THE WYNDHAM LECTURE

LIVESTOCK MANAGEMENT FOR CATCHMENT CARE: WHAT ROLE QUALITY ASSURANCE?

J. WILLIAMS and R.A. HOOK
CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601

INTRODUCTION

This review is essentially concerned with the hydrological and closely associated nutrient cycles which operate in catchments and the way grazing modifies these key processes to affect land and water quality. Whilst it is recognised that grazing operations involve often major modifications to habitat and thus catchment biodiversity, this is not a focus of the analysis. Attention will be given to the application of quality assurance concepts to livestock production and sustainable catchment management. Quality Assurance (QA) is seen by some in the livestock industries, as a means of establishing a set of ‘best practices’ that can minimise the effects of grazing on the environment, thereby allowing the marketing of animal products as ‘clean and green’ in that their production conforms to ecological sustainability principles. In our opinion, over the next 15 years quality assurance will emerge as a primary driving force in the search for more sustainable livestock, farm and catchment management practices.

Graziers in many parts of the irrigated and high rainfall (greater than 600 mm/year) regions of south-eastern Australia currently are pursuing higher productivity through improving their systems of pasture and livestock management. A key element in their strategy is the increased use of fertilisers, often at rates well above those required for optimum pasture growth and replacement of nutrients exported in animal product. This paper examines this increase in fertiliser use and stocking rate for dairy, meat and wool production in terms of the catchment and environmental issues which must be addressed by these industries if they are to move towards ecological sustainability.

POSSIBLE EFFECTS OF GRAZING ENTERPRISES ON CATCHMENT PROCESSES

Increasing production is an important concern for milk, wool and meat producers, particularly in the current economic climate. We have learned from past experience, however, that focussing on particular aspects of farming systems, in this case animal production, can lead to degradation in our land and water resources. Such resource degradation is counter to maintaining and increasing productivity in the longer term.

Resource degradation as a result of grazing comes about because processes which occur naturally in the environment are changed. These processes involve the storage and transfer of energy, water and nutrients. The introduction of grazing affects these processes primarily by altering characteristics of the vegetation and soils. Animal grazing, for example, can affect plant species composition (through selective foraging and facilitating the movement and establishment of weeds), plant cover, plant root depth and soil surface condition. The effects of animals are often pronounced around watering points and, where animals have access to creeks and rivers, there can be loss of riparian vegetation, erosion of banks and direct input of nutrients and microbial pathogens to the water. Grazing management practices are particularly important. Clearing and pasture improvement affect the same landscape characteristics as animal grazing but usually to a greater extent, especially with respect to reducing the natural habitat and biological diversity. In addition, pasture improvement introduces non-native species and usually also involves additional nutrient input, mainly nitrogen (N) and phosphorus (P) but also sulphur (S).

Changing the soil and vegetation characteristics of a landscape changes the rate at which the various hydrological, and nutrient and energy transfer processes operate. For example, by reducing plant cover, grazing can reduce infiltration and increase runoff by exposing the soil to raindrop impact which, combined with the loss of soil organic matter associated with reduced plant cover, can lead to surface sealing. Loss of plant cover and trampling of the soil by animals can also reduce surface microtopography and hydraulic roughness, which in turn decrease surface water storage and increase the rate of runoff. Loss of soil organic matter not only affects soil structure and hydraulic properties directly but also indirectly through a reduction in soil organism activity. There are also affects on soil fertility.
Increased runoff can move sediment and attached nutrients, dissolved nutrients, seeds and other organic matter. As a result, resources necessary for plant growth can be transported out of the local system and lost from grazing land. Organic matter, sediment and nutrients transported to waterways will be variably transported through the drainage network to the catchment mouth. Changes in water, sediment and nutrient inputs to aquatic and marine environments have the potential to change the ecology of these systems. Increased sediment and phosphorus inputs to Oyster Harbour from predominantly grazing land in southwest Western Australia, for example, have reduced considerably the extent of seagrass beds (Weaver et al. 1996). Users dependent on the continued healthy functioning of freshwater and marine ecosystems may be affected. Also damage to regional water quality imposes costs and social burdens on government and local communities. For example, the cost of treating water received from rural catchments into the South Australia’s Mt Lofty Reservoir system is $20 million per annum. These reservoirs serve metropolitan Adelaide and major rural regions of South Australia and the treatment costs are borne by water users. In some instances water quality can affect local tourist income as, for example, when algal blooms proliferate in lakes and rivers.

Tree clearing and the introduction of pastures have another set of hydrological and nutrient effects. Land cleared and sown to exotic pastures has often been found to have a different water use regime from the vegetation that was replaced (for example, Sharma et al. 1987 and Williamson et al. 1987). In many grazing areas of southern Australia, replacing the natural forests and woodlands with introduced pastures has typically resulted in reduced interception and evapotranspiration so that a greater volume of water has been available to move through the soil profile and recharge the groundwater. Eventually, groundwater recharge causes wettable to rise and intersect the land surface, increasing waterlogging. Where the groundwater is saline or moves through regolith with a high salt content, salinisation of soils and surface water results. The length of time for groundwaters to rise depends on the amount of water draining below the root zone, the permeability and water holding capacity of the regolith, and the depth of the watertable.

Leguminous and/or N fertilised pastures have also been found to affect soil quality and, indirectly, water quality. Increased rates of acidification, partly as a result of increased nitrate leaching, have been recorded under leguminous pastures (for example Chartres et al. 1990 and Helyar et al. 1990) and Kikuyu pastures that have been fertilised with ammonium sulphate (Helyar et al. 1990). Increased soil acidity will result in reduced pasture productivity as a result of increased availability of aluminium and manganese, ions which are toxic to most plants and reduce plant vigour and yield, and as nutrients such as phosphorus and molybdenum become less available. Reduced plant growth will reduce plant cover, with similar effects to that caused by overgrazing. Soil acidification and the resultant decline in pasture productivity are a major influence on catchment land and water quality (Williams and Chartres 1991).

Table 1 summarises the various effects that grazing enterprises can have on the land and the associated water quality problems. Of particular interest in this paper, given the current renaissance in grazing management, are the effects of grazing on nutrient cycles.

A RENAISSANCE IN GRAZING MANAGEMENT

Leading graziers and dairy farmers have observed that in some land types, livestock performance and financial returns are enhanced significantly by adopting improved and intensive grazing systems (Saul 1990; Sale 1995). This has been achieved by simultaneously renovating pasture (leading to improved pasture quality and digestibility); increasing fertiliser levels; and increasing stocking rates (optimising pasture utilisation). The prospects for generating greater wealth from improved pasture management and livestock intensification has been demonstrated clearly by the dairy industry in Victoria, Tasmania (Rose and Thompson 1993) and South Australia where improved management has led to substantial and sustained increases in milk production and milk yield per cow since the early 1980s. The factors underpinning these consistent and often major gains are not fully understood and are likely to be complex and possibly additive (Sale 1995).

In these dairy enterprises, the productivity and quality of the pasture is of paramount importance and must match the demands of the intended grazing pressure. Production efficiency is focussed strongly towards rapid growth of high quality pastures and efficient pasture utilisation. Commonly, high fertiliser levels are applied. Reuter et al. (1996) report that over 35% of dairy farms in Victoria and Tasmania applied on average 50 kg/ha of N and 56 kg/ha of P in the mid 1990s. In some instances, application rates were as high as 126 kg/ha of N and 140 kg/ha of P. On some sandy dairying soils in north-west Tasmania, applications of 800 kg/ha single superphosphate (about 70 kg/ha of P) were common in 1995.
<table>
<thead>
<tr>
<th>Form of land degradation</th>
<th>Causal process change</th>
<th>Generalized type of disturbance producing change and farming practice involving such disturbance</th>
<th>Associated water quality problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical residues</td>
<td>Introduction of new chemicals to the soil</td>
<td>Primarily fertiliser (including sewage effluent) and pesticide or herbicide applications</td>
<td>Chemical pollution</td>
</tr>
<tr>
<td>Loss of biodiversity</td>
<td>Direct loss plus changes in hydrological and nutrient cycles and energy balances and transfers</td>
<td>Primarily clearing of natural vegetation; indirect changes due to processes causing other forms of land degradation</td>
<td>Change to riparian habitat influences stream ecology</td>
</tr>
<tr>
<td>Nutrient loss</td>
<td>Changes in biogeochemical (nutrient) cycles and components of the hydrological cycle</td>
<td>Alteration of vegetation, particularly perenniality, leaf area index, root depth and total biomass production; harvesting of produce and export beyond the farm or catchment; addition of nutrients Pasture types selected (will affect potential for nutrient leaching beyond the root zone), excess fertiliser application and pasture renovation practices</td>
<td>Eutrophication; nitrate pollution</td>
</tr>
<tr>
<td>Organic matter loss</td>
<td>Changes in total biomass production and biomass return to the soil; chemical transformations</td>
<td>Changes to vegetation, harvesting of produce and produce export beyond the farm or catchment. Also increased exposure of surface soil and soil disruption causing loss by erosion and/or oxidation. Selection of pasture type, fertiliser addition and grazing intensity</td>
<td>Dissolved organic matter</td>
</tr>
<tr>
<td>Salinisation</td>
<td>Changes in hydrological cycle components, particularly a decrease in interception and evapotranspiration, where there is high salt storage in the regolith or groundwater</td>
<td>Primarily alteration of vegetation, particularly perenniality, leaf area index and root depth</td>
<td>Increased water salinity</td>
</tr>
<tr>
<td>Soil acidification</td>
<td>Changes in biogeochemical cycles (increased nitrogen input and loss of nutrients in produce) and in the hydrological cycle (increased leaching)</td>
<td>As for <code>Nutrient loss</code> described above. Inclusion of legumes in pastures and type of fertiliser used are particularly important.</td>
<td>Streams have declined in pH due to acidification of surrounding soils but the extent of the phenomenon is unknown</td>
</tr>
<tr>
<td>Soil structural decline</td>
<td>Primarily changes in the balances and transfer of energy</td>
<td>Increased removal of vegetation and exposure of surface soil (soil exposed to energy of rainfall; loss of roots and other organic matter reduces cohesion of soil aggregates), increased soil disruption and pressure on soils Pasteure type selected, grazing intensity (affects ground cover and soil organic matter), and characteristics of vehicles</td>
<td>Indirectly affects water quality through the potential for increased erosion</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>Primarily changes in hydrological cycle components, particularly a decrease in interception and evapotranspiration; can also result from a decrease in soil permeability in some instances</td>
<td>As for <code>Salinisation</code> described below</td>
<td>Changes in soil redox potential can result in release of acid drainage, dissolved organic carbon and other compounds to waterbodies</td>
</tr>
<tr>
<td>Soil loss</td>
<td>Changes in the balances and transfer of energy and components of the hydrological cycle</td>
<td>As for <code>Soil structural decline</code> and <code>Waterlogging</code></td>
<td>Increased stream sediment loads and turbidity</td>
</tr>
</tbody>
</table>

Adapted from Hook (In press)
In direct contrast, the renaissance in management of dairy pastures has yet to occur in wool and meat production. For example, fertiliser application to pastures on 18 wool-producing properties in southwestern Victoria ranged from 4 to 9 kg/ha of P between 1990 and 1994 (A. Patterson, pers. comm.). Some properties, however, are beginning to intensify their systems and there are programs in place to encourage this development in grazing industries (e.g., Victorian Grassland Society's Pasture Improvement Program; Target 10; Beef Manager; Tasmanian TOP Dairy Extension Program, Prograze).

With the progressive adoption of these more intensive grazing systems across southeastern Australia, it is imperative that practices adopted by graziers, particularly those associated with fertilisers, be cost effective and ecologically sustainable, posing minimal threat to local or downstream environments.

The twin goals of achieving high productivity and environmental sustainability must be sought by acquiring site-specific knowledge on the mobility and fate of nutrients and developing and using best practices to minimize nutrient leakages from the farm. It is well known that the farm nutrient cycle is increasingly ‘leaky’ as stocking rates are increased and matched by significantly increased nutrient inputs to the grazing system. Rarely, however, do we have quantitative information on the fluxes of nutrient associated with the different pathways of nutrient cycles on grazing properties. To build a sustainable grazing ecosystem, nutrient cycles should be closed except for the nutrients which are incorporated in agricultural products that leave the farm or catchment. In Figure 1, the nutrient cycle is shown diagramatically in terms of inputs, storages and outputs. It provides a valuable framework for considering how nutrient management affects the agricultural ecosystem (Williams and Hook 1991).

**Figure 1. The nutrient cycle structured as inputs, storages and outputs for grazing systems** (Williams and Hook 1991)

**EFFECTS OF GRAZING ANIMALS ON NUTRIENT CYCLING AND TRANSPORT IN CATCHMENTS**

It is now acknowledged that nitrogen, phosphorus, potassium, dissolved organic matter, solutes and dispersed clays are entering streams and rivers from diffuse rural sources, degrading water quality and contributing to eutrophication of regional water bodies (Anon 1995). The environmental concerns in intensive grazing and supplemented animal industries revolve about nutrient management and the leakage of nutrient to rivers and streams from the agricultural ecosystem. Nutrient movement from grazing systems needs to be fully understood from paddock to large catchment scale. This, however, is a difficult task as pathways and processes important within a paddock may not be equally important over the catchment as a whole. Whilst the principal pathways by which nutrient and chemical contaminants reach waterways and aquifers vary with land use and soil and landscape features, the major possible pathways by which water and nutrients can move are shown diagrammatically in Figure 2.
At paddock level, New Zealand work (Williams and Haynes 1992, Haynes and Williams 1993) and the review of Magdoff et al. (1997) provide valuable insights into nutrient cycling and movement under grazed pasture ecosystems. Grazing animals have a dominant effect on the movement of nutrients through the soil/plant/animal system. Animals redistribute 60% to 99% of ingested nutrients to the pasture surface (Barrow 1987) where they are concentrated in dung and urine patches. Although these patches may occupy 30 to 40% of the pasture they can be responsible for 70% of the pasture growth. Also, it is from urine and dung patches that nutrient is lost to the environment by leaching and gaseous emission. Deposition of large amounts of dung and urine on camp sites, and unproductive farm areas (laneways, stock yards, holding sheds, gateways and feeding/drinking troughs) can result in a major transfer of nutrient away from the main grazing areas. Also, since cycling is often minimal in these locations, there is usually increased opportunity for runoff and leaching to transport nutrient to rivers, streams, wetlands and to groundwater.

The evidence for significant leaching of nitrate under grazed pastures is well established (Haynes and Williams 1993). Nitrate leached under urine patches in intensively utilized pastures ranged from 23 to 162 kg/ha/year of N in New Zealand studies (Haynes and Williams 1993). Under grazed unfertilised clover/rye grass pasture in southern Australia, it is not uncommon for 20 to 30 kg/ha of N to be leached beneath the root zone in a year. Sulphate is leached to a similar extent in most soils. This loss of nitrate and sulphate is critical to the soil acidification process (Williams et al. 1990). It is important to appreciate that leaching under grazed swards can be from 6 to 10 times larger than leaching under ungrazed swards.

Work by Pakrou and Dillon (1995) showed that more than 20% of applied urine-N moves beyond the root zone (45 cm) by macropore flow in both dryland and irrigated systems (Table 2). In the lower south-east of South Australia, leaching of nitrogen from excreta of cattle grazing both dryland and irrigated legume-based pastures (Pakrou and Dillon 1995), to unconfined aquifers has caused progressive nitrate contamination of these aquifers which are the sole source of reticulated water in the region.

Table 2. Leaching of urine-N via macropore flow to groundwater

<table>
<thead>
<tr>
<th>Soil depth (cm)</th>
<th>Irrigated</th>
<th>Dryland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leachate</td>
<td>Plant</td>
</tr>
<tr>
<td>15</td>
<td>41</td>
<td>13</td>
</tr>
<tr>
<td>30</td>
<td>27</td>
<td>21</td>
</tr>
<tr>
<td>45</td>
<td>13</td>
<td>31</td>
</tr>
</tbody>
</table>

Pakrou and Dillon (1995)
Whilst it is accepted that N and S are mobile and subject to leaching (Goh and Nguyen 1990, Nguyen and Goh 1992), it is generally believed that P is not leached. However, the work of Lewis et al. (1981, 1987) on P leaching on sandy soils in South Australia demonstrated that between 40% and 70% of applied P leached beyond 30 cm. The movement of phosphorus beyond the root zone in sandy soils is also reported by Reuter et al. (1996). This work shows that for the environment of Mt Bold in South Australia more nutrient is moving in the subsurface pathways than over the soil surface. Soil macropore structures are important. Naidu et al. (1993) found subsurface transport of mobilized and leached nutrients and colloids, and their discharge at lower topographic positions, to be important in landscapes with duplex soils.

Greenhill et al. (1983a,b) showed that overland transport of phosphorus in storm runoff was approximately 1% loss of fertiliser applied over the range from 10 to 40 kg/ha of P. Thus, if 200 kg/ha of single superphosphate (17.2 kg/ha of P) were applied to a 10,000 ha catchment, it is possible that 1720 kg of P could be delivered to catchment streams following this storm event. In contrast, P concentrations in runoff from unfertilised grazing land were shown to be much smaller at approximately 36 g/ha or about 360 kg from the 10,000 ha catchment. Nash and Murdoch (1997) also demonstrate a significant loss of P with heavy rainfall following fertiliser application.

Reuter et al. 1996 present data (Figure 3) which demonstrate that P can be readily lost in runoff under irrigated and well fertilised grazed pastures. As expected, loss is greatest in the first irrigation following application. The greatest loss of nutrients from the paddock to the catchment appears to be under flood irrigation (Austin et al. 1995).

Point source contaminants (e.g., dairy shed effluent) also contribute nutrients to these pathways, but few quantitative data are available.

Whilst the data presented here are limited, they provide sufficient evidence to indicate that, with increasing use of fertiliser by grazing industries, significant nutrient can be lost to catchment waterbodies. State EPAs are progressively imposing harsher regulations in order to minimize the impact of agricultural practices on water quality. If agricultural industries are unable to halt loss of nutrient from the farm, prime land will ultimately be lost from agricultural production.

The pathways and processes by which valuable nutrient may leak from our agricultural ecosystem depend on the interaction between fertiliser application, soil and pasture properties, the rainfall or irrigation pattern, and the catchment geomorphology. Each of the major possible pathways (i.e., surface and subsurface flow, and leaching to groundwater) has been found to be of primary importance under a particular set of conditions.
Also, some regions of a catchment will have greater impact on water quality than others due to variation in sediment (and attached nutrient) storage and transport within a catchment as a result of differences in geomorphology. As a result of these various differences in nutrient movement, the time between the farming action and the catchment reaction can vary between hours and decades. This needs to be kept in mind.

It also needs to be kept in mind that there is variation in the influence that different sources of nutrient have on water quality. For example, Wasson (in press) suggests that sediment derived from gully walls and stream banks, rather than topsoil sediment or applied fertiliser, is the greatest source of P in the upper Murrumbidgee River in NSW. The importance of different nutrient sources on catchment water quality also depends on catchment characteristics (particularly geomorphology), climate, and the land management practices in use.

There is a definite need to predict water flow paths, and the spatial mobility and retention of nutrients and solutes within pastoral catchments. This must involve estimating sources, pathways, loads and forms of nutrients transported from land to regional water bodies. Also, soils and landscapes most at risk to the movement of nutrients through the soil profile (eg in macropore flow) rather than in overland flow need to be identified as their management needs will be different. New approaches and techniques, developed in Australia and overseas, need to be applied to this challenging field of study.

GAPS IN OUR KNOWLEDGE OF NUTRIENTS IN INTENSIVE GRAZING SYSTEMS

Recognising the potential for water quality problems, the Victorian government framed a ‘Nutrient Management Strategy for Victorian Inland Waters’ (Anon 1995) which subsequently led to the development of several regional strategies. These strategies, both in Victoria and elsewhere in south-east Australia, will be catchment-specific. To be effective and to ensure that the best solutions are developed and adopted by regional communities, these strategies need to be underpinned by strategic and tactical Research and extension.

Evidence has been assembled to indicate our present knowledge is inadequate, and in some cases rudimentary, in a number of areas critical to the sustainable management of nutrients. Some of the evidence was collated and reported in Reuter et al. (1996). Important gaps in our knowledge of nutrients in the environment include:

• the off-site impact of fertilisers (see McKay 1995);
• the fate of nutrients and the extent to which they cycle in grazing systems;
• the efficiency with which nutrients (soil and applied) cycle under high grazing pressures, and the mode and magnitude of off-site nutrient loss;
• the impact of intensive grazing systems on soil properties, particularly those determining nutrient mobility and retention by soil organic matter;
• the causal factors and processes underpinning the productivity gains being achieved in high-input grazing systems (see Sale 1995).

It is of particular concern that the mode and extent of nutrient transport off-site into waterways remains poorly understood. Recent research indicates that nutrients, such as P, can move in soluble forms through soil, as well as by overland flow (Nash and Murdoch 1997). Both routes, together with the transport of particulate nutrients, have the potential to contribute to eutrophication of regional water bodies.

• As a consequence of these deficiencies, necessary areas for research can be identified.
• Determination and quantification of the dynamics of soil and fertiliser nutrients for different grazing enterprises and environments, particularly the fate of fertiliser nutrients and nutrient losses from the system. The extent of immobilisation and release of organically-bound nutrients needs to be established. These data could then be used to further develop and verify nutrient cycling models that could be used in decision support systems to aid nutrient management.
• develop generic chemical tests which predict more reliably, the nutritional status and requirements of soils used for grazing. Such improvements, including the use of site descriptors (Reuter et al. 1995), would provide superior interpretation guidelines for use by commercial testing laboratories which serve the grazing and dairy industries.
• develop an understanding of the effects that grazing systems, and especially high-input grazing systems, have in the long-term on shifts in soil properties which underpin the capacity of the soil resource to sustain grazing enterprises. Of particular concern is the effect of soil acidification on soil nutrient retention, especially phosphorus.

MANAGEMENT OF NUTRIENT IN AGRICULTURAL ECOSYSTEMS

Inappropriate fertiliser practices, as well as being wasteful economically, will adversely affect the fragile soil and water resources of south-eastern Australia. To optimise the use of nutrients on farms, interactions between weather conditions, soil and catchment characteristics, farm management, and nutrient applications need to be considered. No longer can the response function to nutrient input be the focus of interest. The nutrient balance, including leakage to the environment, and productivity response must be treated together. Computer models and decision support systems based on them, need to be developed to provide a means whereby best nutrient management practices can be planned. Models based on simplified nutrient mass balances are available and are useful as the input information required is minimal and the principles are readily understood by advisers and farmers (Haynes and Williams 1993). They allow the long term consequences of adopting alternative fertiliser strategies to be explored in terms of productivity and financial risks. They have very limited ability, however, to evaluate the environmental risk associated with a given fertiliser strategy.

There are few tools available in Australia that can analyse the interactions between nutrient (fertiliser) addition, soil, climate, irrigation strategies, pasture growth and animal activity, and indicate the effect on both production and the catchment. It is unlikely that an experimental approach alone will enable decision support systems to be developed which cover all the dynamic interactions that take place on the farm. The development of simulation tools coupled with actual experimentation will prove to be the way forward. Appropriate tools could include the nutrient cycling submodule of GrazPlan (Moore et al. 1991), the nitrogen dynamics of urine patches as modelled by Hutchinson and King (1995), or components of the CSIRO Division of Animal Production model of nutrient dynamics (Hutchinson, in press), developed and tested using data generated from the well designed field studies.

The structure for the GrazPlan submodule, based primarily on the nutrient simulation model developed for perennial pastures by McCaskill and Blair (1990), could be extended to include quantitative information to predict water flux and nutrient leakages within soils with different hydraulic properties and flow paths. New work on this topic is being undertaken within the CSIRO Multi-Divisional Program ‘Dryland Farming Systems for Catchment Care’ which, in the longer term, plans to provide a new generation of useful tools and solutions.

QUALITY ASSURANCE: FROM ISO 9000 TOWARDS ISO 14000

Since the mid 1990s, livestock industries have sought to use QA programs such as ‘Cattlecare’ (Francis 1995), to improve the market quality of meat and particularly to reduce the risk of pesticide contamination. ‘Cattlecare’, as the first national QA program, was a code of practice developed and coordinated by the Cattle Council of Australia and loosely based on the ISO 9000 series of QA standards. A property becomes accredited following audit by an external quality auditor.

There are numerous QA programs being proposed or implemented in the dairy and wool (Bent et al. 1997) and beef industries. Not all are built around ISO 9000 and sections of the beef industry have started promoting beef under brand names which serve both as export guarantees of quality and an indication of pride in the product they sell nationally and internationally. Names like ‘Hereford Prime’ and ‘Midco Black’ are assuring customers that the meat is under a quality control program from the moment it is born, with attention paid to feeding pattern, carcass-fat proportions, eventual butchering and hanging (Holuigue 1997).

Around 70% of beef in Australia is bought by major retailers, especially Woolworths and Coles-Myer. There are indications that these corporations will buy beef only when registered QA programs are in place from the farm onwards. Even more indicative of the power of QA driving industry change are the popular media articles (eg Holuigue 1997) which champion the consumer protection in QA (Falk et al. 1997). Whilst ISO 9000 is established in Australia with a focus on service or product quality and is slowly being applied in agriculture, QA with an emphasis on environmental management following the ISO 14000 standard is only now emerging as a possibility.

Global markets require quality produce and assurance that animal products are free of chemical residues, free of disease, and produced in a manner that is benign to the environment. Quality assurance procedures
Animal Production in Australia 1998 Vol. 22

and practices have evolved at an international level and are essential to Australia’s global positioning in export markets. Use of ISO 14000 standards could play a key role in providing procedures to establish Australia’s credibility in global markets as a supplier of animal products that are ‘clean and green’. Environmental QA through ISO 14000 seeks to establish a consumer guarantee that the product or service is provided using codes of practice that are known to protect the environment. Certification with ISO 14000 allows a product to carry the ‘Green Dove Award’ and is gaining international acceptance as a symbol that the company or product employs the very best practices in environmental management. A property becomes accredited to ISO 14000 following audit by an external quality auditor. To satisfy ISO 14000 standards, a property would need to be able to show that livestock management is conducted according to practices that have minimal impact on catchment land and water quality. It would be difficult to establish ISO 14000 QA for a property that had rising saline water tables or where nutrients from dairy shed wastes were detectable in local streams. The importance of having sustainable land use practices in place that could satisfy ISO 14000 or similar environmental codes of practice for production, is now recognised as critical to Australian industries supplying export and local products that have a QA backing, to substantiate a ‘clean and green’ image (Kennett 1996; Oxley 1996).

BEST MANAGEMENT PRACTICES INCORPORATED INTO QA STANDARDS

It will be essential that new findings from research are rapidly incorporated into best management practices and that these practices widely promoted, to ensure that productivity gains are realised and environmental threats are minimised. A diverse range of best practices need to be compiled and packaged for rural industry and community clients. Pasture management practices to maximise soil cover, surface roughness, return of litter to soil, soil organism activity and nutrient cycling are well known and fundamental to a set of best practices. Management necessary to control the loss of nutrients and agricultural chemical contaminants to the environment is an area which is less well understood and one that needs attention.

One of the key measures for controlling nutrient movement to streams in overland flow, is the use of strategically located grass buffer/filter strips, natural riparian vegetation and artificial wetlands. Recent papers illustrate that buffer strips and natural riparian vegetation have proved effective in regions associated with the Victorian dairy industry (Hairsine 1996; Mackenzie and Hairsine 1996; Wilson et al. 1996), provided that nutrients are transported with particulate material. Where nutrients are dissolved, as described by Nash and Murdoch (1997), filter strips and riparian vegetation will have little benefit. Information on the soil, climates and landscape positions where buffer/filter strips and reconstructed riparian zones will be most effective, and the size, composition and structural form required, remain subjects of active investigation. Fencing riparian vegetation and providing watering points outside the riparian region have been found to result in marked improvement in stream health. The use of artificial wetlands for management of nutrient loss from farm yards, dairy sheds, and feedlots will also be important. The management of perennial pastures and trees in various forms of agroforestry will become increasingly important on grazing properties to control salinity and soil acidification, and to maintain habitats within the catchment. The challenge for livestock managers is to formulate scientifically credible codes of practice that minimise damage to the catchment and which can be built into the standards required by ISO 14000 type environmental QA.

CONCLUSIONS

The large increases in fertiliser use and stocking rates combine to produce agro-ecosystems with increasingly ‘leaky’ nutrient cycles (Williams 1991). Thus the opportunity for nutrient to leak into the water systems of the catchment is greatly increased.

The process by which nutrients enter streams and waterbodies can vary from overland flow, lateral flow above heavy textured B horizons, to vertical leaching beyond the root zone and entry to groundwater systems. The transport pathways and the mobility of nutrients appear, under high intensity grazing systems, to be mechanisms that are not well documented or understood. The important role that organic forms of nutrients, particularly phosphate, play in these processes needs our urgent attention. Further the interaction between increasing soil acidity and nutrient reaction, mobility and transport is an emerging issue that requires examination. The development of nutrient management ‘best practice’ will be very difficult until this new knowledge is obtained.

For Australian grazing industries to gain a competitive advantage in world markets, the development, testing and implementation of best practices which conform to ISO 14000 QA standards will be essential.
Animal industries are beginning to see the value of ISO 9000 type QA in giving some guarantee to national and international consumers, that Australian meat and wool are of premium quality and free of contaminant. The opportunity to give Australian grazing industries a competitive advantage on national and world markets could be captured if best management practices which satisfy ISO 14 000 standards for catchment care, are developed urgently. Sustainable catchment management within livestock industries is not an optional add-on, but rather an immediate imperative that will allow some advantage to be gained before it becomes an essential ticket for market access.

ACKNOWLEDGMENTS
This paper has drawn extensively from an earlier paper with Doug Reuter, Ken Peverill and Jim Cox, colleagues in CSIRO, Agriculture Victoria, and the CRC for Soil and Land Management. The authors acknowledge and thank them for their assistance. We are indebted to Trish Taylor, who laid out the paper and prepared the manuscript under a very tight schedule.

REFERENCES


