Land 3

3.1 Management of soils and land

Soil resources in New South Wales are in fair condition overall, both on a statewide basis and at the regional scale. Significant land degradation issues still remain. Increasing pressures on soil resources are a result of growing populations, increasing intensification of agriculture and degrading vegetation conditions.

Significant specific land degradation concerns are apparent across the state, with 74% of the 124 priority soil monitoring units examined being rated as poor or very poor for at least one degradation hazard.

Conservation farming practices such as reduced tillage have helped improve soil condition generally – soil structure in particular – and also control erosion. The extent to which they improve organic carbon levels and prevent acidification is less clear and these remain issues. Wind erosion is an ongoing concern in the western parts of the state. Both inland and coastal acid sulfate soils have improved in condition with wetter seasons recently and ongoing rehabilitation initiatives.

Land and soil capability and land use have been mapped across NSW for the first time showing the capability of the state's soil resources and the land-use pressures on those soils. Current land management practices are broadly sustainable and generally lead to only a moderate risk of degradation but the level of risk varies across soil health indicators and catchment management areas.

NSW indicators

Indicator and status	Trend (over decade)	Information availability
Soil health index (overall)	Stable	✓✓
• Soil acidity	Stable	✓✓
• Soil carbon	Stable	✓✓
• Soil structure	Stable	✓✓
• Acid sulfate soils	Stable	✓✓
• Soil salinity	Stable	✓✓
• Sheet erosion	Stable	✓✓✓
• Gully erosion	Stable	✓✓
• Wind erosion	Stable	✓✓
Land use within capability	Increasing	✓✓
Land management within capability	Increasing	✓✓
• Soil acidity control	Increasing	✓✓
• Soil carbon decline control	Increasing	✓✓
• Soil structure decline control	Increasing	✓✓
• Acid sulfate soils control	Increasing	✓✓
• Salinity/waterlogging control	Increasing	✓✓
• Sheet erosion control	Increasing	✓✓
• Gully erosion control	Increasing	✓✓
• Wind erosion control	Increasing	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

The economic and ecological prosperity of NSW depends in part on improving soil health and ensuring that land is managed and used sustainably. Despite improved soil health in some areas in recent years, human-induced soil degradation remains widespread due to the high levels of disturbance from traditional approaches to preparing the land for cropping. Major climatic events, such as high intensity rainfall and prolonged droughts, can also exacerbate land degradation processes. Soil degradation represents one of the most difficult environmental management problems facing NSW and reflects a global trend in the decline of finite soil resources (Bai et al. 2008).

A key factor constraining the sustainable use of soil is that it is essentially a non-renewable resource, as soil formation is an extremely slow process. Soil renewal rates are very slow and beyond human time frames (Bui et al. 2010).

Some impacts from land use, such as dryland salinity, have a time lag before changes become evident and may continue to unfold over a number of decades. Cumulative exposure of land to inappropriate practices increases the risk of incremental and often significant degradation. The consequences of some types of land degradation, such as soil loss from accelerated erosion, dryland and irrigation salinity, and subsoil acidity, are long term and often irreversible. Other forms of degradation, such as nutrient decline and surface soil acidification, can be remediated if addressed early, but this can be very expensive (Lockwood et al. 2003).

Status and trends

Soils make a significant contribution to the prosperity of NSW, but this comes at a considerable cost. A significant proportion of the state is experiencing at least one form of soil degradation and many areas are facing a number (NSW SSPWG 2008). Degradation in some areas was noted decades ago (SCS 1989). Although improvements in soil health have been evident in some areas in recent years, human-induced soil degradation continues elsewhere, remaining widespread due to historic factors and representing one of the most difficult environmental management problems facing the state (NSW SSPWG 2008).

There is a critical and ongoing need to better understand the impacts of land use and management practices on the state's soils and continuously improve them so NSW is able to meet the demands placed on its terrestrial ecosystems by current and future generations. The land's capacity to meet these demands is constrained by intrinsic factors (such as soil properties, water availability and climatic variability) and extrinsic social and cultural factors (for example, rural population decline).

This section presents a snapshot of the health of NSW soils, taking into account recent trends relating to weather. Note that the terms 'soil health' and 'soil condition' are used interchangeably.

Soil health across NSW

Soil health is the ability of soil to deliver essential ecosystem services, including decomposition, nutrient transformation, exchange and cycling, water partitioning, climate regulation (such as through carbon storage and cycling), provision of habitat for biota, and provision of media for primary production and food resources.

Soil health is characterised by testing key soil attributes that can be used as soil health indicators at appropriate sites. NSW uses eight indicators which relate to soil characteristics (soil acidity, soil carbon, soil structure, acid sulfate soils and soil salinity) and soil processes (sheet, gully and wind erosion) as described in **Table 3.1**. A quantitative value is derived by comparing the current state of the indicator with that of an undisturbed 'reference' soil under natural conditions (Chapman et al. 2011).

Soil health indicators can be combined in various ways to produce soil health indexes. For example, a soil health index for a particular region may be based on data for all the soil health indicators for that area; alternatively, data on a particular soil health indicator from many regions may be used to produce an overall index for that indicator. The state soil health index is an overarching index that combines all the soil health indicator data from regions across NSW. Indexes are a useful way of looking at what is happening overall. However, information can be lost when data is averaged and therefore indexes should not be used to make site-based management decisions.

The most recent systematic statewide assessment of NSW soil health was undertaken under the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (MER Strategy) (DECCW 2010a) and commenced in 2008. The monitoring program aimed to establish a baseline of NSW soil condition by setting up a permanent network of condition monitoring sites. For soil acidity, soil carbon and soil structure, this means up to 10 monitoring sites in each of 10 priority soil monitoring units (SMUs) in all of the 12 rural catchment management authority (CMA) regions and four SMUs in the Sydney Metropolitan area, a total of 1240 sites. SMUs were selected on the basis of their importance, expected changes in use and number of soil issues present. Where possible, sites were paired on the same soil type but across different land uses, including undisturbed reference sites. Approximately 6% of sites across the state (around 50) are in national parks, state forests and nature reserves and these are commonly used as reference or control sites (Chapman et al. 2011).

A program of soil data collection, with laboratory analysis, was undertaken at each site, together with the collection of land management data. By May 2009, 850 sites had been established and full laboratory testing took another two years to complete. The MER program provides most of the data used to assess soil condition and the extent of sustainable land management, as reported in this chapter. This dataset will provide a valuable baseline allowing changes in NSW soil resources and land management behaviour to be assessed into the future.

Table 3.1: Soil health indicators

Indicator	Degradation process
Soil acidity	Soil acidity is a major indicator of soil chemical health. Acidification can reduce soil health and productivity and ecosystem function. Acidity is associated with erosion, soil structure decline and salinity.
Soil carbon	Organic carbon is a prime biological determinant of soil health. Organic carbon is sensitive to land management practices, including those which sequester carbon from the atmosphere. Soil has the largest concentration in the carbon cycle (Bolin et al. 1979).
Soil structure	Soil structure is the arrangement of soil particles and voids. It governs soil water storage and movement and gas exchange and is the prime physical determinant of soil condition. Soil structural condition is sensitive to land management practices.
Acid sulfate soils	Coastal acid sulfate soils are low-lying coastal soils from previous marine environments which, when drained or exhumed, can discharge sulfuric acid. They have the potential to cause profound terrestrial and aquatic ecosystem damage. Sulfidic sediments have often been thought of as only a coastal phenomenon but are now known to be common in inland wetlands (MDFRC 2007). One study of 81 wetlands in the Murray–Darling Basin found 17 (roughly 20%) were characterised as actually or probably containing sulfidic sediments. Although most were adjacent to the Murray River, potential acid sulfate soils were also found in wetlands in the Murrumbidgee, Lachlan and Macquarie valleys (Hall et al. 2006).
Soil salinity	Soil salinity is the accumulation of salt on or near the ground surface. It has the potential to cause profound terrestrial and aquatic ecosystem damage, including massive erosion.
Sheet erosion	Sheet erosion is caused by rain splash and diffuse water flows. It removes topsoil and reduces productivity, terrestrial biodiversity and ecosystem functions. Many soils have eroded severely in the past to the extent that the topsoil has been completely removed. Off-site sediment and nutrient export affects water quality, aquatic ecosystem function and productivity.
Gully erosion	Gully erosion is the erosion of topsoil and subsoil by concentrated overland water flow. It reduces land management options, water quality and terrestrial and aquatic ecosystem function through the delivery of sediment. Gully erosion is expected to be sensitive to climate change.
Wind erosion	Wind erosion reduces air quality, land management options and terrestrial ecosystem function. Burial and deposition of nutrients can harm biodiversity. Dust deposition can significantly alter aquatic ecosystems. Wind erosion is expected to be sensitive to climate change.

Notes: The NSW Government has not systematically monitored the condition of inland acid sulfate soils, but has surveyed land management actions that might cause their acidification.

Updated soil health indicator ratings for CMAs in NSW (seven ratings each for the south coast CMA and the nine inland CMAs, and eight ratings each for the remaining three coastal CMAs) and the state as a whole have been derived using the updated MER data. Additional data was collected for acid sulfate soils (Tulau 2010). Advances in modelling using improved digital elevation models and time series-based satellite monitoring of ground cover also allowed data on sheet erosion to be updated (Yang et al. 2011).

The results indicate that, on a statewide basis, soils in NSW are in fair condition. On average, there has been a noticeable and moderate decline in the condition of NSW soils relative to their undisturbed reference condition. There has also been a moderate loss in the ability of NSW soils to provide ecosystem services, including agricultural productivity.

Some parts of the state and some particular soil condition indicators, however, are in an overall poorer condition and exhibit a significant loss of soil function. When considering the 94 reported soil condition ratings, 38% are in good condition, 46% are fair and 16% are in poor condition. Of the state's 124 SMUs, 74% were rated as poor or very poor for at least one degradation hazard. This indicates that although most regions appear to have broadly stable soil conditions, significant specific issues of land degradation remain.

Figure 3.1 depicts the proportion of soil monitoring sites that fall into the four classes of soil health for each of the soil health indicators.

Map 3.1 presents the most dominant soil health issue, according to the relative cost of rectification, within each SMU. The results suggest that on a statewide basis, low soil carbon and sheet erosion are moderate issues of concern, with soil structure and salinity also being of concern. Acid sulfate soils are of significant concern in some coastal and drying inland riverine areas. Map 3.1 shows that sheet erosion and salinity are the critical soil condition issues in the eastern part of the state, while wind erosion and soil carbon decline dominate in the west. Further details on the apparent recent trends are provided in the following discussion.

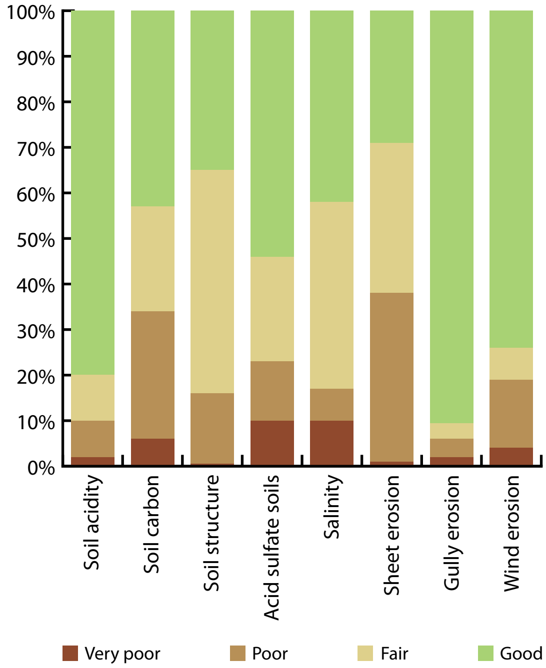
Recent trends in soil health

Much of the observed decline in the condition of NSW soils can be attributed to historic management approaches. Since the 1990s, there have been improvements in soil management, such as conservation farming and cell grazing, that can help minimise further loss of soil condition. The analysis of recent land-use and management practices over NSW reported in the 'Pressures' section below supports the ongoing improvement in sustainable land management.

The interaction of seasonal weather conditions with land use or land management actions can increase the risk of land degradation that affects soil health. Over the last two years, with the end of the drought, degradation hazards such as wind erosion and acid sulfate soils have diminished with the wetter conditions. However severe widespread flooding in the summers of 2010 and 2011 exacerbated erosion, mass movement and salinity because ground cover had not yet re-established after years of drought.

The impacts of recent events on selected soil health indicators, including wet conditions, are discussed below.

Figure 3.1: Proportion of soil monitoring sites within each soil health indicator category



Source: NSW Office of Environment and Heritage (OEH) data 2012

Notes: Data from the 2009 MER Strategy soils project published in *SoE 2009* (DECCW 2009) has been augmented with further testing of MER samples, re-analysis of the full MER dataset, and the inclusion of new unpublished data on inland acid sulfate soils and sheet erosion.

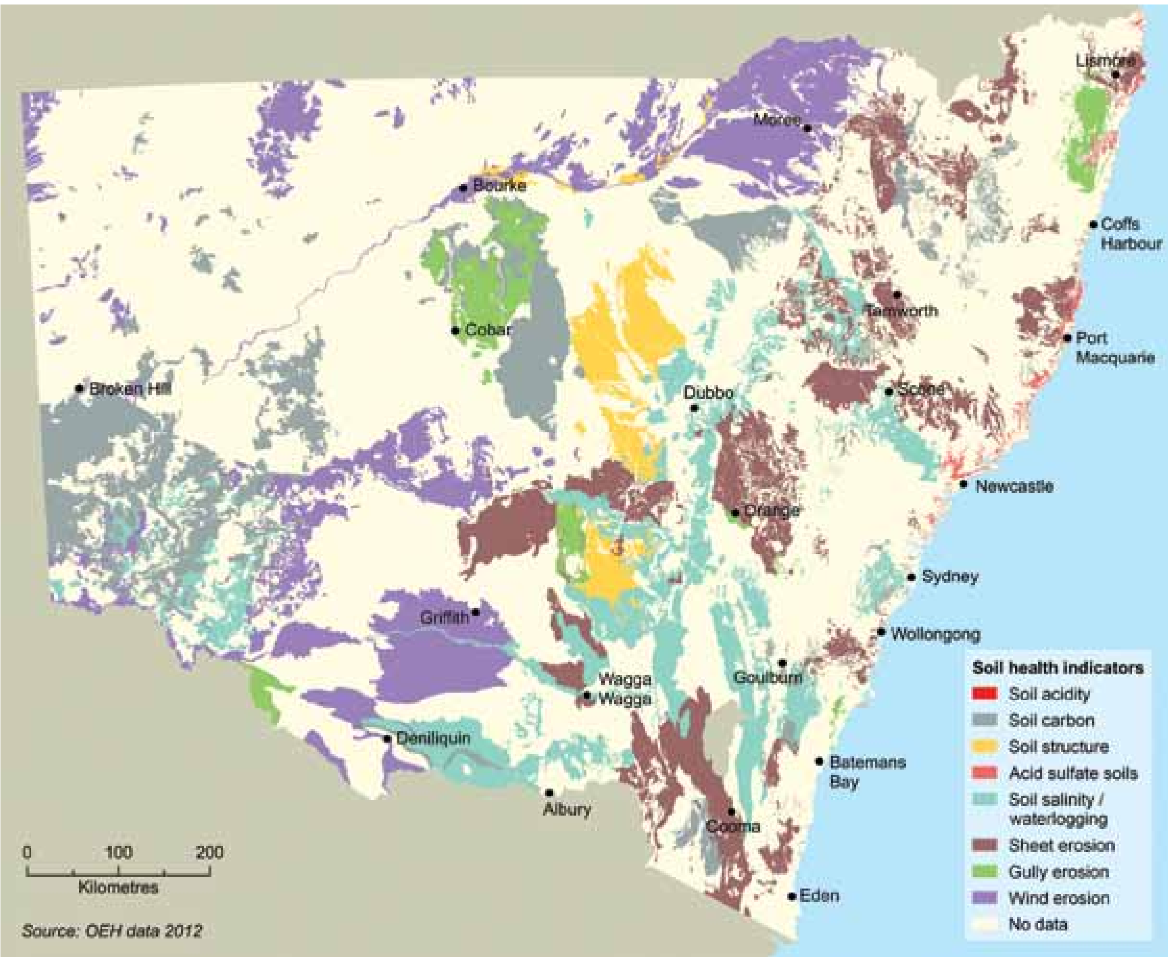
Soil acidity

Increased soil acidification is expected in southern NSW as a result of higher summer rains and a shift toward canola production. Grazing on fertilised annual pastures is also contributing to acidification. Agricultural lime is normally used to ameliorate acidity with usage increasing over recent years. 'Land management within capability' analysis reveals this issue is being managed the least sustainably of all potential land and soil hazards across NSW.

Soil carbon

Benign wet and milder growing conditions have led to increases in pasture and plant growth which, combined with low stock numbers after the drought, are generally expected to increase carbon levels in soil. Organic carbon is assessed as being a moderate issue of concern across the state, with land management for this issue being broadly sustainable.

Map 3.1: Dominant soil health issues within soil monitoring units in NSW



Notes: Areas of 'no data' fall outside the soil monitoring units' dataset, but other information may be available about them.

Soil structure

A generally increasing uptake of conservation farming techniques and low stocking rates after the drought have seen improvements in soil structure. Saturated soils are particularly prone to structure decline from mechanical disturbances, such as machinery traffic, stock movement and cultivation, but the extent of any recent damage is not known. Structure decline is a particular issue in areas with sodic surface soils.

Acid sulfate soils

Acid sulfate soils have generally improved in condition with rehabilitation initiatives, better land management practices and continuing wetter seasons.

Soil salinity

Above-average rainfall in 2010 and 2011 has caused groundwater levels to rise and remobilise the salt which had previously concentrated in the soil during drier conditions. As a result, increases in stream salinity levels have been observed and previously inactive salinity sites are becoming active again (Allan Nicholson, OEH, pers. comm., 24 May 2012). There is a lag time between climatic events and the expression of salinity symptoms, so the area of land affected may increase again in response to the recent wetter conditions. This is significant because agricultural productivity is substantially reduced in areas affected by salinity. Also salt present on the soil surface is more likely to be dispersed into the wider environment, including waters. Land management for this hazard is broadly sustainable on a statewide basis.

Sheet erosion

Sheet erosion has increased over most of NSW with the exception of the Murray, Murrumbidgee and Lachlan floodplains over the last 10 years. Following the breaking of the drought in 2010, continuing wet conditions have resulted in improved ground cover due to the soil moisture available. However, analysis of sheet erosion rates compared with the amount of bare soil vulnerable to erosion shows that over the last two years increases in ground cover have been insufficient to effectively reduce erosion. A reduction in severe bushfires has brought with it less erosion in bushland.

Land management for this hazard is broadly sustainable on a statewide basis using the 'land management within capability' analysis in the 'Pressures' section below.

Gully erosion

Increased rainfall from two consecutive La Niña events in eastern Australia since April 2010 has increased concentrated channel flow, worsening gully and streambank erosion. Gully erosion is a concern on the north coast and western slopes and tablelands. It is generally associated with unstable granite-based soils and dispersible (sodic) subsoils on rolling to moderate slopes. Over the longer time scale, however, land management for this hazard appears to be broadly sustainable.

Wind erosion

Wind erosion is a significant issue of concern in the western regions of the state. It is only an issue in limited areas of the central regions and is stable in eastern regions. Data from the DustWatch network shows that during the current reporting period, dusty conditions peaked in north-western NSW in spring 2009 and then declined substantially with 2010's record-breaking rainfall. In south-western NSW, retention of adequate ground cover during autumn, especially in years of below-average rainfall, remains a critical factor in the management of wind erosion (John Leys, OEH, pers. comm., 23 May 2012). 'Land management within capability' analysis reveals this issue as one of the least sustainably managed of all potential land and soil hazards across NSW, particularly in the western regions (see the 'Pressures' section below).

The worst dust storm to hit Sydney since reliable records began in 1940 lasted for nine hours from the morning of 23 September 2009 and reduced visibility at the airport to 400 metres. The dust storm was the product of drought and extreme wind conditions. The source of the dust was the red sandplains of western NSW and the sandplains, riverine channels and lakebeds of the lower Lake Eyre Basin and Queensland's Channel Country. The rate of dust loss off the coast near Sydney peaked at over 70,000 tonnes per hour with an estimated 2.54 million tonnes of total suspended particulate sediment deposited off the Australian coast along the 3000-kilometre-long storm front. Impacts and costs included increases in respiratory diseases and traffic accidents; cancelled air, road and ferry services; power supply disruptions; and the cost of cleaning homes, businesses, machinery and infrastructure (Leys et al. 2011).

Future trends in soil health

Climate changes – including higher temperatures and evaporation levels, along with generally lower but more erratic and more intense summer-dominated rainfall – are predicted to lead to various increased pressures on NSW soils.

Soil acidity

Changes in rainfall and evaporation are likely to affect leaching and therefore modify soil acidification in many areas. In the south of the state, reduced winter rainfall is expected to decrease the amount of deep drainage and, in turn, soil acidification (DECCW 2010b). However, acidification is likely to remain a problem because leaching is only one of its causes and changes in particular areas will depend on local factors.

Soil carbon

Hotter dryer conditions, especially in the south, are expected to reduce soil carbon (DECCW 2010b).

Acid sulfate soils

Major changes are likely in the character and development of acid sulfate soils on coastal plains. Initially, a change in the seasonality of rainfall is expected to increase the production and mobilisation of acid. However, reductions in acid development will occur over the next 50–100 years as watertables rise with sea levels (DECCW 2010b).

Soil salinity

Likely changes in rainfall and evaporation in all regions will have an impact on the balance between runoff and overland flows, and shallow drainage and deep drainage. These changes are expected to affect the mobilisation and concentration of salts, with responses differing between catchments. Impacts on soil salinity are likely to be complex and difficult to predict. Whether salinity will increase or decrease in particular areas will depend on local factors for each catchment (DECCW 2010b).

Soil erosion

Changing climatic conditions are likely to have implications for agriculture and food production in NSW because of an increased frequency of drought, a declining availability of water (from changes to both rainfall and evaporation), and altered storm and flooding patterns. The resulting poorer growing conditions will reduce vegetation cover and increase soil erosion, especially in the vulnerable sodic soils of the western clay plains of NSW. The consequent soil erosion will heighten the need to increase the resilience of water infrastructure and land management systems (Climate Commission 2011).

The combination of more intense storms, especially in summer and spring, and an overall reduction in vegetative ground cover (possibly exacerbated by changes to bushfire regimes) is likely to lead to more sheet and rill erosion and increased gully erosion if overland runoff increases. Wind erosion could also increase due to the loss of protective vegetation, especially grasses and other ground-cover plants (DECCW 2010b).

Pressures

Pressures on soil condition are primarily due in the short term to weather conditions and land management actions, often in combination. The extent of risk and type of degradation depends on the resilience of the soil and vegetation cover to withstand degrading processes. Over the long term, land management is the prime determinant of soil condition. Land management tools and techniques will need to be adapted to maintain or improve soils as climate change impacts become more apparent.

'Land use' is defined as the purpose to which land is put (such as forestry or cropping) whereas 'land management' operations are the detailed activities involved in undertaking the land use (such as tree thinning or stubble burning). 'Land capability' is the inherent capacity of land to sustain land use or land management risks or pressures. It is the intensity of disturbance – created by human intervention, coupled with seasonal conditions and features of the land (such as soil type and slope) – which carries a risk of land degradation. Prolonged exposure to risk increases the probability of a loss in soil condition. The degree of land degradation in turn depends on the resilience or capability of the land.

Pressures that influence land use and land management are numerous and involve economic, social and environmental factors. Land use and land management regimes can sometimes lead to improvements in soil condition or prevention of its deterioration (Strudley et al. 2008). On the other hand, inappropriate land management practices can place land at a risk of significant degradation. The key to sustainable land management is to understand the processes that lead to land degradation at any particular place and then manage the land within its inherent capability.

Land management decisions are often made with imperfect knowledge of future weather and markets. As fuel becomes more expensive and competition for essential resources like water and fertilisers increases, there will be significant challenges to sustainably managing the land (Cribb 2010). This will be exacerbated in the future by increased population pressures: for example, a 70% increase in global demand for food is predicted by 2050 (CSIRO 2012). These pressures will be coupled with the expected climate change effects of drying and extreme weather events for much of NSW (DECCW 2010b). Changes in climate are expected to lead to changes in land use as well as changes in land management.

This section considers how land capability is assessed and whether current NSW land use and land management practices are conducted within the land's capability.

Assessment of land capability

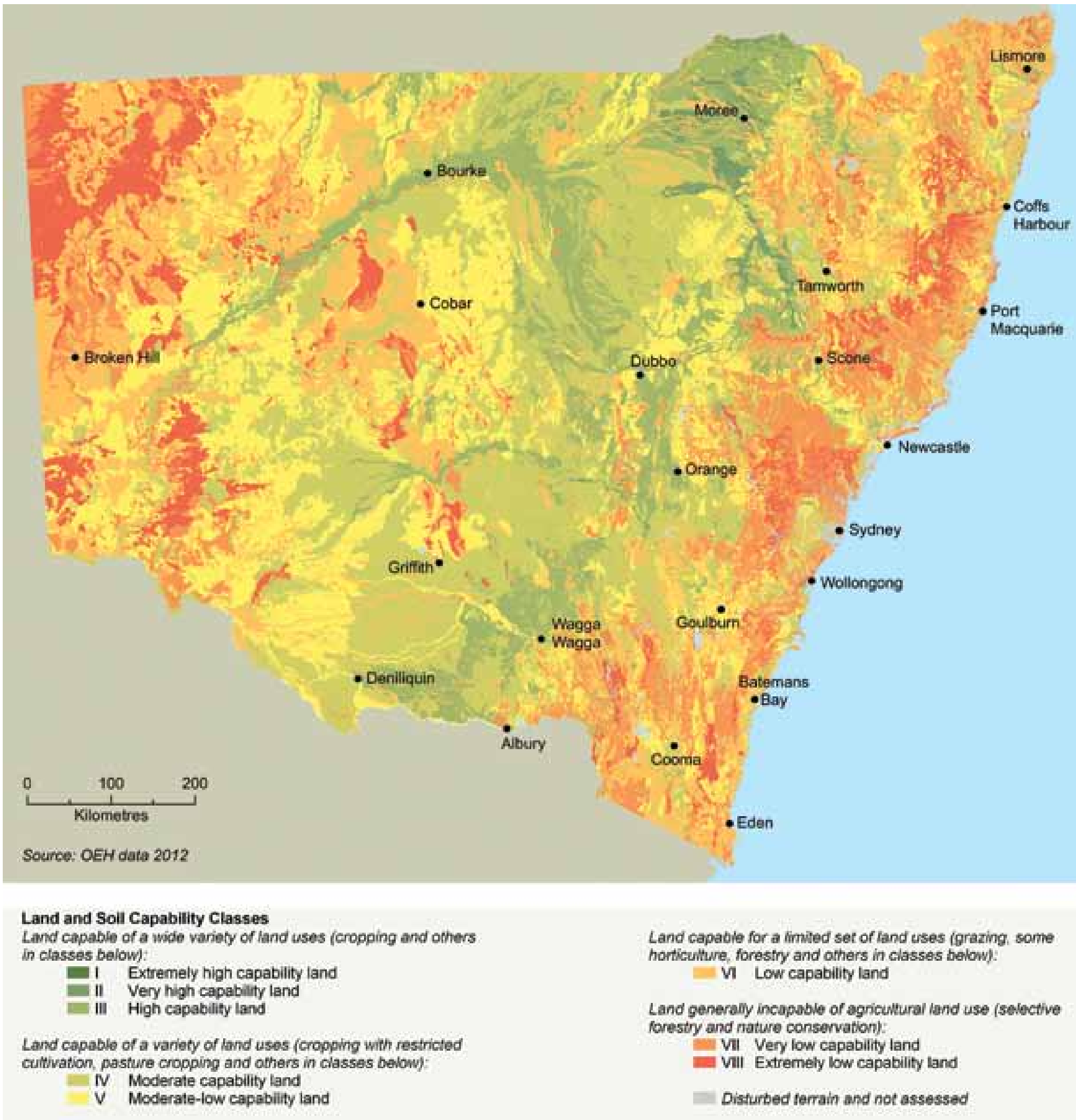
While many land degradation causes and processes are understood, the complex relationships between variable climate and interdependent land management risks and the cumulative impacts on soil condition are difficult to assess or readily quantify (Bennett et al. 2010).

To help assess these complex relationships, the NSW Government developed the Land and Soil Capability (LSC) classification system. This is a rules-based approach for allocating land into one of eight land and soil capability classes based on both on-site and off-site limitations of the land, that is, the resilience of land to withstand the various known impacts of land use and land management.

Within each class there are limitations caused by differences in climate, soil type, existing erosion, slope, landform position, acidity, salinity, drainage, rockiness and a range of other factors. Each limitation has its own sub-rule set and each has to be managed to avoid land degradation and make full use of the potential of the land.

Map 3.2 is the land and soil capability map for NSW. Land shown in green has the most resilience to withstand disturbance and land in red the least.

Map 3.2: Land and soil capability in NSW



The distribution of the most limiting types of land and soil hazard (including, for example, soil erosion, salinity and rockiness) using the land and soil capability map is shown in **Map 3.3**. Where more than one land and soil hazard is present within the same land and soil capability class, the most difficult to remediate is shown on the map.

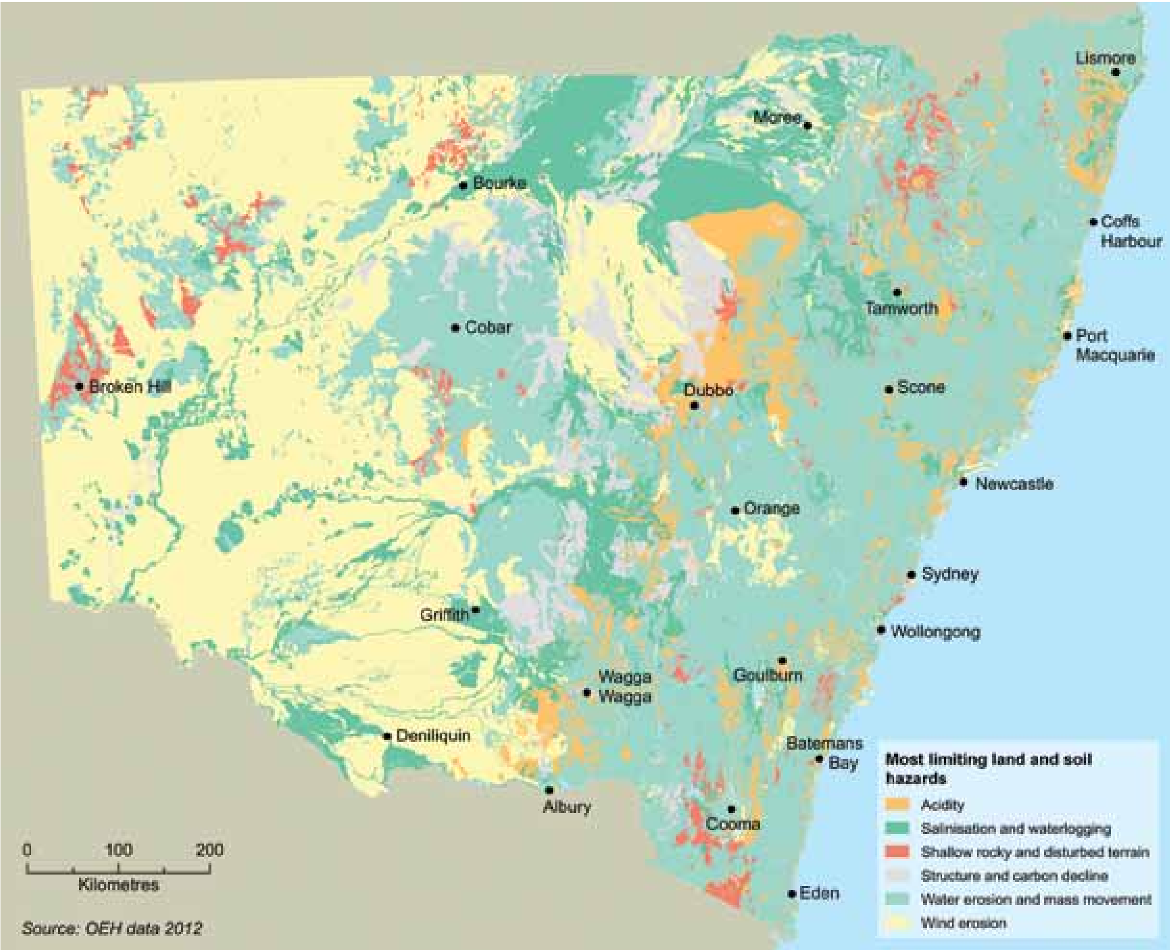
Unless land is used and managed within its natural capability, there is a risk of land degradation and permanent loss of many ecosystem services including biological (photosynthetic) productivity. For example, a parcel of land may be capable of being used for grazing but if not managed within capability, such as overgrazing by failing to reduce stock during drought, it would be placed at risk of degradation.

Land capability has been compared against current land use in NSW and then against land management actions using available records of land management practices by landholders from the network of soil condition monitoring sites.

Land use within capability

The land and soil capability and land-use maps for NSW have been combined for the first time in **Map 3.4** using technical limit rules developed for the assessment of land and soil capability classes for activities that are common to land uses. These rules give the 'upper sustainable' LSC class, that is, the class beyond which the land use is no longer sustainable (Gray et al. 2011). This was done to provide a statewide view of the extent of land use within capability in NSW. Land uses such as industrial, infrastructure, mining and urban (which together occupy about 2% of NSW) are not included as they are not primarily used for the provision of soil ecosystem services.

Map 3.3: Most limiting land and soil hazards in NSW



The areas assessed as being at significant risk of degradation as a result of land use are not large: rather there are clusters of locations where the land use is marginal for the district. Many of these are associated with irrigation on the western slopes and plains and are being degraded by salinity. They occur on the black soil plains of the Gwydir and Barwon rivers and in the Lachlan around Rankins Springs, the Murray irrigation areas south of Balranald, and lakebed irrigation areas of the Western Division. Other examples of significant risk are market gardening in coastal areas and sugar cane cropping on coastal acid sulfate soils. Slight to moderate risks of degradation are also due to cropping and grazing on marginal land that is either too steep or located in the drier parts of the Western Division.

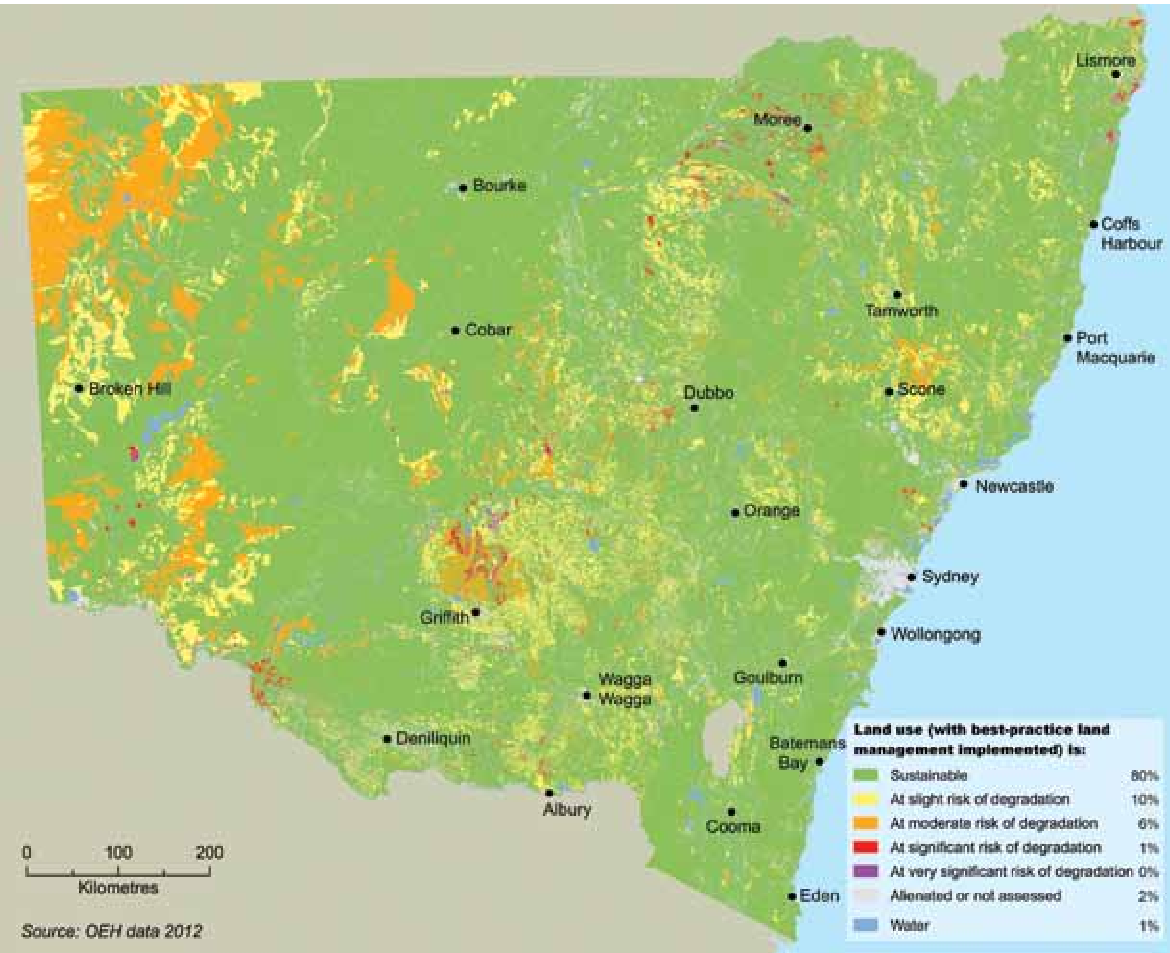
The vast majority of NSW is used for grazing/cropping, forestry and nature conservation. As is expected, more intensive land uses are at greatest risk of being used beyond natural capability.

Land-use trends

Land-use changes that involve greater levels of soil disturbance carry a high risk of reducing soil condition. In many parts of NSW, land use is changing to more intense types as the population increases, particularly along the coast and near major urban areas. These areas have growing populations (see Table 1.1 in People and the Environment 1.1) and this can lead to intensification of soil disturbance on all types of land.

Conversely, isolated parts of the state are becoming less populated with fewer people of working age available to manage pests and weeds, thereby increasing the risks of further land degradation. In parts of western NSW, for example, the control of overgrazing by feral goats and loss of ground cover associated with invasive native scrub is becoming increasingly problematic (Ballard et al. 2011; Kimball & Chuk 2011). In addition, declining farm profitability and/or poor terms of trade can also lead to more intensive production activities (see *SoE 2009*, Land 5.1 'Status and trends' and Appendix 2 'Private landholder capacity to manage natural resources').

Map 3.4: Land use within capability in NSW



Source: OEH data 2012

Land management within capability

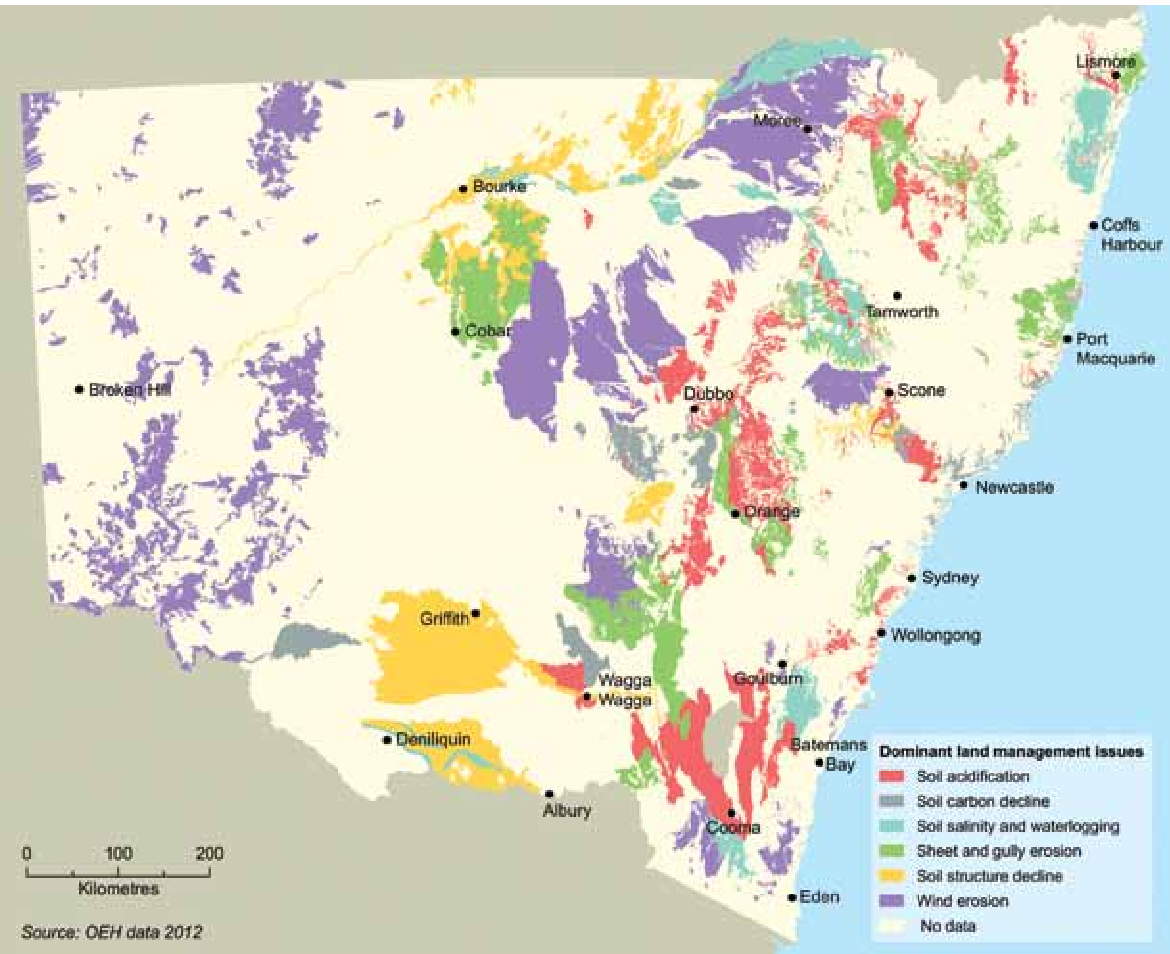
Appropriate land management is vital for the sustainable use of soil and land resources. Managing land within its capability is the primary means in NSW for maintaining soil condition and valuable ecosystem services. Although different land uses are associated with landscape and soil health, it is the suite of land management practices employed within particular land uses that is more directly associated with landscape and soil health. For example, different land management practices used in cropping systems (such as direct drill vs ploughing) may have a bigger impact than the choice of land use (such as irrigated vs non-irrigated cropping). Land management is often inappropriate where it does not adequately consider soil properties or seasonal conditions.

Eight soil health indicators are used to describe the current status of soil health, with a composite Soil Health Index providing a statewide summary. The same indicators (but with waterlogging combined with salinity) are used to describe the overall sustainability of current land use and land management practices and how well individual land degradation hazards are being managed to reduce the risk of them occurring. This is important, given the lag between changes in land use or management practices and the subsequent appearance of land degradation or recovery. Soil health indicators, in contrast, describe the current status of soil health.

Site-based 2008–09 landholder data, which has become fully available since *SoE 2009*, was recently assessed against rules provided in the MER land management technical report (Gray et al. 2011). The analysis involved the quantitative comparison of land management actions at the 662 sites against their Land and Soil Capability ratings.

Map 3.5 shows the main issues of concern for land management within capability, that is the *potential* land degradation hazards most likely to need control for various soil monitoring units in NSW, based on the re-assessment of 2008–09 data.

Map 3.5: Dominant land management issues within NSW soil monitoring units



Notes: The map only presents assessments for soil monitoring units with adequate data.
The map shows the land degradation hazards that potentially need to be controlled to ensure land is managed within its capability into the future. As such, the mapping should not be viewed as representing current, on-ground conditions.

On a statewide basis, the results suggest that, overall, land in NSW is being managed at a level in accordance with its inherent physical capability, although there are widespread issues of concern. The overall index for Land Management within Capability across the state is 3.7 (in a 1-to-5 rating scheme) suggesting overall 'fair' land management relative to capability. However, individual hazards are being unsustainably managed over many areas. Of the individual sites examined, 53% had a 'poor' or 'very poor' rating for at least one hazard. In these areas, there is a risk of ongoing land degradation from particular hazards that are not currently being adequately managed.

The results suggest that on a statewide basis, all hazards are being managed fairly sustainably. However, acidification, wind erosion, salinity/waterlogging and organic carbon decline are the land degradation issues that are being managed the least sustainably.

Land management trends

Continuing improvement in the extent of sustainable land management throughout NSW is a broad, long-term trend, as reported in SoE 2009. The recent updated MER results presented here confirm this trend, but cannot provide precise information on trends since 2009.

Increasing use of practices, such as crop stubble retention, no-till farming, fallow weed control, precision farming and controlled traffic, are leading to improvements in soil structure, soil moisture storage, soil carbon utilisation and more efficient use of pesticides and fertilisers.

Stock levels that were depleted during the drought are being rebuilt on recovering pastures, reducing the prevalence of overgrazing. Increased adoption of cell grazing has led to improved ground-cover management in these areas. Some soil structural damage from trampling stock compacting wet soils may be expected.

Responses

Managing and protecting the soils of NSW involves initiatives and programs at the state, regional and federal levels. These all ultimately aim to promote the adoption of sustainable land management practices by all landholders across NSW.

Established responses

State level activities

The NSW Government guides natural resource management throughout the state through *NSW 2021: A plan to make NSW number one* (NSW Government 2011) and various legislation, policies, strategies and programs.

NSW 2021 is the Government's 10-year plan for NSW. Goal 22 in *NSW 2021* is to 'Protect our natural environment'. One of the targets listed to help achieve this goal is to 'Protect and conserve land, biodiversity and native vegetation.' The protection of NSW soil and land resources is a key component of the current plan for NSW. It contains commitments to protect and restore priority lands and strategic agricultural land, and improve agricultural productivity. The NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (MER Strategy) (DECCW 2010a) is being implemented to monitor progress towards all Goal 22 targets, with its associated program providing for the collection and analysis of information relating to soil condition and land management.

Important legislation providing for the protection and management of soil and lands in NSW includes the following.

- The *Soil Conservation Act 1938* provides for the conservation of soil and farm water resources and the mitigation of erosion. It establishes the Soil Conservation Service, a state-owned soil conservation and environmental consulting business.
- The *Native Vegetation Act 2003* regulates the clearing of native vegetation on all land in NSW, with some exceptions, by outlining requirements for landowners when they clear native vegetation. Proposals for broadscale clearing of native vegetation must be assessed to determine whether this will improve or maintain environmental outcomes using the Environmental Outcomes Assessment Methodology. This methodology establishes specific criteria for the assessment of impacts on land and soils when clearing is being considered.

- The *Catchment Management Authorities Act 2003* established 13 catchment management authorities (CMAs) and outlined their responsibility for natural resource management.

Various other Acts provide direct and indirect mechanisms for soil protection and management, including the *Protection of the Environment Operations Act 1997*, *Environmental Planning and Assessment Act 1979* and *Crown Lands Act 1989*.

Policy instruments supporting soil management include *State Environmental Planning Policy (Rural Lands) 2008*, as well as the older *Policy for Sustainable Agriculture in NSW* (NSW Agriculture 1998), the *NSW Soil Policy: Looking forward, acting now* (1987) (currently being revised) and the *Total Catchment Management Policy* (1987).

Regional and local level activities

Many response activities are under way within the catchment management regions of NSW (see, for example, catchment action plans in 'Developing responses' below).

The SoilWatch performance monitoring system is being used by most CMAs. It complements and supplements surveillance monitoring throughout the state.

Locally, the Landcare network provides an invaluable contribution to integrated natural resource management at a grass-roots level. Nationally there are over 4000 Landcare groups and almost 2000 of these are registered in NSW. Groups are involved with a wide variety of land and water management issues, which can include weed control, revegetation, soil erosion by water, streambank erosion, river corridor/estuary corridor degradation, farmland improvements and urban environment protection. The projects and issues addressed by Landcare groups can often directly or indirectly assist in effective soil conservation and promoting the sustainable use of soils. The importance that Landcare plays in education and community awareness on natural resource issues, including soils, is also of extreme importance.

National level activities

The National Committee on Soil and Terrain coordinates and provides advice on soil and land assessment standards and policy. The committee previously commissioned a soil policy discussion paper (Campbell 2008), which was followed by a stakeholder survey and a stocktake of Australia's soil research development and extension capacity (DAFF 2011).

National protocols for monitoring water erosion, wind erosion, soil acidification and soil carbon have been developed and published (CSIRO 2011).

As part of the Clean Energy Futures project, the Federal Government has established and funded a Carbon Farming Initiative. This includes the soil carbon sequestration segment of a national carbon trading market which it is expected will lead to large additions to soil carbon and, as a result, improved soil condition.

Developing responses

The following policies and plans designed to protect land and soil resources are being developed.

- *Taking on the Challenge: NSW Salinity Strategy* (DLWC 2000) operated from 2000 to 2010. Although it has come to an end, it may be replaced by a new document for coordinating a whole-of-government response to salinity management within the state. Emerging issues that will need to be considered in the near future are the management of saline water released during the extraction of coal seam gas (CSG) and implementation of the Murray–Darling Basin Plan, which will require water quality and salinity management plans for each constituent river basin.
- As an update to the *NSW Soil Policy: Looking forward, acting now* (1987), the State Government is preparing a NSW Soil Strategy. The new strategy will guide the direction and strategic vision for the management, protection and, where possible, improvement of soils in NSW.
- Catchment action plans (CAPs) are currently being prepared for all of NSW's 13 CMA regions. The CAPs are key documents that coordinate and drive the effort to improve natural resources across their regions. They describe a whole-of-government approach to soil condition and sustainable land management targets at the regional scale and specify regional targets and activities to contribute to the achievement of statewide targets. The updated plans will set the direction for investment in natural resource management over the next 10 years.

Future opportunities

Opportunities for further protecting soils and landscapes in NSW include:

- rapid assessment of risks to assets as a result of rainfall events in areas burnt by wildfires
- incorporating acid sulfate soil management in local environmental plans.

3.2 Chemicals in the NSW environment

The presence of hazardous chemicals in consumer products has been identified as an emerging issue.

The National Waste Policy identified hazardous chemicals in consumer products as an emerging issue, while the Productivity Commission recently made recommendations for identifying and dealing with the risks of chemicals from consumer products.

Existing chemicals available for use in Australia are largely unassessed, with limited risk-based guidance available to provide chemical users and consumers with information on which chemicals are safer and less environmentally hazardous. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) has a goal to screen 3000 industrial chemicals for potential health and environmental risks within four years.

There has been an increase in reports of potentially contaminated sites in New South Wales – approximately 970 since December 2009 – following amendments to the *Contaminated Land Management Act 1997* which clarified notification reporting requirements. A majority of the significantly contaminated or potentially contaminated sites are associated with leaking underground petroleum storage systems.

NSW indicators

Indicator and status	Trend	Information availability
Number of regulated contaminated sites	Increasing	✓✓
Exceedences of maximum residue levels in food and produce	Stable	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Manufactured chemicals play an essential role in the production of foods, equipment, fuels, goods, cosmetics, medicines and many other products and services that maintain and improve our quality of life. Chemicals, however, can also present risks to human health and the environment during their manufacture, use and disposal.

NSW is part of a national chemicals management system that applies across various sectors of the economy, including primary production, industry, pharmaceuticals and construction. Management of chemicals involves assessing the risk of any potential hazards that may arise through a chemical's life cycle by examining the information available on its toxicity and how humans and the environment are exposed to it via intended uses and disposal pathways. Responsibilities for regulating chemicals are shared, with Commonwealth assessment and control of them up to point-of-sale and states and territories regulating their use, disposal and emissions. The national system operates within the context of international treaties and obligations agreed to by Australia.

This section broadly examines the information available on the potential impacts of manufactured chemicals on human health and the environment in NSW and the responses to these.

Status and trends

Assessing the risk from manufactured chemicals relies on comprehensive information about chemicals in the environment as well as their exposure levels and effects on living things. Assessment informs many decisions that need to be made, including for regulators about which chemicals require stricter controls or removal from use; for chemical users looking to use safer chemicals in manufacturing and production; and for consumers wishing to make more ecologically sustainable purchases. However information about the impacts of chemicals on the environment; and for living things is only available for a relatively small number of chemicals. Current understanding of the acute effects of single chemicals is well-studied, as are the chronic effects of certain types of chemicals, such as heavy metals and persistent organic pollutants.

Chemicals in the environment

There is limited data on the levels, fate and distribution of commercial chemicals and their breakdown products in the NSW environment. When exposure levels are not available, information on chemical releases or use is often used as a surrogate for exposure. However, good information is available on contaminated sites and chemical residues in food. Contaminated land and sediments, which are primarily legacies of poor waste management and past industrial practices, have been actively regulated for decades in NSW. Data on contaminated sites and chemical residues in food and produce has been reported for some time and current indicators for chemicals in the NSW environment are based on these and similar sources of data.

Chemical releases to the environment

Data on the total load of chemicals released into the environment has been estimated using the total volumes manufactured and/or imported or used. These estimates show that very large amounts are released into the environment, either directly during manufacturing or use or indirectly when products containing the chemicals degrade over time.

The Australian National Pollutant Inventory (NPI) reports on the releases of 93 chemicals across Australia from various sources, including mines, power stations and factories, as well as houses and transport. The program was designed to provide information to the community about those chemicals recognised as posing risks and typically targets pollutants released in large volumes (see Atmosphere 2.1).

Chemical release data is also reported for point sources on many premises that are licensed under the *Protection of the Environment Operations Act 1997*. In NSW, recent changes designed to strengthen this legislation will make monitoring data publicly available for the first time. The chemicals covered in this reporting, as for the NPI, primarily target those known to pose risks.

Ambient monitoring data

A relatively small number of chemical pollutants are monitored in different parts of the NSW environment, including in water, air, soil, sediments and household dust for a variety of specific purposes. This monitoring is used to evaluate compliance of licensed premises with licence conditions, determine whether the restrictions on emissions and discharges from licensed premises are appropriate, and assess the risks from a particular substance or contaminated site.

The information available shows that numerous chemicals are found throughout the NSW environment in complex mixtures (with individual chemicals mostly present at very low levels). Examples include personal care products and endocrine disruptors in biosolids (Langdon et al. 2011) and the fluorinated chemicals used in many consumer and industrial applications in Sydney Harbour (Thompson et al. 2011). Consumer products are an important source of chemical pollutants in the environment and include pharmaceuticals, personal care products and chemicals leaching from tiny pieces of plastic arising from the partial breakdown of waste plastic and the washing of synthetic textiles and clothing (ASoEC 2011).

Contaminated land data

Significantly contaminated land is regulated under the *Contaminated Land Management Act 1997* (CLM Act). Sites declared contaminated have data recorded about them, including the types and levels of contaminants and stage of remediation. However, this information cannot be used to make inferences about overall chemical levels in soils across the state. This is because these regulated sites are special cases of intensive use of hazardous chemicals typically over long periods, where known poor management practices were involved or particular sectors or activities (such as petroleum storage) operated. Contaminated sites that do not pose an unacceptable risk under the current or approved use are regulated under the planning process using the *Environmental Planning and Assessment Act 1979* and *State Environmental Planning Policy No. 55 – Remediation of Land*.

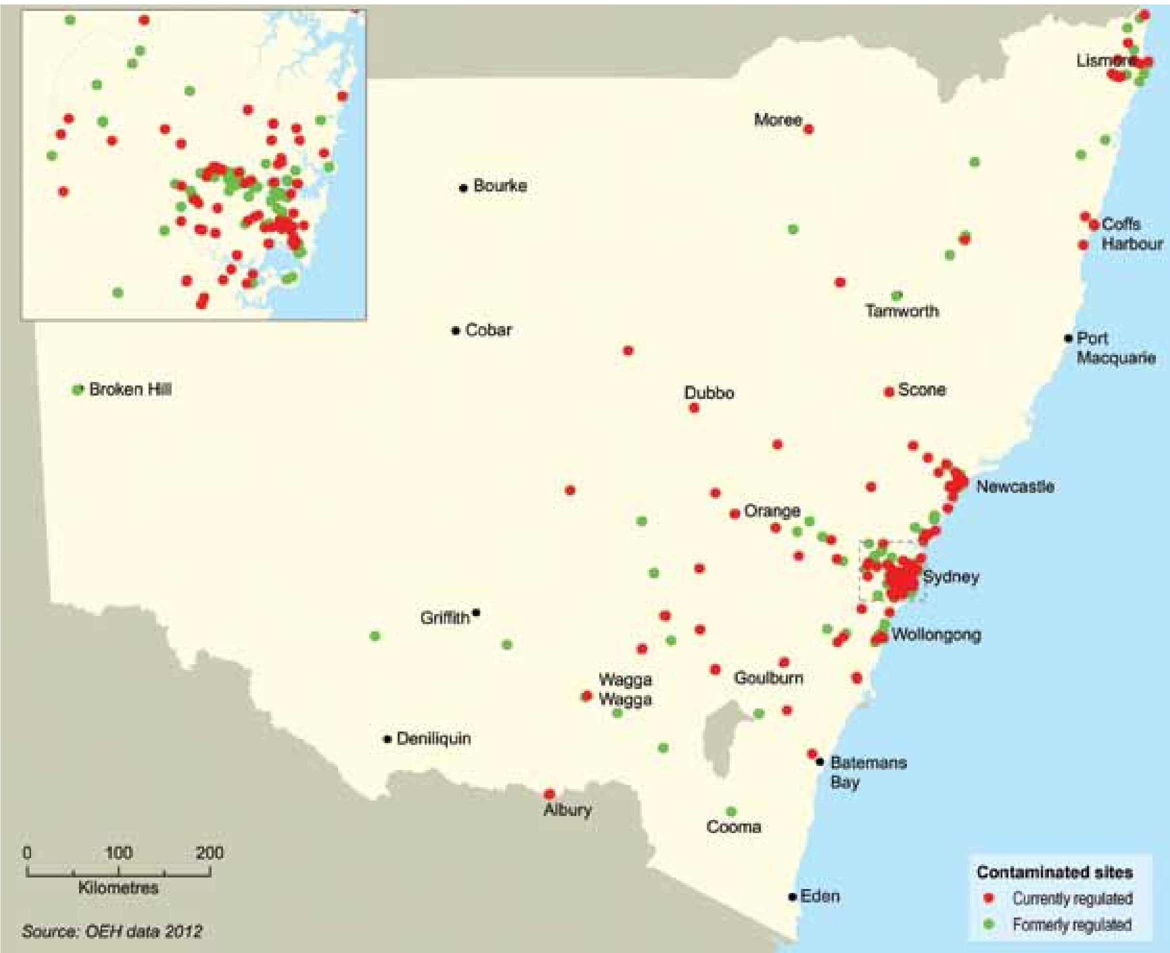
In April 2012, approximately 300 contaminated sites had been reported and were being regulated under the CLM Act (**Map 3.6**). Key contaminating activities include service stations and other petroleum industrial sites (37% of contaminated sites), chemical, metal and other industrial sites (10%, 7% and 16%, respectively) and former gasworks and landfill sites (12% and 9%, respectively).

The number of potentially contaminated sites being reported has increased due to passage of the *Contaminated Land Management Amendment Act 2008* which improved the clarity of reporting requirements under the CLM Act. Approximately 970 have been notified since December 2009, after new triggers for notification and regulatory action were based on endorsed national guideline criteria rather than the previously used concept of 'significant risk of harm'. This large increase in the number of contaminated sites being reported to the NSW Government compares with around 500 site notifications received between 1998 and 2009. Screening of the sites reported since December 2009 has identified a further 150 sites that will be regulated under the CLM Act.

By June 2011, the NSW Government had facilitated the remediation of around 100 sites since 1997. Between July 2008 and June 2011, 32 sites were remediated under the CLM Act.

A number of large remediation projects have been completed in 2012, including the Rhodes Peninsula in Sydney and BHP Billiton's Hunter River remediation. Rhodes Peninsula, which has undergone remediation since the 1980s, has resulted in productive land being turned into a populous residential area open to the community. Finalisation of the remediation at the Hunter River site in Mayfield has been deemed Australia's largest-ever sediment remediation project. Its completion marks the removal of the risks posed to the aquatic environment and enables redevelopment of a former contaminated site, with improved access to the river and better opportunity for local industries still operating there.

Map 3.6: Contaminated sites regulated and reported under the Contaminated Land Management Act 1997 in NSW



Since the commencement of the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation in 2008, more sites with leaking underground storage systems have been investigated. This has led to over 750 sites with leaking fuels being reported. Leaks from underground systems can go unnoticed for many years and cause significant environmental and financial impacts on the communities affected.

Contaminated food and produce

The inappropriate or illegal use of chemicals in farming, silviculture and horticulture, and leakage from contaminated land can leave residues and contaminants in produce intended for human or animal consumption. Information on chemical residues in food is available through national programs that test for a number of chemicals. Food Standards Australia New Zealand (FSANZ) publishes the Australian Total Diet Studies, which report comprehensive data every two years on consumers' dietary exposure to a range of food chemicals. The program recently found that dietary exposures to agricultural and veterinary chemical residues were all below the relevant reference health standards, consistent with the findings from previous studies of this kind (FSANZ 2011).

The National Residue Survey analyses samples of animal and plant food products in Australia for the presence of chemical residues and environmental contaminants, such as heavy metals. Chemical and commodity combinations for sampling are self-nominated by participating industries. During 2009–10, samples were collected from 21 grain commodities and products, pulses and oilseeds, and five horticultural commodities. The overall rate of compliance remained very high, consistent with previous surveys (DAFF 2011).

FSANZ also conducts one-off analytical surveys that target particular chemical contaminants that may be present in food, such as bisphenol A, dioxins and brominated flame retardants. In 2010, FSANZ analysed the levels of bisphenol A in food and drinks available in Australia. This chemical is used in many applications, including the lining of food and beverage packaging, to protect food from contamination. Only a limited number of products were found with detectable levels of bisphenol A, well below the levels of potential concern (FSANZ 2010).

Chemicals in living things

Effective mechanisms for detecting and mitigating acute impacts arising from exposure to chemicals are in place in NSW. However, it is not clear whether the chemicals that have been detected in the NSW environment as a result of human-related activities are causing adverse ecological or human health impacts in the long term. In order to rigorously assess this, better information is needed about chemical levels found in living things. Overseas monitoring of a selected number of chemicals has shown that, while the general public is widely exposed to mixtures of hundreds of manufactured chemicals (or their breakdown products), the levels of individual chemical components are generally present at levels well below those expected to pose risks (CDC 2009). One small study found 287 commercial chemicals, pesticides and pollutants in the umbilical cord blood of 10 newborn infants (EWG 2005).

Monitoring for the presence in NSW people and the environment of persistent organic pollutants and heavy metals (chemicals known to pose risks at relatively low levels) is mostly based on one-off activities, generally at single locations and points in time. For example, chemical residues in fish have been monitored to determine whether they should be eaten; blood-lead levels in children have been measured to determine the effectiveness of regulatory campaigns and lead management programs; and a small number of chemicals in animals killed at roadsides have been measured to determine the levels in wildlife and the effectiveness of pest abatement programs.

This monitoring, although limited, has shown that pollutants like triclosan (used in consumer products), brominated flame retardants (chemicals applied to prevent electronics, clothes and furniture from catching fire) and fluorinated chemicals are all found at low levels in NSW in humans (Toms et al. 2008; Toms et al. 2011) and flora and fauna (Thompson et al. 2011). Monitoring has also demonstrated the effectiveness of regulatory programs and health campaigns in greatly reducing chemical levels in people and other living things, such as the phasing out the use of lead in petrol (Gulson et al. 2006; Boreland et al. 2008).

Effects of chemicals on humans and the environment

There is growing evidence that chemicals in the environment may contribute to a range of adverse human health and environmental impacts (Diamanti-Kandarakis et al. 2009), including certain cancers (PCP 2010), asthma, developmental disorders (Grandjean et al. 2008), reproductive impairment, neurodegenerative conditions (such as Parkinson's disease), diabetes (Patel et al. 2010) and obesity (Holtcamp 2012). In particular, concerns have been raised about the potential impacts of manufactured chemicals, including those released from certain consumer products, on children and pregnant women (AAoP 2011).

Although the impacts posed by chemical exposures are complex and therefore attract considerable debate, some negative effects are well-documented, for example in the case of lead, asbestos and many pesticides. Toxicity varies depending on the amount an organism is exposed to (even water is harmful if ingested in very large quantities); the timing (certain stages in a life cycle, such as during early stages of development, have been shown to be particularly vulnerable); and the presence of other exacerbating factors, such as poor nutrition, stress and other chemicals.

The Organisation for Economic Cooperation and Development (OECD) is particularly concerned about those substances that may be hazardous, but which have not yet been characterised as such due to a lack of toxicity data and are therefore not listed anywhere as being priority pollutants that require controls (OECD 2001a). Possible combined effects of exposure to mixtures of numerous chemicals at low levels in the environment or in consumer goods, especially young children, are receiving particular attention by scientists, policymakers and community groups (Bonnefoi et al. 2010). Furthermore, some adult diseases are linked to early-life or even prenatal exposures (EEA 2010).

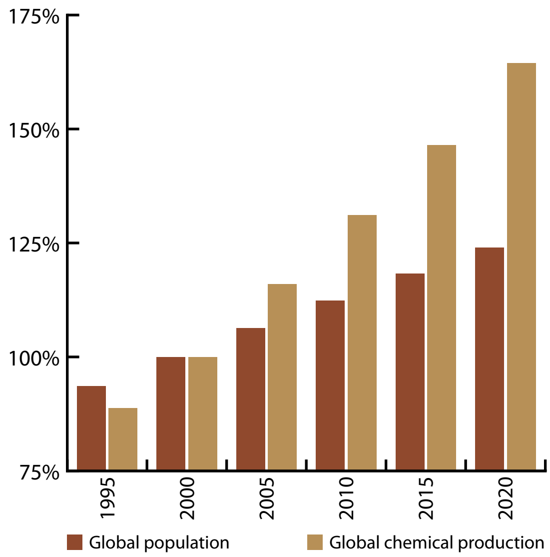
Most Australian data on chemical-related health effects relate to acute effects and high exposure levels, for example, data collected by Poisons Information Centres (NSWPIC, VPIC, QldPIC and WAPIC), rather than potential effects related to environmental exposures which are typically chronic low doses. As the chronic exposure data to chemicals is unavailable, assessments are performed to estimate the risks on a case-by-case basis.

Pressures

A number of pressures will have an impact on the regulation of chemicals. These include the growing global population and greatly increasing global production of chemicals, technological changes, climate change in relation to the fate, distribution, and even toxicity of chemicals, and finally the increased drive for sustainability.

Figure 3.2 shows projected increases in global chemical production compared with global population growth. Production is expected to grow 3% per year, while population increases 0.77%. On this trajectory, chemical production will jump 330% by 2050, compared with a 47% increase in population, relative to the year 2000 (OECD 2001b; UoC 2008). This imbalance will not necessarily lead to increased risks to human health and the environment if the toxicity and persistence of chemicals manufactured and used are significantly reduced through cleaner production approaches. There is increasing consumer demand for safer chemicals and a growing number of businesses are capitalising on this trend, simultaneously reducing their liabilities and the extra regulatory requirements associated with using more hazardous substances (Environment California 2010).

Figure 3.2: Projected increases in global population and chemical production



Source: OECD 2001b

Technological changes will bring both potential benefits and potential risks. For example, nanotechnology is being used to tackle a range of environmental issues, including purifying water, monitoring pollutants in the environment and more efficient generation of energy. However, there has been much discussion about the potential for the unique features of nanomaterials to pose new environmental, health, occupational and general safety hazards. The challenge for society is to realise the benefits of technologies but be alert to potential risks and take appropriate and timely action to avoid them.

Climate change will affect the quantity, fate and transport of chemicals released to the environment. For example, as global average temperatures rise, additional unintentional releases of chemicals to the environment are expected following accidental fires in buildings and landfills. Changes in rainfall patterns and a greater frequency and intensity of storms in some regions will increase and widen the distribution of debris containing a range of contaminants, such as asbestos and heavy metals. Landfills and contaminated sites may need better flood protection upstream and contamination barriers downstream to filter the groundwater leaching out of them (CRC CARE 2012). The melting of ice, which has previously trapped persistent organic pollutants and other contaminants, is leading to recirculation of these substances back into the environment (Ma et al. 2011). Increased ambient temperatures, such as might occur with climate change, may cause mean metabolic rates to increase in cold-blooded animals (such as reptiles, fish and invertebrates), possibly altering their susceptibility to the toxicity of some chemicals. For example, one NSW study found that exposure to a chemical at a level formerly believed to be harmless actually affected the ability of fish to tolerate higher water temperatures (Patra et al. 2007).

A key challenge for achieving a sustainable society will be to balance or otherwise address trade-offs so that environmental improvements in one area do not introduce new or increased risks elsewhere. This is particularly important with respect to resource recovery. For example, successful water saving campaigns will increase the concentration of contaminants in sewerage treatment plant discharges as the volume of discharges from plants decreases, potentially increasing risks to the aquatic environment. Similarly, NSW policy recognises that beneficial reuse of wastes must ensure that this does not cause the dispersal of hazardous substances into the environment (see People and the Environment 1.3). These considerations also apply to protecting and conserving water, air and soil resources.

Responses

In response to an increasing production of chemicals, new information about the presence of chemicals in living things and the environment, and a growing understanding of the potential associated risks, greater attention is being paid to the appropriate regulation of chemicals. This is reflected in the number of chemical-related reviews, regulations and proposals worldwide and in Australia.

Established responses

An increasing number of international agreements recognise the need for appropriate controls throughout the entire life cycle of chemicals. In the case of persistent bioaccumulative toxic substances, this has meant action early in the life cycle by preventing the use or generation of these chemicals: for example, the *Stockholm Convention on Persistent Organic Pollutants* (the Stockholm Convention) aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). In 2010, nine more pollutants were proposed to be added to the list in addition to the original 12, including certain pesticides and industrial chemicals such as DDT, PCBs and dioxin. Newly listed chemicals include lindane (a pesticide no longer used in Australia and soon to be prohibited), pentachlorophenol (an industrial by-product), certain flame retardants (no longer used in new products in Australia) and PFOS (used in a wide range of products and processes).

At the state level, the following legislation controls the use or release of chemicals into the environment:

- the *Protection of the Environment Operations Act 1997* (POEO Act), which regulates chemical pollution and wastes, establishes management and licensing requirements, and includes chemical offence provisions
- the *Environmentally Hazardous Chemicals Act 1985*, which regulates chemicals of particular concern throughout their entire life cycle, thereby minimising potential environmental impacts from hazardous chemicals and chemical waste in NSW
- the *Contaminated Land Management Act 1997*, which regulates sites that are contaminated with chemical wastes that pose a significant risk of harm to human health and/or the environment
- the *Pesticides Act 1999*, which regulates and controls the use of pesticides in NSW.

NSW has taken the following action to reduce risks arising from present and past activities involving chemicals:

- The Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation, which commenced in June 2008, focuses on a preventative approach to minimising the risk of soil and groundwater contamination from leaking underground storage tanks. In recent years, industry in NSW has adopted best recognised practices for the operation of underground systems, such as inventory control and regular monitoring of systems. These practices have helped reduce the risk of fuels leaking from the storage systems and thus the risk of serious harm to the local community and environment.
- A campaign was completed in 2011 to reduce chemical emissions from industry that caused photochemical smog in Sydney and Illawarra. Licence conditions under the POEO Act required major industries to adapt their operations to alternative, more efficient and cleaner methods and materials production. As a result of shifting to a cleaner production approach, much of major industry reaped many benefits, in particular, saving operational costs associated with raw materials and energy.
- In October 2011, a survey of NSW businesses and research organisations that work with nanotechnology or nanomaterials sought to better understand their operations, including workplace practices and knowledge gaps in the use and handling of these materials. The information from the survey will be used to inform further work by the government in relation to nanotechnology, including helping regulators to monitor safe work practices and understand the risks associated with this emerging technology.
- In 2009–10, a program of bilingual extension officer services aimed to increase the participation of farmers from diverse cultural and linguistic backgrounds in mandatory training courses on the safe use of pesticides. The ongoing courses also promote best practice methods for using chemicals that reduce the risks to human health and the environment.
- Preventative strategies are being implemented for certain high-risk industries, such as sites with underground petrol storage systems, marinas, galvanisers and timber treatment sites. Strategies include targeted environmental audits, identification of best practice measures, and revisions to licensing conditions.

Developing responses

Given the division of responsibilities for regulating chemicals between state and national governments and the desire to harmonise legislation, much of the work to develop policies and programs that promote effective controls on chemicals is coordinated at the national level. The Council of Australian Governments (COAG) has nominated chemicals and plastics as a priority for regulatory reform and reducing red tape (COAG 2009). A 2008 study by the Productivity Commission recommended a broad range of reforms, many of which have now been endorsed by COAG (Productivity Commission 2008).

NSW has been very active in these reforms covering industrial chemicals, agricultural and veterinary chemicals, waste and consumer products. NSW is working with other jurisdictions to implement reforms to achieve a national approach to managing the impact of chemicals on the environment through the National Framework for Chemicals Environmental Management (NChEM). The COAG Standing Council on Environment and Water is overseeing these reforms which are discussed below.

Industrial chemicals

The potential environmental and health risks of industrial chemicals are assessed under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). All new chemicals are assessed before being marketed in Australia, except when chemicals are eligible for an exemption. However, as in other countries, 39,000 older chemicals that were on the market prior to the establishment of the scheme may be used without assessment. NICNAS is planning to evaluate approximately 3000 chemicals within the next four years as part of the staged implementation of a new Inventory Multi-tiered Assessment and Prioritisation Framework. This is the first time that information about the risks associated with a large group of industrial chemicals will be available to regulators, chemicals users and consumers. It will help inform choices about the use of safer chemicals and the identification of appropriate controls for those still in use.

Agricultural and veterinary chemicals

In late 2011, the Australian Government announced a range of proposed enhancements to the legislation governing the operation of the Australian Pesticides and Veterinary Medicines Authority, which is responsible for the regulation of these chemicals up to, and including, their point-of-sale. The proposed reforms are expected to result in improved health and environment protection for the broader community by requiring companies to regularly demonstrate that their chemicals meet health and environmental standards and placing an upper limit on the time taken for chemical reviews. In many cases, particularly for low-risk products, the proposed amendments will reform the current system to provide more timely outcomes. The proposed reforms also introduce a time limit on the approval and registration of agricultural and veterinary chemicals, providing a periodic review of a chemical's safety.

Product stewardship and waste management

Important reforms in waste policy and product stewardship are being progressed nationally. The *National Waste Policy: Less waste, more resources* (EPHC 2009), agreed to by all Australian environment ministers in 2009, leads the way for a new, coherent, efficient and environmentally responsible approach to waste management in Australia. It establishes a comprehensive work program for national coordinated action on waste across six key areas, including reducing hazard and risk in products. This is the first time that reducing the toxicity of chemicals in products has been recognised, putting Australia in line with other countries at the forefront of ecologically sustainable approaches. National Product Stewardship legislation has been passed recently. This important development will require producers to take more responsibility for their products, including reducing the toxicity of ingredients (see People and the Environment 1.3).

A growing number of non-government initiatives are encouraging a progressive approach to chemicals management through substitution of hazardous substances with safer alternatives, including non-chemical options. For example, a new $72.8-million green chemistry and engineering project announced in 2010 is developing a Green Chemical Futures facility at Monash University in Victoria. This nationally co-funded initiative will provide opportunities for the Plastics and Chemical Industries Association, CSIRO and other partnering institutions from Australia and overseas, including the United States, India and Japan, to develop and promote environmentally safer chemicals. The project is an expansion of work undertaken at the Centre for Green Chemistry at Monash University, which currently conducts innovative research, develops and promotes green chemistry in educational materials, and provides training in sustainable chemical policy for regulators.

Future opportunities

The OECD has identified chemicals in the environment and in products, particularly persistent bioaccumulative and toxic chemicals, as a 'red light' issue (OECD 2001a). Views on how to respond effectively to these concerns have been changing. Until recently, regulatory attention worldwide focused on managing risks at the end of a chemical's life cycle through regulating emissions, discharges and wastes – the so-called end-of-pipe approach. The human and financial costs associated with legacy issues from once commonly used chemicals, such as asbestos, CFCs and DDT, are encouraging a shift toward the use of safer, greener chemicals at the outset.

The primary difficulty in chemicals management, however, is the lack of knowledge about the properties, effects and exposure patterns of the great majority of chemicals, industrial chemicals in particular. Many programs are under way worldwide, including in Australia, to address this concern, leading to much new information about chemical risks and better alternatives. Examples are the existing NICNAS chemical assessment and prioritisation program and the Monash University Green Chemical Futures program. This new information will support application of the substitution principle (choosing safer chemicals) and open up opportunities for its use in sustainability programs.

The initial focus of many sustainability initiatives has been on reducing the use of energy and water as well as the generation of waste. It is not clear how successful this has been in promoting the development and use of greener chemicals or non-chemical alternatives. This crucial aspect of sustainability, however, may be given more attention in NSW as new information about the risks of chemicals and their alternatives becomes available. For example, overseas, organisations, including retailers, manufacturing and hospitals, are developing their own chemicals policies and action plans, going well beyond current regulatory requirements (Environment California 2010). These proactive approaches include using screening tools to identify potentially hazardous substances as well as developing their own lists of priority substances to phase out of their operations and supply chains. There are opportunities to explore similar initiatives in NSW.

Current indicators focus on chemicals at the end of their life cycle, that is, chemical residues in food or chemicals in contaminated sites. As more data becomes available, indicators that provide a more comprehensive picture regarding chemical impacts on the environment may be developed.

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