SOIL EROSION IN QUEENSLAND CROPPING LANDS – AN HISTORICAL PERSPECTIVE AND NEW CHALLENGES

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Abstract
By the middle of the last century, soil erosion in the cropping lands of Queensland had reached unacceptable proportions. The government established a soil conservation service to achieve adoption of soil conservation. Various initiatives were progressively implemented to better address the causes of soil erosion and develop sustainable management practices. Much work has been done but the job is still unfinished.

More recently, State agencies have curtailed their soil conservation extension services. Soil erosion control has been incorporated into the addressing of broader environmental issues such as salinity, biodiversity and water quality management. This has coincided with a period of reduced visual impact of soil erosion in cultivation decreasing the perceived need for soil conservation. There is a challenge to ensure that farmers and the community do not become complacent about soil erosion. The roles and responsibilities for soil conservation are no longer limited to State government and farmers. The challenge is to ensure that the other stakeholders including local governments, regional bodies, primary industry organisations and community groups can access adequate technical and planning resources to assist in adopting soil conservation measures.

Additional Keywords: landcare, land capability, catchment, planning, extension, water quality, controlled traffic.

Introduction
Most of the agricultural land in Queensland is used for grazing cattle and sheep. While there are significant erosion problems in the area used for grazing, this paper concentrates on soil erosion in the cropping lands of the State. Soil erosion is an insidious threat to the continued productivity of cropping in Queensland. The area used for cropping in Queensland covers 3 million ha. Although this is less than 2% of the State, it is significant in terms of contribution to the economy and the viability of regional and rural communities. Figure 1 shows the distribution of cultivated land in Queensland. Table 1 shows the rate of expansion of the area of cultivation since 1950.

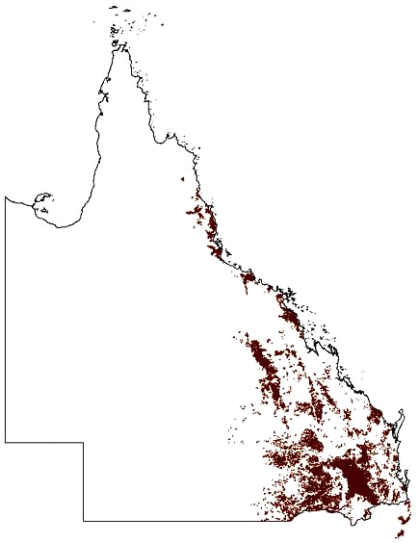
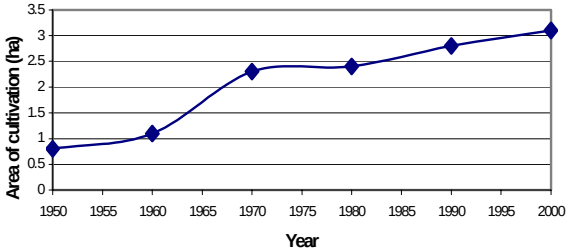


Figure 1. Areas where land is cultivated in Queensland

Table 1. Area of cultivation in Queensland (ha)

Year	Area of cultivation (ha)
1950	825 000
1960	1 160 000
1970	2 300 000
1980	2 440 000
1990	2 840 000
2000	3 130 000
Source: Australian Bureau of Statistics	



The outstanding driver of the erosion hazard was the mismatch between the cropping pattern and the rainfall pattern. The predominantly summer rain is exceptionally variable by world standards because of the El Niño Southern Oscillation phenomenon. In grain growing areas, cropping patterns tend to be opportunist with a variety of crops grown in both summer and winter. Winter crop yields depend on a fallow period to store the highly variable summer rainfall in soils with generally high moisture storage potential.

Erosion of topsoil reduces crop productivity, while advanced erosion leads to rills and gullies that make paddocks unworkable (Figure 2). Turbid runoff is likely to contain nutrients, fertilisers or pesticides causing adverse downsteam effects and impacting on coastal assets like the Great Barrier Reef (Hunter *et al.*, 1996).

By the middle of the last century, soil erosion in Queensland cropping lands had reached disastrous proportions. By 1950 over 16 000 ha of land (2 % of the cultivated area) had been withdrawn from cultivation because of extensive rills and gullying (Ladewig and Skinner 1950). There was considerable silt movement with fences being buried and road authorities facing unacceptable maintenance costs. Farmers could see that their livelihoods were under threat, leading to community-wide interest in overcoming the problem.

Figure 2. Gully formation in cropping lands on the Darling Downs

Figure 3. Soil conservation layout featuring contour banks and constructed waterways

Building on work started in the 1930s but discontinued because of World War II, the Queensland Government established a soil conservation service in the late 1940s in the then Department of Agriculture and Stock. The service was similar to those being established in other Australian states at the time. This service assisted farmers with planning and implementing soil conservation measures, and aimed to gain wide adoption of soil conservation. Considerable progress was made in control of erosion in cropping lands over the last 50 years, but it remains an unfinished story. The last Land Conservation Branch Annual Report for Queensland (Department of Primary Industries, 1991) reported 1040000 ha of land had been treated with contour banks, which is about 55% of the area needing such measures. A further 202000 ha of floodplain country were protected by strip cropping measures. At the time this was considered to represent only 25% of the land requiring this treatment. However the adoption of reduced tillage practices has obviated the need for strip cropping on land that is less susceptible to erosive flooding.

Changes in technology have been significant. The cropped area almost quadrupled from 1950 to 2000 (Table 1) while at the same time steeper lands were being retired from cultivation. Economies of scale were only possible by expanding cropping onto flatter areas with larger paddocks. More powerful tractors made it possible to farm the heavier soils of the plains. In these areas some of the off-farm impacts of erosion were either reduced or less obvious and simpler measures such as strip cropping or stubble retention were largely adequate to reduce soil loss. The interplay of new land development and old land retirement reduced the rate of increase in the age of cultivated lands and there was an associated decline in productivity with increased age and nutrient loss.

Technical Approaches to the Management of Soil Erosion

Management systems to protect the soil resource against rainfall and overland flow can be classified into three broad categories; land capability approaches; surface cover management and runoff management.

Land capability

Judging by contemporary standards, the early European settlers had inadequate knowledge of the constraints and limitations of the soils being developed for agriculture in Australia. Land was believed to be in unlimited supply and the need to retain vegetation for biodiversity was a little appreciated concept. Land subdivision was often based on a geometric, rectangular system with little consideration of natural drainage systems, topography and soil types.

Where land was leased from the government this often carried a requirement to develop the land as a lease condition. There were many examples of clearing land that was unsuitable for agriculture. For example, many

sugar-growing areas were landlocked. All the suitable land had been used up but the controlled 'assignment' system in place made it more or less imperative to expand cultivation onto unsuitable land.

Knowledge of land capability became a key to the successful adoption of soil conservation practices. The first formal land evaluation in Queensland was conducted in 1944 by the Bureau of Investigation of Land and Water Resources (Thwaites and Lloyd, 1995). Extension material in the 1950s used a variation of the United States Soil Conservation Service's eight-class land classification system, which identified the agricultural potential of land based on its limitations (Rosser *et al.*, 1974). Since then, a wide range of soil and land classification studies including land capability assessments were carried out in Queensland by State agencies and CSIRO. In more recent years a series of land management field manuals for each cropping district of the State were produced. These manuals provide information on the natural resources and include detailed descriptions of use and management of major soils.

Runoff management

The severe gullying in cultivated land in the 1940s to 1960s required a concerted effort to recover damaged land and ensure the soil remained productive. Using experience from overseas and other States, the Soil Conservation program initiated contour bank and waterway systems and levelling of gullied areas in order to minimise further erosion (Figure 3).

Contour bank and waterway systems were established on demonstration farms on the Darling Downs and the Kingaroy district in the 1950s. Sites were chosen that were easily seen by the travelling public. Farmers at this time were extremely concerned about the impact erosion was having on their properties and there was considerable interest in the program. Field days were conducted on farmer properties or government research stations as a means of communicating information. Some of these early field days attracted up to 700 farmers.

While contour banks and waterways were used to manage runoff on upland areas, floodplains subject to erosive flooding required a different strategy. Strip cropping was first adopted on the Darling Downs floodplains in the late 1950s by a progressive landholder, Hector Tod. A tribute to his innovation was his inclusion in an early government fact-finding visit to the United States that brought back innovations for adoption in Queensland.

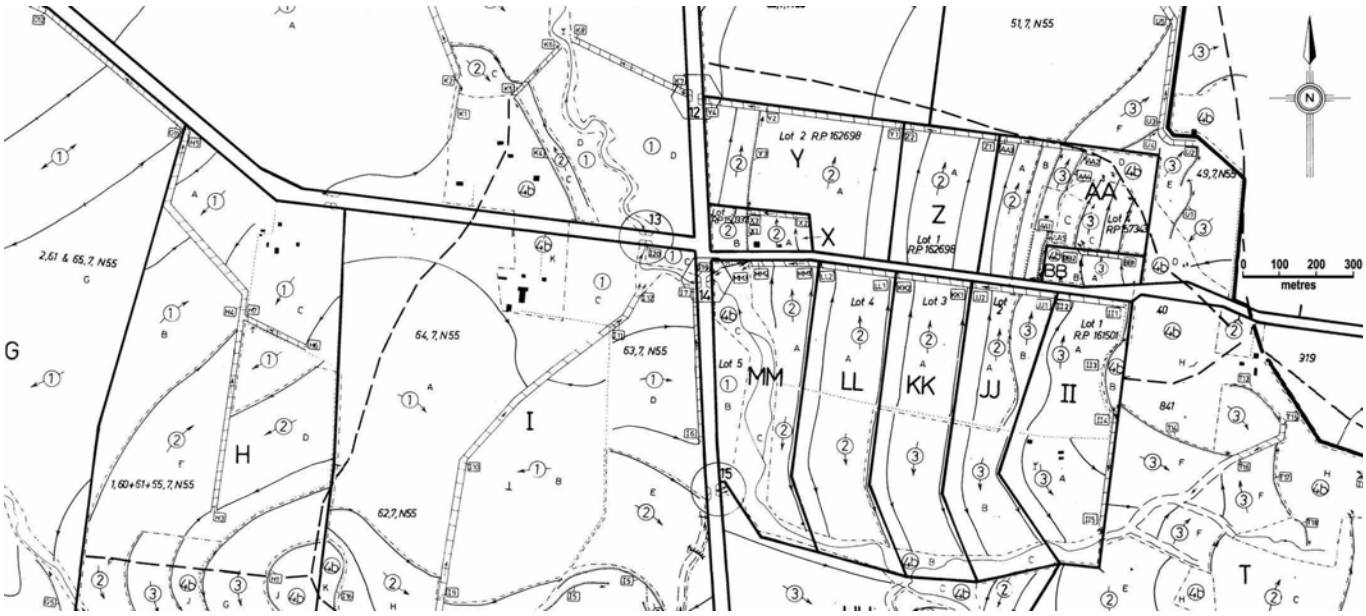


Figure 4. Part of the Cambooya Number 11 Project Plan gazetted in 1983

With contour banks and built waterways it was possible to alter the natural drainage patterns of catchments, making it necessary to address landscape and catchment characteristics. Runoff may pass through many properties, roads and perhaps a railway line between the top of the catchment and the permanent watercourse. Figure 4 shows an example of the detailed level of planning required in the preparation of a soil conservation plan. It covers a section of a Project Plan approved in 1983 under the *Soil Conservation Act 1965* covering 14 properties including small rural residential blocks comprising the sub catchment.

A principle used in Queensland soil conservation planning is that a property should accept the runoff from higher land that it would receive under natural conditions. While this principle should be easy to apply, there are occasions when the manner in which the land was originally subdivided can lead to debate and dispute as to how runoff should be co-ordinated. Such situations are easily handled when neighbours are cooperative. However the situation becomes more complex if neighbours are not in agreement. The legislative approach was one response to this issue.

Surface cover management

The need to keep the soil surface protected with vegetative cover was well known by the 1950s, but farming equipment at that time could not accommodate crop stubbles. Consequently, crop residues were burnt prior to the commencement of the summer rainfall season and cultivation, often using disc ploughs, followed each rainfall event to control weeds. This system dramatically reduced surface cover and by the end of summer the soil had been worked into a fine, bare condition. The soil was exposed and vulnerable to erosion in intense storms.

There was no improvement in stubble retention until specialised machinery designed to handle stubble was introduced in the 1970s. Farmers quickly adopted this machinery or modified existing machinery to improve stubble-handling capabilities. The Government provided limited subsidies to assist farmers to acquire machinery with high stubble clearance. Today the ability to handle stubble is a standard feature on most tillage and planting equipment.

The availability of herbicides to control weeds in crop fallows in the 1980s led to the adoption of minimum, reduced or zero tillage farming. Despite the benefits in reduced soil loss without compromising crop yields, adoption in the initial stages was slow due to the costs of herbicides and the limitations of spray equipment. In the sugar cane industry, the development of machinery to harvest green cane enabled the adoption of 'trash blanketing'. This practice is now almost universally accepted in the northern cane growing areas, which experience higher and more intense rainfalls, and has dramatically reduced soil loss from cane lands.

In the cereal cropping areas, farmers saw the benefits of crop rotations using summer and winter crops to improve weed and disease management. The term 'opportunity cropping' describes the planting of a crop as soon as there is sufficient soil moisture stored rather than adhering to calendar planting. A pioneering simulation study by Berndt and White (1976) evaluated three cropping systems on cracking-clay soils in a summer-rainfall environment. This showed there were substantial economic, social and environmental benefits ('triple bottom line') in adopting such a rainfall and soil moisture driven flexible cropping pattern that was more attuned to the environment. Today another result is the use of soil moisture in growing crops rather than its deep drainage below the root zone into shallow groundwater systems where it may raise the water table leading to dryland salinity problems. Freebairn and Silburn (2004), provide a more detailed review of research, development and extension activities related to the adoption of such sustainable cropping systems in Australia's semi arid tropics.

In recent years, perhaps the most dramatic change in farming practices has been the development of controlled traffic farming systems (CTF) (Yule *et al.*, 2000). CTF offers many advantages including efficiencies in farming operations, and less soil degradation by compaction. One of the iconoclastic (myth breaking) aspects of CTF is the ability to cultivate up and down the slope and across contour banks. Further assessment is required to determine the long-term effects of this practice on soil erosion (Titmarsh *et al.*, 2004).

Facilitating Adoption of Soil Conservation Practices

Legislation

Queensland has had soil conservation legislation since 1951 (Stephens, 1988). Under The 1965 version of this Act, 13 shires in southeast Queensland were declared 'Areas of Soil Erosion Hazard' in the 1970s. This was in response to a particularly serious set of erosion events. It was felt then that the 'voluntary advisory' approach was unlikely to be able to respond and achieve sufficient urgency in the uptake of necessary soil conservation measures. A total of 100 'Project Plans' were prepared (see example in Figure 4) with each plan describing detailed soil conservation requirements for somewhere between 10 and 40 properties. State subsidies were provided to assist with construction of soil conservation measures, recognising there were wider off-farm community benefits. The Act had the power to enforce the construction of soil conservation works, but these powers were rarely used. The 'Areas of Soil Erosion Hazard' program resulted in the planning of large areas but also resulted in some loss of trust within the farming community, some counterproductive conflict and led to a syndrome that soil erosion was a government responsibility rather than primarily a landholder responsibility. No further 'Areas of Soil Erosion Hazard' have been declared since the 1970s. Today both Government and industry anticipate that the more

cooperative and capacity-building approaches such as Landcare, Integrated Catchment Management and the adoption of best management practices can achieve similar or better results.

The current Queensland Soil Conservation Act was proclaimed in 1986. Its emphasis has been mainly on the approval of plans where runoff coordination issues exist between properties (Carey and Stone, 2001). Any such planning is initiated by landholders who wish to have a plan approved rather than being a requirement of government. The Act also recognises the role of soil erosion research, field experiments and demonstration areas to provide greater understanding of processes and solutions.

There is now less emphasis on the Soil Conservation Act and other statutes like the *Queensland Environmental Protection Act 1994* which allow for the preparation of Codes of Practice to clarify actions required of farmers in order to comply with their general environmental duty. While several such codes with soil conservation content have been prepared, their efficacy has not been tested under litigation.

Extension delivery

At its peak, the Queensland government soil conservation service had a presence in over 30 towns and cities throughout the State. This program provided a local service by staff who had been trained and mentored by experienced colleagues. The service promoted the concept of using land within its capability and assisted with management of soil erosion and other land degradation problems. Field officers worked with individual landholders and with groups in catchments in preparing soil conservation plans, as well as surveying contour banks and waterways. Landholders undertook construction and maintenance of their runoff-control works at their own expense. Perhaps the Service's decline could have been an over-dependence on a particular technical solution by using disproportionate input of public sector resources. Soil conservation did not fully take on the wider role of integrating social, economic and ecological issues at an enterprise and catchment level.

Extension delivery included producing information materials, field days, show displays and attendance at farmer, industry and Landcare meetings. Since these extension officers were not selling any physical product, they were considered to provide impartial advice. Great emphasis was placed on the development of effective relationships and those farmers tardy in adopting soil conservation practices often received a friendly visit.

As governments and community groups have become more focussed on externalities (especially off-farm environmental issues like salinity, biodiversity and water quality) soil erosion has become less featured. Thus fewer public sector resources are now directly devoted to soil conservation. Over the last decade State agencies have greatly reduced (particularly one-on-one) extension services to farmers. A serious driver has been 'competitive neutrality' (Governments need to be mindful they do not provide unfair competition to private consultants) where certain and appropriate activities (if primarily of private benefit) are delivered by private practitioners or are 'fee for service'. A soil conservation service contains both private and public benefits and hence the role of agencies versus private practitioners is unclear. More recently in Queensland, new vegetation management practices and controls on tree clearing has required staff with particular skills and knowledge, and this drew heavily on former soil conservation extension staff.

While private agronomists now assist and advise farmers on growing crops, including zero tillage and controlled traffic, there are few consultants who assist farmers with the time consuming process of planning and implementing a soil conservation layout. Such planning often includes runoff coordination and negotiations with neighbouring properties within the catchment, and discussions with authorities responsible for roads, railway lines, electricity, communications, pipes and cable services. Coordination issues can be quite complex where overland flow passes through many properties before meeting a well-defined watercourse. Addressing runoff coordination is a casualty of the demise of soil conservation staff.

Proactive Landcare groups and catchment management committees have been able to address some of this void. Group members have been assisted through initiatives like the National Landcare Program (NLP) to acquire basic surveying equipment, farm planning materials and some of the necessary skills to use these tools. Current institutional reforms include the formation of Regional Natural Resource Management (NRM) Bodies, which have the responsibility of integrated planning, use and management of natural resources and biodiversity in their regions and catchments. Current priorities for these NRM Bodies include preventing salinity, improving water quality and the more sustainable use of natural resources including protecting biodiversity assets. These NRM Bodies will receive some taxpayer funds to invest in or to subsidise on-ground works to achieve 'end of valley targets' that

reduce nutrients and sediments in runoff. Such funds stem from initiatives like the Natural Heritage Trust (NHT), the National Action Plan for Salinity and Water Quality (NAP) and the National Landcare Program (NLP). Such interventions will include the development of social capital in rural and regional areas. Currently in Queensland over $9 million per year is invested in coordinator and facilitator staff employed by Regional NRM Bodies.

Regional NRM Bodies could provide an extension type service to assist farmers with the adoption of sustainable land management practices. But this will not happen unless staff are appropriately skilled with necessary technical backup. They will also require the equipment and resources to maintain a permanent record of the planning that is carried out. Applying 'user pays' and 'beneficiary pays' concepts will be the key to such services being successfully implemented.

Special funding

A variety of funding program initiatives mentioned above like the NHT, NAP and NLP have been available to assist implementing soil erosion control. Other programs such as those funded by industry research and development and Sustainable Farming Systems projects now also contribute. Landholders are now encouraged to adopt Environmental Management Systems (EMS) which are based on best management practices and codes of practice as a means of addressing the 'triple bottom line'. Concessional loans are now available for certain landcare works on a property where a code of practice is being observed. These works includes soil conservation works, erection of fencing, the modification of tillage and harvesting machinery and reclamation of degraded land.

The Australian Government's $2.5 billion NHT program is currently a significant investor in natural resources and environmental management. It has four themes – Landcare, Coastcare, Bushcare and Rivercare. One component called Envirofund enables community groups, and some individuals, to apply for grants to carry out on-ground actions to target local problems including soil erosion. Perceived public benefit is one of the grants' success criteria. Some Landcare groups have an interest in soil conservation. However they are unlikely to have capacity to provide technical or specialist assistance to landholders in soil erosion control.

There are some good examples of NLP projects with a strong soil conservation component, for example:

- The Brigalow Jimbour Floodplain Management Group project which is a community-driven 'whole of catchment' approach for six sub catchment groups within a 300,000 hectare area on the Condamine floodplains. Through its cooperative and partnership-based approach there is now coordination with individual landholders and also with utilities and road authorities.
- Two Neighbourhood Catchment groups have been established in the Fitzroy Catchment to develop and encourage the uptake of farming practices specifically aimed at protecting in-stream water quality, riparian zones and waterway health (Carroll *et al.,* 2004). Within these focus catchments, the effects of land management practices on water quality have been recorded. The process involves both group meetings with landholders and one-on-one extension. The success of the project has resulted in the Regional NRM Body adopting this approach as a service delivery model for dealing with land management issues in the Fitzroy catchment.

Industry and training support

Industry organisations are also taking steps to promote soil conservation. For example, the sugar cane industry assists and encourages canefarmers to grow cane in a more sustainable and profitable manner with their major code of practice/best management program called COMPASS - Combining Profitability and Sustainability for Sugar (Azzopardi, 2001). The pineapple industry has developed partnerships with State agencies, the Pumicestone Region Catchment Coordination Association and the processing company Golden Circle Limited, to produce more sustainable practices. Envirofund assistance was obtained to publish their own specific handbook on erosion control. The Conservation Farming Information Centre is a farmer-supported group based at Toowoomba which promotes the adoption of sustainable farming practices with a special emphasis on conservation tillage in broadacre grain growing.

The Queensland Department of Natural Resources, Mines and Energy (NRM&E) is currently producing a manual on the design of soil conservation measures in cropping areas for use by government agency staff, community groups and private operators. NRM&E recently conducted a series of workshops in the inland Burnett River district with farmers and contractors to assist them with planning and design of soil conservation measures. The success of the manual and workshop activities will depend on the motivation of landholders to reinforce their practical

knowledge, together with their ability to contact skilled people who can provide additional technical assistance if required.

Challenges

Major advances have occurred in the control of erosion in the cropping lands of Queensland. The visible sheet and gully erosion that was commonplace in the 1950s is no longer so evident. Farmers have generally been very willing to adopt soil conservation measures, although sometimes only in response to damage sustained in larger runoff events. Soil conservation measures such as the adoption of conservation cropping practices that retain crop residues on the soil surface and minimise cultivation have now become mainstream agricultural practice.

For the last decade, the State has been experiencing drought periods and lower levels of soil erosion leading to a degree of complacency by many farmers in the construction and maintenance of soil conservation measures. A return to weather conditions that generate serious erosion events may again heighten the need for soil conservation. Predictions that rainfall intensities are likely to be higher due to global warming climate change may add to this threat (Thacker, 2004).

Soil conservation measures have also provided direct economic benefit through sustaining farm productivity and reducing wear and tear on machinery. Government sponsored soil conservation programs were a forerunner to environmental management systems helping farmers become more aware of the impact of their practices on the external environment and encouraging producers to take advantage of the financial benefits of marketing food produced in an environmentally friendly manner.

While there have been many successes in controlling soil erosion in cropping lands, the task is far from complete. As new legislation will bring an end to broad scale land clearing in Queensland by 2006, and population pressure impacts on cultivated land areas, there is an urgent need to protect our cropping areas from further degradation. Declining water quality and turbid streams provide a constant reminder that many farming practices are still not sustainable and that levels of surface cover need to be improved. Significant areas still require protection with physical measures such as contour banks, grassed waterways and strip cropping. The wider community must be made aware that soil conservation is a continuing issue. A common public perception is that trees will solve all erosion problems. This is obviously not the case. The need to use land for the production of food is sometimes little appreciated.

Conclusion

Queensland's cropping lands represent a valuable resource supporting the expanding need for food production and exciting new products becoming available through biotechnology. However, the promise of future agricultural opportunities will be curtailed unless there is systematic and on-going priority for soil conservation to protect land from further degradation. Queensland's tropical and subtropical climate, intense rainfalls, and extent of clay and loam soils mean that soil erosion is perhaps the greatest threat to the future productivity of cropping land.

There are real private benefits to farmers in using soil conservation practices and there are also public benefits from improving water and soil quality and reducing downstream impacts in catchments. Soil conservation practices have made a significant contribution towards continued productivity of food production while also reducing sedimentation in riverine, estuary and coastal areas such as the Great Barrier Reef lagoon.

Private consultants can provide services in relation to advising farmers on soil conservation but they are unlikely to meet the needs of planning and design of soil conservation measures on a catchment basis. As a result, the need for extension services that promote the use of sustainable land management practices to farmers and the wider community remains. Since government agencies have constrained their provision of these services there is a need to consider and promote alternatives. The recently formed Regional NRM Bodies may take up a considerable part of this role, using a variety of interventions which may include social and economic capacity building; direct subsidy for on-ground works; working with industry organisations to promote market based instruments, accreditation and acceptable codes of practice.

Since extension services to promote sustainable management practices are a national issue, there would be benefit in convening a summit where, political, agency and community investors and stakeholders could negotiate land management policy needs for future years. This will deal with current uncertainties and strengthen the proactive stance of all Australians in the quest for soil and land sustainability.

References

Azzopardi, M. (2001). COMPASS: A Self-Assessment Workbook, BSES Indooroopilly, Brisbane, Queensland.
Berndt, R.D., and White, B.J. (1976). A simulation-based evaluation of three cropping systems on cracking-clay soils in a summer-rainfall environment. *Agricultural Meteorology*, 16, 211-29.
Carey, B. and Stone, B. (2001). Soil conservation planning in cropping lands, *NRM Facts series*, Number L83, Department of Natural Resources and Mines, Queensland.
Carroll, C., Dougall, C., Millar, G., Rohde, K., Stevens, S. and Sugars, C. (2004). How to reconnect landscapes and link people through Neigbourhood Catchments. *Proceedings 13th International Soil Conservation Organisation Conference, Brisbane, Australia*.
Department of Primary Industries. (1991). Land Conservation Branch Annual Report 1990/91. Department of Primary Industries, Queensland.
Freebairn, D.M. and Silburn, D.M. (2004). Soil conservation in Australia's semi arid tropics; pathways to success and new challenges. *Proceedings 13th International Soil Conservation Organisation Conference*, Brisbane, Australia.
Hunter, H.M., Eyles, A.G., and Rayment, G.E. (Editors) (1996) Downstream Effects of Land Use, Department of Natural Resources, Brisbane, Queensland.
Ladewig, J.E. and Skinner, A.F. (1950). Soil Conservation in Queensland — General Aspects. *Queensland Agricultural Journal*, 70,14-24.
Stephens, R.M. (1982). Soil Conservation Legislation in Queensland. Queensland Department of Primary Industries Bulletin.
Rosser, J., Swartz, G.L., Dawson, N.M. and Briggs, H.S. (1974). A Land Capability Classification for Agricultural Purposes. Division of Land Utilization Technical Bulletin No 14. Queensland Department of Primary Industries.
Titmarsh, G., Wockner, G. and Waters, D. (2004). Controlled Traffic Farming and Soil Erosion Considerations. *13th International Soil Conservation Conference Organisation Conference, Brisbane, Australia.*
Thacker, P.D. (2004). As the planet heats up will the topsoil melt away. *Journal of Soil and Water Conservation* Jan-Feb 2004, 59 (1): 13A-15A.
Thwaites, R. and Lloyd, P. (1995). Evaluating Queensland —Fifty Years of Land Resource Assessment, *Australian Journal of Soil and Water Conservation*, 8 (2): 9-14.
Yule, D.F., Cannon, R.S. and Chapman, W.P. (2000). Controlled traffic farming – technology for sustainability. *Proceedings of the 15th ISTRO Conference, Fort Worth.* (Compact Disc).