiversity originate at the property level. Whole farm property plans provide the fine detail for linking stock routes with vegetation in fencelines, creeklines, ridges and property features and also for the provision and maintenance of buffers, and fire and pest control.

Local Government level planning: Stock routes develop multiple uses at this level and there are many objectives to be met: stock movement, landscape amenity, road safety, heritage/tourism, biodiversity etc.

Under the Local Government Act, councils must prepare and adopt a three-year corporate plan covering a complete range of local issues. Planning links stock route biodiversity into the economic and cultural goals of the community.

Local Government is considered to be an appropriate scale for stock route management plans because Local Government has the framework and capacity to provide legal designation, protection and management of corridors. Local Government is responsible for the day-to-day management of stock routes and has staff assigned to this duty.

Many of the planning processes which threaten stock routes are active at this level. Also coincidentally, the scale of Local Government often matches the size of the range of many rare and threatened species.

Catchment or regional level planning: These plans link similar social or geographical units across Local Government boundaries. For biodiversity they link areas of regional significance, including core habitat and sites of rare and threatened species. For cultural or heritage issues they link common, regional tourism or educational themes. For improved coordination of movements of travelling stock across council boundaries, regional level planning is appropriate.

State level planning: This provides a structured approach across administrative boundaries, which includes legislation directed at the whole State or parts of the State.

Community consultation

A significant factor in stock route management is the range of issues and community interests. To appreciate and accommodate the community's understanding of local land management issues, close consultation is needed with all stakeholders. To incorporate diverse community opinion and achieve a suitable outcome requires a management framework that permits negotiation and bargaining by all the stakeholders. This process assumes that all stakeholders are equally skilled at bargaining and negotiation, have equal access to knowledge and information and are adequately resourced; therefore it will need considerable attention from the facilitator.

Stock Route Management Committees

Management success relies on increasing community awareness and involvement in the planning process. The community needs to appreciate the relevance of all the issues and the development of an ecological and community-based extension program is a key requirement.

The formation of a Stock Route Management Committee has potential to ensure all the relevant stakeholders are included in the development of the plan and that all their issues are aired and considered. Councils are responsible for the day-to-day management of stock routes and could be the primary agency responsible for promoting the formation of such a committee.

Photo courtesy of Australian Stockman's Hall of Fame

Through representation from the relevant State land resource management and transport agencies, local users groups and other interested parties, it is possible to achieve linkages into other local planning initiatives and regional planning strategies.

Developing Stock Route Management Plans

STEP 1. Prepare a situation statement

Document your current situation:

- Who is involved in the use and management of stock routes in your area? Refer to Section 3.2 for a list of potential users or interest groups.
- Form a management committee of interested stakeholders.
- What resources do you have available?
- What will help or hinder your efforts?
- What are the main issues you need to consider when using and managing stock routes?

STEP 2. Analyse the data

- Identify priority issues for management based on their scale and importance and the resources available.

STEP 3. Establish clear conservation and economic goals and objectives

- Develop a set of achievable goals and specific activities that should be done to manage the stock route effectively.
- Include a time frame and ways and means to monitor and evaluate progress.
- The plan should now show what is to be done, by whom, how and when.
- Ensure the wider community has the opportunity to comment on the plan at this stage.

STEP 4. Implementation

- Coordinate all the activities as they are implemented and continually monitor progress.

STEP 5. Monitoring and evaluation

- The plan should be reviewed at least every 12 months so that it remains up to date and accurate.
- Are the goals achieved?
- Have the priorities changed?

And so the cycle continues...

A PLAN FOR THE FUTURE:

DEVELOPMENT AND MANAGEMENT OF PUBLIC LAND WITHIN THE MURWEH SHIRE, 1993.

An advisory panel, with representatives from the government and community, prepared a plan to assist the Murweh Shire Council manage all Crown and Public lands under its jurisdiction (Murweh Shire Council 1993).

Their *vision* for the Shire recognises that development of public lands for multipurpose uses is a responsibility of the community. Objectives for the plan are to balance the demands of the community with the capability of the environment.

Stock routes and outlying reserves are recognised as priority areas requiring immediate attention. A number of issues are identified as being in common with other priority areas:

- overgrazing
- clearing practices
- inappropriate and unrealised land uses
- indiscriminate refuse dumping practices
- public apathy and expectations.

Given the importance of stock routes within the Shire, a vision was established for their management: To ensure the Stock Routes and Reserves are managed for their primary purpose of travelling stock and guarantee their ecological viability for the benefit of the community and secondary uses.

The four objectives of management concern on-ground management and administrative and legislative issues. After investigation of the issues, the panel provided recommendations for action by the Council and sought a regular review process.

Legislation

Apiaries Act 1982 (Qld)

Brands Act 1915 (Qld)

Cultural Record (Landscapes Queensland and Queensland Estates) Act 1987 (Qld)

Endangered Species Protection Act 1992 (Cwlth)

Environmental Protection Act 1994 (Qld)

Forestry Act 1959 (Qld)

Grazing District Improvement Act 1930 (Qld)

Land Act 1994 (Qld)

Local Authority (Grazing District Improvement) Transfer of Powers Act 1933 (Qld)

Local Government Act 1993 (Qld)

Nature Conservation Act 1992 (Qld)

Queensland Heritage Act 1992 (Qld)

Rural Lands Protection Act 1985 (Qld)

States Grants (Encouragement of Meat Production) Act 1949 (Cwlth)

Stock Act 1915 (Qld)

Stock Act Regulations 1988 (Qld)

Stock Routes and Rural Lands Protection Act 1944 (Qld)

Stock Routes Improvement and Animal and Vegetable Pests Destruction Act 1936 (Qld)

Transport Infrastructure Act 1994 (Qld)

Water Act 1926 (Qld)

Water Resources Act 1989 (Qld)

References and Further Reading

Akers, D. 1992, 'Pest and pasture management on stock routes', in *Proceedings of a Strategic Planning Workshop–Stock Route System*, 2–3 Dec 1992, Department of Lands, Brisbane, Queensland.

Bradby, K. 1991, 'Management of corridors on public and private land: who should be responsible?', in *Nature Conservation 2: The Role of Corridors*, D. A. Saunders & R. J. Hobbs, Surrey Beatty & Sons, Australia, pp. 395–418.

Brown, J. 1994, 'State and transition models. Ecology as a basis for rangeland management: Performance criteria for testing models', *Journal of the Tropical Grasslands Society of Australia*, vol. 28, pp. 206–213.

Choquenot, D., McIlroy, J. & Korn, T. 1996, *Managing Vertebrate Pests: Feral Pigs*, Bureau of Resource Sciences, Canberra.

Cooney, C. 1994, *Database on Water Facilities and Travelling Stock*, 2nd edn, Land Protection Branch, Queensland Department of Lands, Brisbane, Queensland.

Cultural Heritage Branch 1997a, *What Is a Heritage Place?*, Department of Environment, Brisbane, Queensland.

Cultural Heritage Branch 1997b, *Heritage Listing – What Does It Mean?*, Department of Environment, Brisbane, Queensland.

Department of Environment 1997, *Species Profile; Cadellia pentastylis*, Information Sheet PE051, DoE, Charleville, Queensland.

Department of Environment and Heritage 1994, *Cats and Wildlife*, DEH, Brisbane, Queensland.

Department of Lands 1992, *The Control of Mice in Agriculture*, Pestfact, DoL, Brisbane, Queensland.

Department of Lands 1996a, *Feral Pigs in Queensland*, Pestfact PA6, DoL, Brisbane, Queensland.

Department of Lands 1996b, *Identification of Locusts*, Pestfact AO22, DoL, Brisbane, Queensland,

Department of Natural Resources 1996, *Control of Spur-throated Locusts*, Pestfact, AO23, DNR, Brisbane, Queensland.

Dickman C. M. 1996, *Overview of the Impact of Feral Cats on Australian Native Fauna*, Australian Nature Conservation Agency, Canberra.

Endangered Species Unit 1994, *Cats in Australia*, Australian National Parks and Wildlife Service, Canberra.

Forge, K. 1994, *GRASS Check: Grazier Rangeland Assessment for Self-Sustainability*, Department of Primary Industries, Queensland.

Friedel, M. H. 1990, 'Some key concepts for monitoring Australia's arid and semi-arid rangelands', *Australian Rangeland Journal*, vol. 12, pp. 21–24.

Henry, D. R., Hall, T. J., Jordan, D. J., Milson, J. A., Schefe, C. M. & Silcock, R. G. 1995, *Pasture Plants of Southern Inland Queensland*, Information Series QI95016, Department of Primary Industries, Queensland.

Land Protection Sub Program 1997, *The Fox; Vulpes vulpes*, Pestfact PA13, Department of Natural Resources, Brisbane, Queensland.

Lazzarini, W. 1997, *Planning Your Pest Management*, Department of Natural Resources, Brisbane, Queensland.

Ludwig, J. A., Hodgkinson, K. C. & Macadam, R. D. 1990, 'Principles, problems and priorities for restoring degraded rangelands', *Australian Rangeland Journal*, vol. 12, pp. 30–33.

McKnight, T. L. 1977, The Long Paddock: Australia's travelling stock routes, thesis submitted at University of New England, Armidale, New South Wales.

Milberg. P. & Lamont, B. B. 1995, 'Fire enhances weed invasion of roadside vegetation in south western Australia', *Biological Conservation*, vol. 73, pp. 45–49.

Murweh Shire Council 1993, *A Plan for the Future Development and Management of Public Land Within the Murweh Shire*, compiled by an Advisory Panel to the Murweh Shire Council, Murweh Shire Council, Queensland.

Partridge, I. 1991, *Will it Rain? El Niño and the Southern Oscillation*, Information Series QI91028, Department of Primary Industries, Brisbane, Queensland.

Partridge, I. 1992, *Managing Native Pastures: A Graziers Guide*, Information Series QI92009, Department of Primary Industries, Brisbane, Queensland.

Partridge, I. 1993, *Managing Southern Speargrass: A Graziers Guide*, Information Series QI93037, Department of Primary Industries, Brisbane, Queensland.

Partridge, I. 1996, *Managing Mitchell Grass: A Graziers Guide*, Information Series QI96009, Department of Primary Industries, Brisbane, Queensland.

Press, D., Doak, D. F. & Steinberg, P. 1996, 'The role of local government in the conservation of rare species', *Conservation Biology*, vol. 10, pp. 1538–1548.

Pressland, A. J., Mills, J. R. & Cummins, V. G. 1988, 'Landscape degradation in native pastures', in *Native Pastures in Queensland*, W. H. Burrows, J. C. Scanlan, & M. T. Rutherford eds, Department of Primary Industries, Queensland, pp. 174–195.

Pullar, M. 1995, Historic Routes of Queensland, report for the National Trust of Queensland, Brisbane.

Queensland Beekeepers' Association n.d., Submission: Usage of Roads and Stock Routes by Beekeepers in Queensland, attachment to a letter received 1/10/96, Department of Natural Resources, Brisbane, Queensland.

Queensland Electricity Supply Industry 1993, *Environmental Code of Practice in the Wet Tropics World Heritage Area*, prepared by MANIDIS ROBERTS Consultants in assoc. with Natural Resource Assessments, Siteplan Landscape Architects, & Resource Consulting Services, Cairns, Queensland.

Queensland Parliament 1930, *Report from the Royal Commission on Rabbit, Dingo and Stock Route Administration* (W. L. Payne, Chairman), Brisbane.

Roadside Conservation Committee 1991, Minutes of the inaugural meeting 29 January 1991, Department of Environment, Queensland.

Roadside Conservation Committee of Victoria 1995, *Roadside Management Planning: Background & Guidelines*, Roadside Conservation Committee of Victoria, Melbourne.

Roads and Traffic Authority 1995, *Roadside Environment Strategic Plan*, Roads and Traffic Authority, New South Wales.

Roberts, B. 1994, *Stock Route Survey for Potential Habitat Network in Queensland*, final report to World Wide Fund For Nature Project, Land Use Study Centre, University of Southern Queensland, Toowoomba, Queensland.

Robertshaw, J., Panetta, D., Thompson, J. & Brassington, B. 1994, *Wild Rabbit: A Pest Status Assessment*, Technical Series, Department of Lands, Brisbane, Queensland.

Rural Lands Protection Board 1993, Minutes of meeting 8–9 March 1993, Department of Lands, Brisbane, Queensland.

Sattler, P. S. & Williams, R. D. (eds) 1996, *The Conservation Status of Queensland's Bioregional Ecosystems*, Conservation Technical Report, Department of Environment and Heritage, Brisbane, Queensland.

Saunders, G., Coman, B., Kinnear, J. & Braysher, M. 1995, *Managing Vertebrate Pests: Foxes*, Bureau of Resource Sciences, Canberra.

Spackman, G. (ed.) 1996, *Control of Spur-throated Locusts in Grain Crops, Clermont 1995*, Department of Natural Resources, Brisbane, Queensland.

Stanisic, J. 1997, Land snail diversity in Queensland: an overview, in possession of Queensland Museum.

Tindal v. Cameron (1910) 4 *Crown Land Law Reports* (Queensland) 171.

Tongway, D. J. & Smith, E. L. 1989, 'Soil surface features as indicators of rangeland site productivity', *Australian Rangeland Journal*, vol. 11, pp. 15–20.

Wasson, R. 1987, 'Detection and Measurement of Land Degradation Processes', in *Land Degradation: Problems and Policies*, Chisholm, A. & Dumsday, R., eds, Cambridge University Press, Sydney, pp. 49–69.

Wildlife Preservation Society of Queensland 1987, *A Survey of Reserves and Stock Routes of South East Queensland*, Wildlife Preservation Society of Queensland Inc.

Williams, K., Parer, I., Coman, B., Burley, J. & Braysher, M. 1995, *Managing Vertebrate Pests: Rabbits*, Bureau of Resource Sciences & CSIRO, Canberra.

Wilson, A. M. & Lindenmayer, D. B. 1996, *Wildlife Corridors and the Conservation of Biodiversity: A major review*, Centre for Resource and Environmental Sciences, Australian National University & Greening Australia, Canberra.

Wilson, B. A. 1995, *Artesian Springs of the Great Artesian Basin in Queensland*, Department of Environment, Toowoomba, Queensland.

Wilson, G., Dexter, N., O'Brien, P. & Bomford, M. 1992, *Pest Animals in Australia: a survey of introduced wild mammals*, Bureau of Rural Resource & Kangaroo Press, Canberra.

Index

Q

R

S

T

W