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Impacts of Acid Soils in Victoria

A Report for

Department of Natural Resources and Environment,
Goulburn Broken Catchment Management Authority,
North East Catchment Management Authority,

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Executive Summary

Soil acidification: the invisible issue

Soil acidification: a major threat to productivity and lifestyle in Victoria.

Background

Naturally acidic soils and acidifying soils generally occur in areas where rainfall exceeds 500mm/year, affecting some of the most productive agricultural land in Victoria. More recent data (Slattery et al. 1996) would suggest that even soils in the <500mm rainfall zones are becoming strongly acid in the surface soil profile. Estimates suggest that 3 million hectares or 23% of the State's agriculturally productive soils are affected by losses in productivity due to acidity. In addition, soil acidification is likely to have substantial off-site effects on water quantity and quality and as a result, on dryland salinity (Scott *et al*. 2000). The most strongly acidic soils occur in permanent pasture areas. More than half of the affected soils are located in North East Victoria.

This report aims to improve the awareness of the impact of soil acidification and identifies issues that should be considered in developing a strategy to manage acid soils.

The report examines the issue of soil acidification in Victoria and highlights that soil acidification may have both on-site and off-site effects. It also identifies options for promoting the sustainability of these acid soils. These options include modifying the grazing system, the use of perennial species, changing land-use, forestry or land retirement.

Causes of acidification

While acidification is a natural process, agricultural practices greatly accelerate the rate of acidification on all soil types. The reasons for this increased rate can be explained by understanding the main causes of soil acidity.

The four main causes of soil acidity are:

- Removal of product from the farm or paddock
- Leaching of nitrogen as nitrate below the plant root zone
- Inappropriate use of nitrogenous fertilisers
- Build up of organic matter

Soil acidification rates vary according to the agricultural production system in use.

- Cropping (product removal and nitrate leaching are usually the most significant factors)
- Grazing (nitrate leaching and build up of soil organic matter are the major causes)
- Horticulture (much of the acidification is related to fertigation)

Irrespective of the production system the challenge is to manage the causes of acidity to either slow the acidification rate or neutralise the extra acid. Soil acidification affects the chemical and biological balance of the soil, causing toxicities of some elements and deficiencies of others. The major impact is reduced plant growth and productivity which has a significant economic impact for the land holder.

Farming, which interrupts the natural cycles by removing (exporting) crop and animal products, makes soils more acid. The technical solutions of applying lime and changing farm systems are expensive and challenging. Without additional solutions, soil acidity will not only lead to a reduced gross value of agricultural production, but a reduction in the effectiveness of strategies tackling dryland salinity. Soil acidification is insidious and not obvious in the landscape. Acidity is more effectively tackled before it is apparent. By the time plant decline is obvious, the chances of complete soil restoration could be hampered.

The use of acid tolerant plants has been advantageous in maintaining the ability to grow productive crops on strongly acid soils. The use of tolerant plants alone however, is not a sustainable solution, as the soil will continue to acidify. However, tolerant plants do provide an opportunity to regain control of the acidity problem by providing cash flow for longer term solutions. If soils are allowed to become strongly acid the consequence is that irreversible soil damage may occur. The task of returning these soils to a productive state will become increasingly difficult and costly. In addition, there may be increased and avoidable offsite costs, particularly if off-site impacts of declining water quality and infrastructure decline are linked to soil pH decline.

Impacts of soil acidification

The impacts of acidification are not constrained solely to farm based issues, but are likely to have a far reaching effect on the natural resources that ultimately determine the quality of life in our urban and rural communities. For

example, soils that are allowed to become strongly acid with a pH_{Ca}[1] of 4.0 or lower are subject to losses in the fine clay fraction (Slattery *et al.* 2002) which may ultimately lead to landscape degradation.

Soil acidification is likely to have both on-site and off-site effects (Cregan and Scott 1998). Off-site effects are associated with reduced plant growth and reduced plant water use because acidification infleunces root growth and access to nutrients. The opportunity costs of not being able to grow species sensitive to soil acidity may be significant and also impact on management of other land degradation problems such as erosion in high rainfall zones or dryland salinity in the 500 - 600 mm rainfall zone due to the lack of vegetative cover or inability to grow perennials..

Other off-site impacts may include turbidity (from decreased ground cover as a result of poor plant growth) and elevated phosphate (due to soil loss) and increased nitrate concentrations of waterways. Low ground cover predisposes land to erosion. In addition, soil acidification could ultimately have signficant off-site effects on water quantity and quality. Off site impacts of soil acidification raise many research issues, some of which are listed in Table I.

Table I. The known and unknown impacts of soil acidification for a range of issues.

Issue	Impacts of soil acidification Known	Unknown
Agricultural production	• reduced agronomic choices • toxicities of Al to plant growth • reduced plant growth of sensitive species • increased loss of fine clay fraction	• movement of nutrients beyond paddock • ability of organic matter to protect plants from low pH
Terrestrial biodiversity	• reduced earthworm numbers • reduced rhizobium survival and persistence	• microbial populations • soil fauna biodiversity
Aquatic biodiversity		• impact of acid soils on stream pH • impact of declining stream pH on aquatic life • degree of sedimentation caused by declining soil pH • impact of soil pH decline on water quality
Utilities		• impact of acid soils on road structure, power generation, water quality • impact of acid soils on concrete foundations • impact on road surfaces due to a lack of roadside vegetation
Industry	• concrete and steel deterioration in acid soil conditions	• Increased wear and tear due to reduced water pH, and increased sedimentation
Regional and Urban communities	• gradually declining economy due to agricultural production losses	• Flow on effects of externalities on lifestyle and sustainable land management

[1] Unless otherwise stated, all pH values referred to in this document are measured in 0.01M $CaCl_2$ (These values are generally 0.8 of a unit lower than when measured in water)

Predicting the future condition of Victorian landscapes

A projection of surface soil pH levels for the year 2050 has been estimated using:

a) current rates of acidification for the major enterprises within a broad catchment area,

b) current amounts of lime applied in Victoria and

c) best available knowledge of surface soil pH values (Fig 1).

In this scenario the amount of land in Victoria that will have become strongly acid will have doubled (Soil acidification rates based on Slattery *et al.* (1996) for surface soil on maps published on the *Victorian Resources Online* websit *)* to be around 6 million hectares. This will effect principally the North East and Goulburn-Broken catchments as illustrated.

The estimated lost agricultural production where soil acidity is an issue, would be considerable, assuming soils are treated at current lime application rates and at current rates of adoption of improved farming systems. The cost of soil acidification to rural and urban communities will be dependent upon the impacts on economic growth, whereas the cost to the broader community will be from the impacts on water quality, biodiversity decline and the deterioration of infrastructure, if proven. These impacts will be highest in the North East, Goulburn-Broken, Glenelg-Hopkins, West Gippsland, *Southern* North Central and *Southern* Wimmera catchments (Table 2).

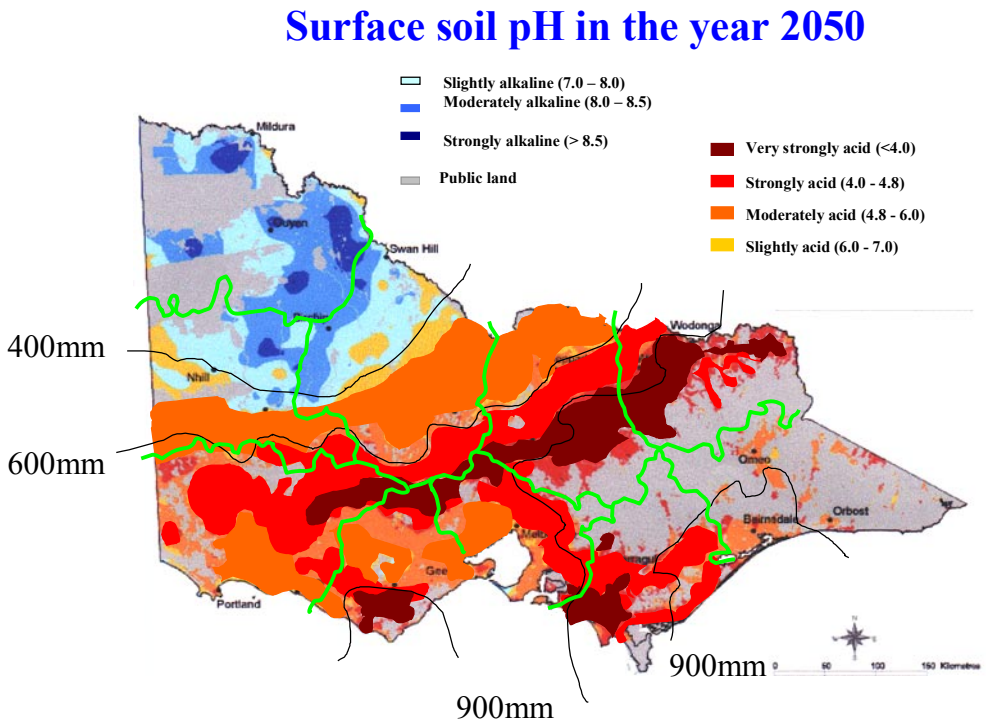

Figure 1. A predictive view of surface soil pH_{Ca} in Victoria in the year 2050.

Table 2. Acidification rating, impacts and remedial actions for each CMA catchment in Victoria.

Risk rating	CMA Catchment	Future Impacts	Remediation and monitoring activities
High	**North East** **Goulburn-Broken** **Glenelg-Hopkins** **West Gippsland** ***Southern* North Central** ***Southern* Wimmera**	Production loss, Decreasing ground cover, Increasing salinity as a result of poor ground cover, Declining biodiversity.	Education, liming, increase perennial pastures, and monitor soil pH and Al. Research required to maintain productive soils.
Medium	**Corangamite** **Port Phillip** ***Northern* North Central** ***Northern* Wimmera**	Production loss, Decreasing ground cover, Increasing salinity as a result of poor ground cover,	Education, lime, increase perennial pastures, and monitor soil pH and Al
Low	**Mallee** **East Gippsland**	Decreasing production if soils allowed to become strongly acidic. Unlikely for some time.	Monitor soil pH.

In order to tackle the soil acidification issue a strategy & planned approach is required. Such approaches should include setting targets for catchments that are realistic to achieve widespread environmental and economic benefits and also recognise that in some cases there may be enterprise change options needed to account for acid soils that are too costly to revert back to productive agriculture.

Strategies to increase the rate of adoption of liming programs, maintain vegetation cover and evaluate enterprise change options need to be considered for the continued economic and social viability of catchments. Soil acidification strategies need to be developed and include initiatives aimed to improve communication between stakeholders in the community. Development of environmental management systems for farmers offer improved tools for landholders to monitor and manage acidity. Simple paddock soil testing programs are essential for all farmers. A clearer understanding of the current status of surface and subsurface soil pH is needed in order to plan liming programs or strategies that consider alternative land use. The fundamental understanding of the impact of soil acidification on water quality is also needed.

Recommendations

This report collates both current knowledge and knowledge gaps on the status and effects of soil acidification in Victorian catchments. The initiation of future research, development and extension activities in acid soils will require partnerships between community and private sector groups with a clear understanding of what can be achieved by each. In order to facilitate such programs it will be important to link the outcomes from any acid soils strategy to that of other natural resource programs.

Acidification issues on soils should not be studied in isolation, but should be inextricably linked to other land degradation problems such as erosion, vegetation and soil biological biodiversity, salinity, greenhouse gas emissions and water quality. A strategic approach to controlling the threats of soil acidification might consider the tasks listed in Table 3.

Table 3. Actions required in the development of a strategy to manage acid soils.

Priorities	Task
Cost and Impact Analysis (Identifying distribution of causes and impacts)	Develop a concise estimate of causes of soil acidification in Victoria and the distribution between land owners and Government of financial costs and benefits of treatment. : Examples of private may include increased production, reduced costs and production losses, and increased land value Possible public benefits may include improved water quality, amenity values, reduced expenditure by governments on repairs to public assets damaged by land and water degradation, maintaining land-use options for future generations, and conservation of biodiversity.
Community & Education Program	Develop a focused education program to increase the awareness of landholders and the general public about the causes of soil acidification, the extent of the problem and the impacts on the environment. Communities and landholders will only accept cost-sharing arrangements and acceptable rates of implementation works after trusting partnerships have been developed, and after satisfactory levels of education and demonstration have been achieved.
Adequate Monitoring Program	Understanding the currrent status of surface and subsurface soil pH. Conduct a statewide monitoring program to understand the extent of the acidification problem within each catchment, which will identify priority areas for immediate action. This data will assist in the planning of cost effective actions to protect the most valuable assets and reduce the most significant external impacts on the environment.
Identification of priority zones, regions and/or sub-catchments	For each catchment there is a need to classify and prioritise landuse on the basis of productive capacity, social and economic viability of the region.
Best practice management guidelines	Promote the use of best practice guidelines for a range of industries in order to control the current rate of acidification.
Research & development	A key outcome of R&D will be improved management of the environmental impacts of soil acidification in Victoria and the integration of these management practices with other state strategies, particularly the salinity program. • Investigate alternative strategies (other than lime) for increasing or maintaining soil pH, reduce the offsite impacts from acidifying processes, and maintain or improve productivity with minimal soil pH decline. • Define the impact of soil acidification on water quality and infrastructure • New land management practices to increase the resilience of the soil to acidification and thus allow these acid soil environments to remain economically viable. • Identify targeted programs for high risk soils under a productivity enhancement program to determine where there are off-site impacts and to decrease their impact and maintain the states water and soil resources • Use of novel plant based technologies could provide solutions for ameliorating soils without the use of lime.