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Dryland salinity in Victoria in 2007

An analysis of data from the soil salinity database and Victorian discharge monitoring network

Victoria
The Place To Be

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Summary

The intention of this report is to present the status of soil salinity in Victoria as at the end of 2007. It begins by briefly outlining the role of the state government in collecting and managing soil salinity data, the usefulness of the soil salinity database and the method of data collection (by vegetation assessment). It presents a summary of the extent of mapped soil salinity held on the Corporate Spatial Data Library for the whole state and for each Catchment Management Authority region.

The report discusses the limitations of the soil salinity database for assessing the rate of change of soil salinity and presents rates of change in dryland soil salinity for the Corangamite, North East, Goulburn Broken and North Central Catchment Management Authority (CMA) regions. Based on limited data, it appears that there has been a decrease in the extent of the salt affected area in the Goulburn Broken CMA region (pre 1990 compared to post 2000),although it is hard to determine if there was a change in the severity given the available data. In the North East CMA region (1995 compared to post 2001) and the North Central CMA region (1990 compared to 1999) both the extent and severity of salt affected areas declined. In the Corangamite CMA region (pre 1992 compared to 2001) a slight increase in extent was accompanied by a decrease in severity.

This report also describes the statewide soil salinity monitoring network and its limitations. This network is additional to and separate from the soil salinity database and was set-up specifically to determine rates of change of soil salinity. In contrast to the statewide soil salinity database, field assessment is primarily based on EM38 surveys. A summary of data collected at monitoring sites in the Corangamite, Glenelg Hopkins, Goulburn Broken, North Central, Port Phillip and West Gippsland CMA regions is presented. If sites are examined individually results are mixed, but when data for each region is aggregated, the Corangamite (1994–2000), Glenelg Hopkins (1995-2003), Goulburn Broken (1995-1998) and North Central (1995–2000) CMA regions all showed a noticeable reduction in extent and severity of soil salinity at the monitoring sites. In the Port Phillip CMA region the extent increased marginally and the sites tended to become more saline over the monitoring period (1998–2001), while in West Gippsland the site extents reduced only marginally, but became noticeably less saline over the period 1996–2001.

Based on the available data, it is hard to give a concise answer for the whole of Victoria as to the rates of change of soil salinity. While the results were not totally consistent across the whole state and across both methods (the vegetation based data held in the soil salinity GIS database and the EM38 based surveys monitored as part of the discharge monitoring network) we can say that both datasets tended to show an overall trend of decreasing severity (i.e. translation of severe to less severe and generally a reduction in mapped area).

Further research could be undertaken to attempt to establish the influence of measurement technique and operator error on the vegetation assessments by applying repeat surveys (different measurement, different operators) to sites within the same timeframe. The results of this research would potentially remove one of the unknowns and thereby assist in the current and future data interpretation.

Finally, this exercise has highlighted the need to re-design and properly resource the soil salinity monitoring system to allow meaningful reporting of changes in the extent and severity of saline soil at statewide and regional level so that useful feedback can be provided to funders, land managers and the community. Until then estimates may be misleading.

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Acknowledgments

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Dryland salinity in Victoria in 2007: An analysis of data from the soil salinity database and the Victorian discharge monitoring network

Rob Clark and Wayne Harvey

1 Introduction

The Victorian Soil Salinity Monitoring Project, funded by the Department of Sustainability and Environment (DSE) provides support for standardised collection of data showing the extent and severity of soil salinity. This project also manages the storage of the data on the Corporate Spatial Data Library (CSDL) and distributes information products back to the community. The soil salinity layer represents a compilation of all recorded soil salinity sites in Victoria.

A coordinated, comprehensive mapping of soil salinity has never been funded and so the data is not able to provide a comprehensive picture of salinity across Victoria at one time. Mapping exercises have generally been driven by local needs and funded by various state and federal initiatives. This makes it difficult to report on change in Victoria over the timeframes specified for the Victorian Catchment Management Council (VCMC) and State of Environment (SOE) reporting. While acknowledging these limitations, the soil salinity layer is able to provide the most current record of soil salinity in Victoria and show how salinity has changed over varying intervals where sites have been remapped. In addition, the Victorian Soil Salinity Monitoring Project also set-up a statewide monitoring network comprised of over 50 sites to monitor more detailed changes in the extent and severity of soil salinity.

This report presents the most current estimate of mapped soil salinity across Victoria and, where repeat data exists, shows the change in the extent and severity over various timeframes.

2 Summary of current extent of dryland soil salinity in Victoria

Table 1 lists the area of mapped soil salinity for each Catchment Management Authority (CMA) region in Victoria and Figure 1 shows its distribution in relation to the CMA boundaries. The soil salinity database is a collation of all mapping up to the present time and is comprised of many regional or local surveys collected at a range of times. Where sites have been remapped we have used the latest version of the data. Not all data has been attributed as either primary or secondary, so the estimates of salt affected area in Table 1 combine primary and secondary salinity.

2.1 The method of data collection

To maintain data quality a standard data collection method was developed by Matters (1987), documented (Allan 1996) and later updated to account for changes in technology that improved the efficiency of data collection (Clark and Fawcett in prep). Field reference guides were also developed (Matters and Boruvka 1987; Matters and Bozon 1989, Matters and Bozon 1995) to assist staff undertaking field surveys.

Most of the data was collected prior to the advent of Global Positioning System (GPS) technology and for most of these surveys, the extent of the saline area has been marked on aerial photos following field survey, transferred to a hardcopy 1:25 000 topographic map base, and then digitised. Since the introduction and adoption of GPS technology, the common practice is now to directly walk the entire boundary between saline and non-saline soil at each site and map it using a GPS instrument. An exception to these practices is the soil salinity data collected in 2006 in the Mallee by Grinter and Mock (2007). This survey mapped the extent of saline land in the Mallee using a combination of spatial modelling (based on digital elevation models (DEM) and Ecological Vegetation Class (EVC) maps), air photo interpretation and limited ground surveys. It did not apply the accepted survey standards and did not discriminate primary soil salinity from secondary soil salinity or collect any other of the standard attributes. As such its compatibility with other surveys is limited.

Table 1 Summary of dryland soil salinity

Catchment Management Authority	Salt affected area (ha)
Wimmera	21789
Glenelg Hopkins	27435
North Central	27114
Goulburn Broken	4778
North East	1311
Corangamite	25162
Port Phillip	2890
West Gippsland	24160
Mallee	127756
East Gippsland	273
Total	262668

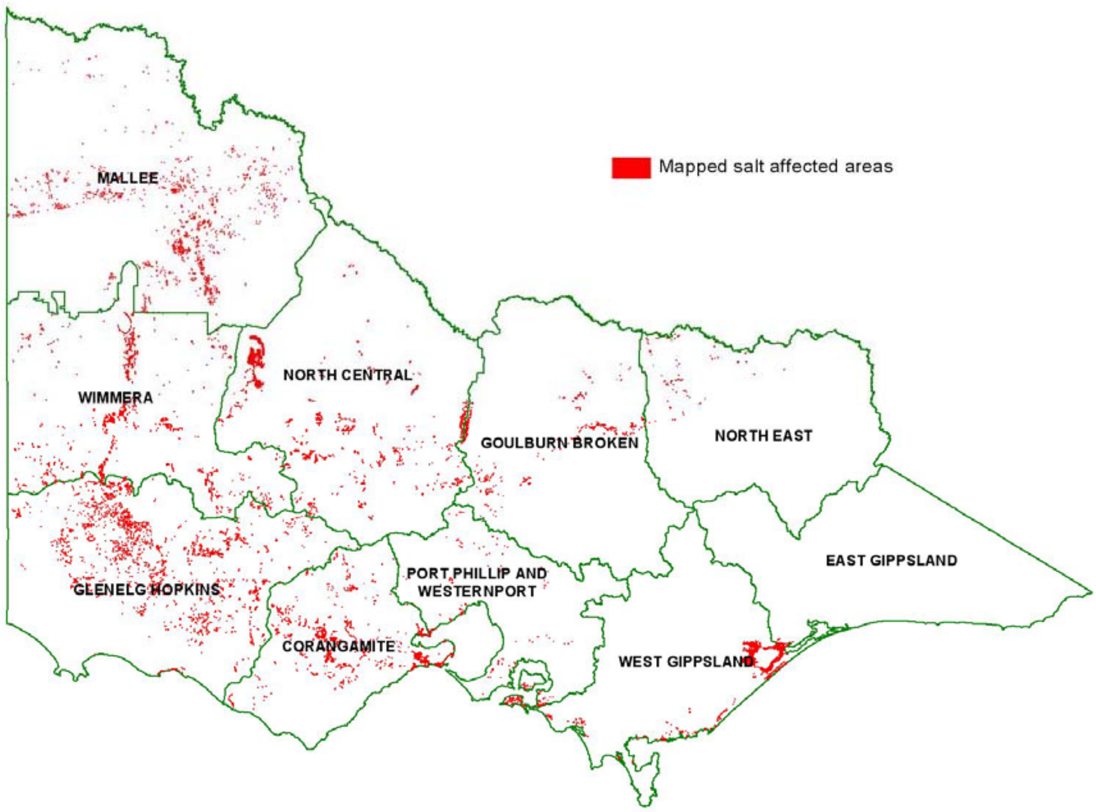

Figure 1 The distribution of mapped dryland salinity in Victoria showing CMA regions

Limitations of the CSDL soil salinity data for assessing the rate of change in soil salinity over time.

Identifying soil salinity and assessing the level of severity

The method for identifying soil salinity and assessing its severity has remained unchanged since the mid 1980s and is based on a visual assessment of the vegetation community and other physical indicators by a field officer at a moment in time. By its nature, such an assessment is subjective. Assessment consistency may be improved by the publication of written and photographic assessment standards, but there is likely to be variation in their application between individuals and even between observations by the same individual over time. This introduces a degree of error into any estimate of change over time.

Delineating the extent of soil salinity

Changes in technology have brought significant improvements to the method used to delineate the extent of saline areas. Up until the early 1990s air photo interpretation was common practice within government agencies. All early mapping relied on interpretation of air photos to:

identify saline areas based on visual interpretation of the air photo

delineate the extent of the salt affected area.

Given that the scale of the soil salinity layer is 1:25 000, this method of delineating the extent of saline areas produced positional errors that were likely to significantly effect calculation of the rates of change because :

field mapping of saline sites onto air photos produces a relatively coarse approach that tended to lump some non-saline areas in with the salt affected areas and vice versa

colour and textural differences of the photo may not be sufficient to identify low salinity areas

air photos may not be current at the time of survey

the actual marking of the boundaries on the photo, transfer to a hardcopy topographic map and digitising of the hardcopy data is likely to propagate significant positional error.

Since the mid 1990s GPS instruments have become widely available and now provide the preferred method for mapping saline sites. Mapping using the GPS requires the entire site to be walked and tends to produce more detailed and reliable maps than previously produced. This occurs because clearly any in-situ assessment of the point where the visual symptoms of soil salinity cease will be more accurate than those interpreted from an aerial photograph, and the positional error of the GPS is less than the error associated with line placement on an aerial photograph (line placement error is >± 12.5 metres at 1:25 000 scale) .

Where possible, GPS data should be differentially corrected. For most mapping grade instruments, differentially corrected GPS data has a 95% probability of achieving a positional accuracy of <± 5 metres. Survey grade instruments are typically capable of sub-meter accuracy after differential correction, but are rarely used for this type of work. Data collected using a GPS that is not differentially corrected (known as an autonomous or stand alone GPS) typically has a 95% probability of achieving a positional accuracy of >± 10 metres (Milner and Hale 2002).

Autonomous GPS instruments are the most common instrument used for soil salinity mapping within DPI and DSE. Sites mapped using such instruments may contain positional errors that have a significant effect on calculation of rates of change. However, error in the GPS positional data is random by nature and its effects on estimation of the salt affected areas are likely to be reduced, as some of the positional errors will tend to cancel other errors. Saline sites mapped using differentially corrected data are unlikely to contain positional errors that will be significant (given that the soil salinity layer is considered to provide data at a scale of 1:25 000).

Of greater concern to GPS users is that the data generated often has an absolute positional accuracy that execeeds that of the 1:25 000 map base. This manifests when the saline site that was recorded on either side of a topographical feature appears to be entirely to one side of that feature when layed over an existing GIS map base. Clearly the location of the feature on the 1:25 000 map base is in error. This requires the discharge site (although accurately located) to be moved to ensure it matches the map base. This is not an uncommon occurrence. Where re-mapping occurs it is difficult if not impossible to ensure that a consistent offset is applied to the newly captured boundaries thereby introducing further positional error. In these cases this will influence the accuracy of locational comparisons but not the ability for comparisions of effected area.

The methods used to map the extent of soil salinity should be considered when analysing data to estimate the rates of change over time. Much of the initial mapping was completed using air photos as a mapping base, and it is likely that these estimates of salt affected area will contain significant errors in comparsion to those mapped using a GPS. This means comparison of the initial mapping with sites remapped using GPS instruments is difficult as there may be a significant variance caused by the change in measurement technique rather than real change in the extent of the site. This error will be reduced when the estimates are derived using a consistent technique and minimsed where differentially corrected GPS data is solely used to calculate the rate of change.

3 Summary of changes in dryland soil salinity in Victorian using field mapping recorded on the soil salinity GIS database

Soil salinity data has been collected by various groups for a range of purposes and regional, state and federal investors have all funded data collection at various times. The data has been compiled on the soil salinity database maintained by the Department of Primary Industries (DPI) for the DSE and held on the CSDL. Some examples from the data held on the CSDL that illustrate the fragmentation, *ad hoc* nature and multiple drivers behind soil salinity data collection are:

Data collected by the Department of Natural Resources and Environment (NRE) staff in the Goulburn Broken catchment while developing the use of GPS technology for field mapping of soil salinity in 1995-1996.

Data collected by the Mid-Loddon Landcare Group (comprised of the Nuggety Hills, Ravenswood, Upper Spring Creek and West Marong Landcare groups) to update existing data and provide a baseline of the extent and severity of soil salinity in the combined Landcare group area prior to the start of implementing a salinity management plan in 2000.

Data collected by DPI staff in the Gardiners Creek subcatchment to monitor change in the extent and severity of soil salinity in this part of the Goulburn Broken CMA (Clark 2006).

Data collected by DPI staff in the Heiffer Station Creek subcatchment of the Wimmera CMA region in 2004 to provide baseline data in an area that had not been previously mapped.

Data collected by DPI for the Corangamite CMA specifically targeted to potential future growth areas in 2005 and 2006 to provide salinity management overlays to assist local government in planning and for protection of assets (Miller 2006).

Data collected by DPI staff in the North East CMA region from 2003 to 2007 to correct perceived errors in their soil salinity database and pick up newly identified saline sites.

Unfortunately, data collected in such a way (even though collected carefully using a standard method) does not necessarily meet the needs for reporting change in soil salinity in the time frames and manner required by the VCMC and SOE reports. Although the amount of change may be estimated by calculating changes in the extent and severity of soil salinity between the survey dates, it is not possible to reliably predict a rate of change or quantified trend in soil salinity unless a number of repeat surveys for the same sites or area have been conducted. Currently it is estimated around 5% of saline sites have been remapped once with less than 1% remapped more than this. It is difficult if not impossible to provide a reliable estimate of change in soil salinity over time for a large region like a CMA based on data of this nature. To resolve this problem a more consistent and structured scheme of remapping (constrained to a subset of sites or areas for cost containment) needs to be in place.

The sections below show the best possible estimates of changes in soil salinity calculated using the available data. In making these estimates only polygons that appeared to overlay earlier mapped polygons were used in the change calculation. Polygons that appeared not to have been identified in the earlier mapping were excluded from the calculations.

3.1 Estimates of changes in soil salinity in the Corangamite CMA region

In 2001 DPI staff in the Corangamite CMA region conducted a soil salinity survey to collect data to evaluate the change in area and severity of saline discharge sites over the previous decade. The method documented by Allan (1996) was used to identify the extent of the saline discharge area and assess its severity. Sites were mapped using a GPS and mobile Geographic Information System (GIS) and change was determined by comparison with previous assessment.

Rather than attempt to map all saline sites within selected subcatchments, a subset of 133 sites was selected for review. In the course of remapping these sites, 23 new sites were located and mapped during the review. The 23 new sites were not included in the estimate of change. Figure 2 shows the distribution of the areas mapped in the 2001 survey (overlaid in red) relative to the associated mapped salt affected areas from earlier surveys (green under colour).

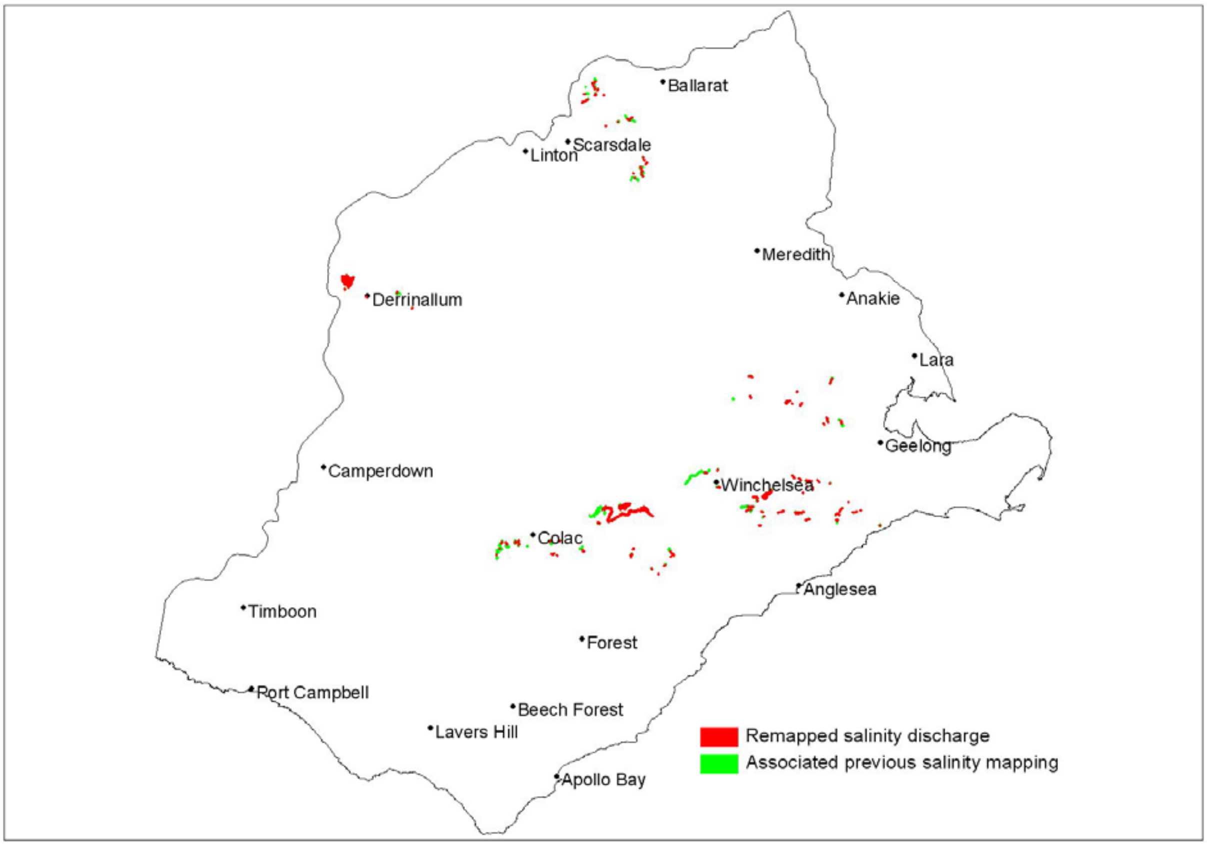

Figure 2 Distribution of the saline areas remapped in 2001 compared to associated earlier mapping of soil salinity in the Corangamite CMA region

The 133 sites selected for reassessment had all been mapped prior to 1992 (by surveys in 1976, 1988 and 1991 using air photos as a map base) and covered 2006 ha of saline discharge area. None had been re-mapped prior to the assessment in 2001. In 2001, reassessment of these sites identified 2243 ha as saline, a 12% increase in area. Identification of severity classes for revisited sites showed an increase of severity class 1 and decrease of classes 2 and 3, compared to the previous assessment (Gardiner 2001). Table 2 summarises change in the extent and severity of the salt affected area in the Corangamite CMA region for sites mapped prior to 1992 and remapped in 2001.

Table 2 Summary of changes in the severity of soil salinity at the saline sites that were originally mapped in 1976, 1988 and 1991 and remapped during 2001 in the Corangamite CMA region taken from Gardiner (2001)

	Area (ha) 1976, 1988 & 1991 mapping	Area (ha) 2001 mapping	Area of change (ha)	Percentage change (%)
1 (slightly saline)	840	1567	+727	+86
2 (moderately saline)	1110	638	-472	-43
3 (highly and extremely saline)	56	38	-18	-32
Total saline area	2006	2243	+237	+12

3.2 Estimates of changes in soil salinity in the North East CMA region

The original mapping of soil salinity in the North East CMA region was undertaken in 1995 to provide a basis for the 1997 *North East Salinity Strategy*. There were 158 sites mapped with varying levels of severity (Macreadie 2007). In recent times, DPI North East regional staff became aware of errors and problems with the original mapping and also wished to map new sites as they were reported.

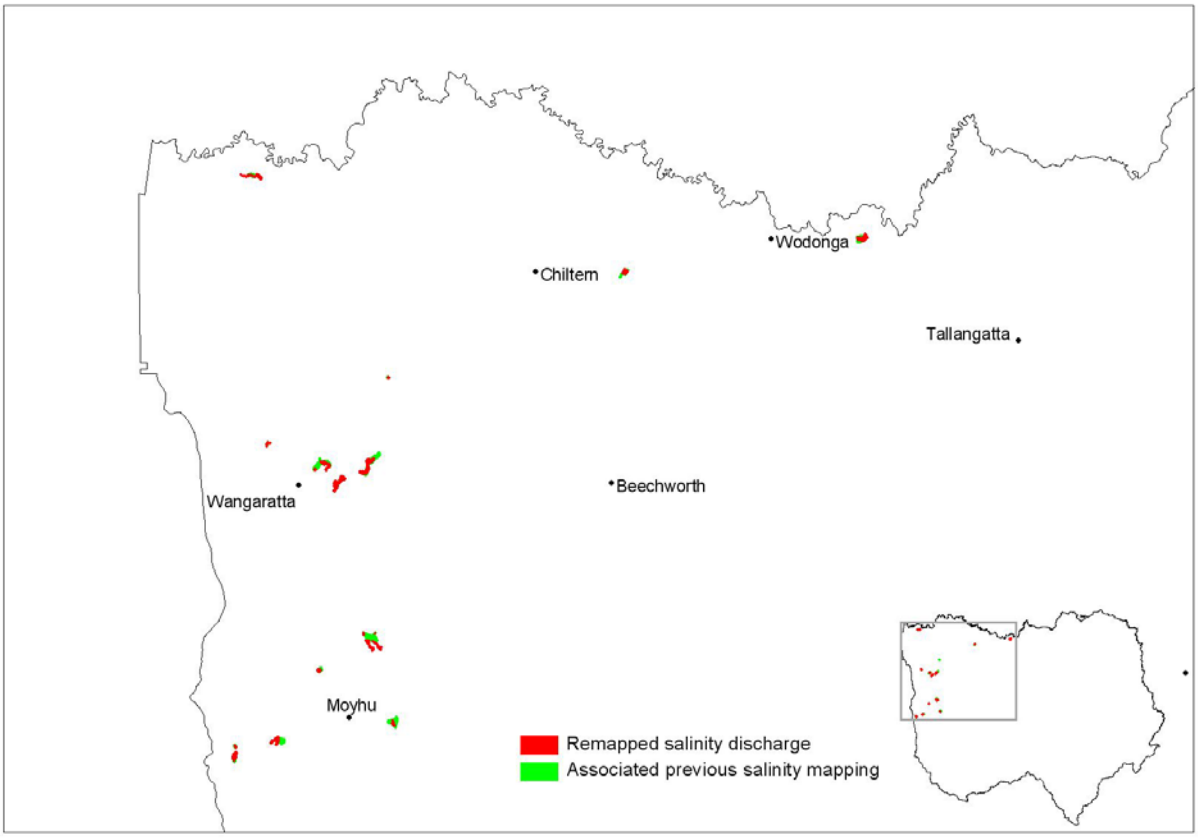

Figure 3 Distribution of saline sites that were remapped in the North East CMA region compared to associated earlier mapping of soil salinity

Sites were selected to be reassessed for the following reasons:

The original mapping showed the sites as being larger than would be reasonably expected.

Sites were identified by staff during field visits as needing further investigation.

To complete the reassessment of selected subcatchments (following the reassessment of other sites within the subcatchment).

Between 2001 and 2005, in the course of checking perceived errors and mapping previously unidentified sites, 25 scattered sites were reassessed using the method documented by Allan (1996). Figure 3 shows the distribution of the reassessed sites compared to associated earlier mapping of salinity in the North East CMA region. Site details were recorded on aerial photos and transferred into Arcview or collected with a GPS (Macreadie 2007). Table 3 summarises the total change in the extent of these 25 salt affected sites over time and shows that the total saline area apparently shrank by 38% from 501 ha to 308 ha. This remapping was not done with the specific aim of monitoring change in the extent of salinity over time, but the manner of the survey where specific sites were reassessed, allows comparison between the 1995 mapping and the mapping after 2000. Although the method of identifying and assessing the severity of the salinity was consistent, some errors are likely to have been introduced as the 1995 survey used air photos as a mapping base and the surveys post 2000 used autonomous GPS instruments to delineate the extent of the salt affected areas.

The data was also analysed to determine if there had been any change in the level of severity of soil salinity. To this end, the area for each Sev class (1, 2 and 3) was summed for the 1995 survey and also for the sites mapped post 2000. The change in area and the percentage change with respect to the 1995 mapped area for each Sev class was calculated (Table 3). This analysis indicates that there was a significant reduction in the severity of soil salinity at sites surveyed in the North East CMA as the moderate, high and extremely saline area (Sev classes 2 and 3) decreased significantly while over the same period the slightly saline area (Sev class 1) more than doubled.

Table 3 Summary of changes in the severity of soil salinity at the saline sites that were originally mapped in 1995 and remapped between 2001 and 2005 in the North East CMA region

	Area (ha) 1995 mapping	Area (ha) post 2000 mapping	Area of change (ha)	Percentage change (%)
1 (slightly saline)	126.6	275.8	+149.2	+118
2 (moderately saline)	269.2	32.6	-236.6	-88
3 (highly and extremely saline)	105.6	0	-105.6	-100
Total saline area	501.4	308.4	-193.0	-38

3.3 Estimates of changes in soil salinity in the Goulburn Broken CMA region

Much of the original soil salinity mapping in the Goulburn Broken CMA region dates back to the mid 1980s and was used to support the draft *Goulburn Dryland Salinity Management Plan* (SPPAC 1989). Only limited remapping has occurred since that time. Figure 4 shows the distribution of remapped sites compared to associated earlier mapping of soil salinity.

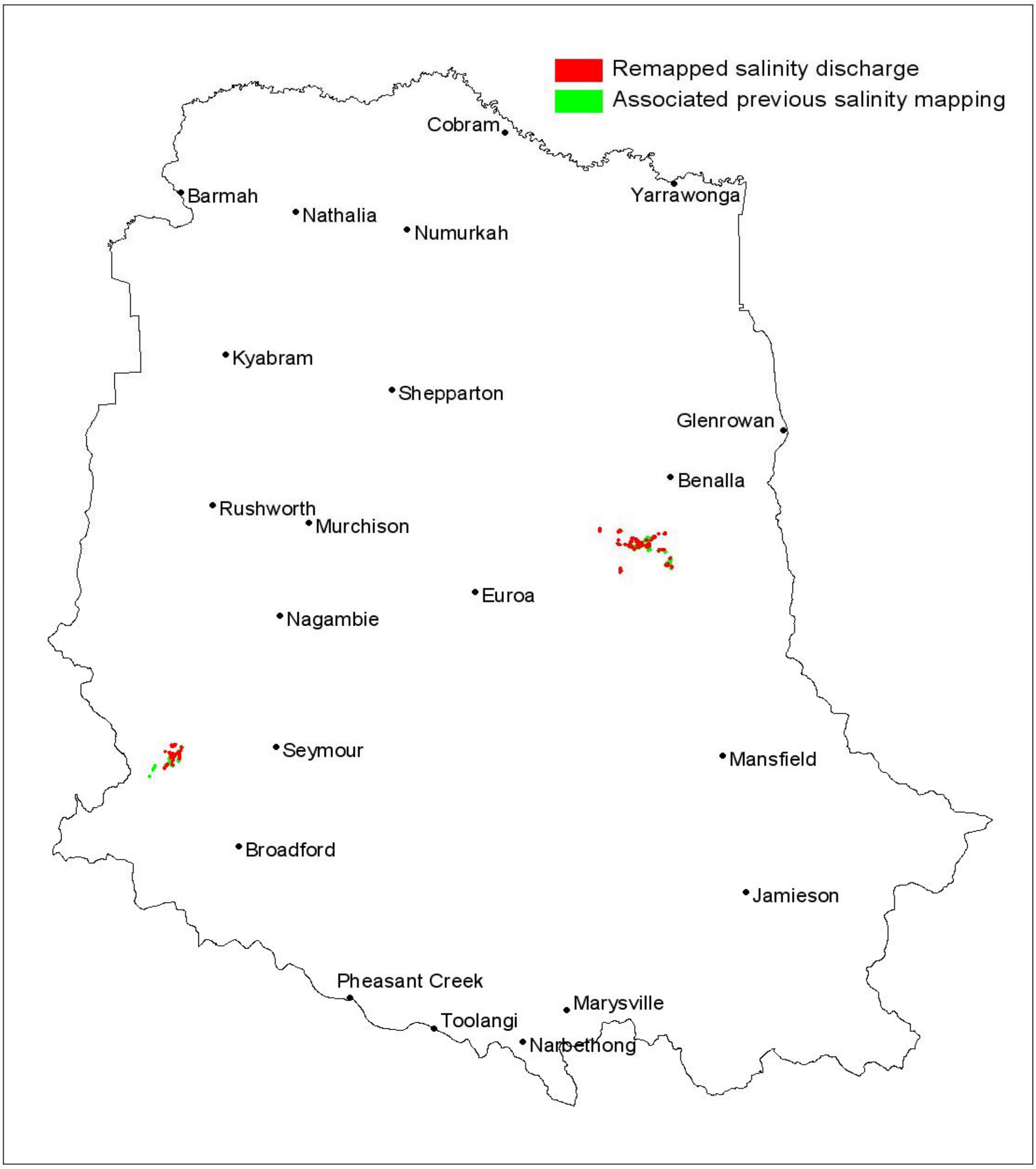

Figure 4 Distribution of saline sites that have been remapped in the Goulburn Broken CMA region compared to associated earlier mapping of soil salinity

Table 4 shows that for the sites surveyed, the salt affected area decreased by 13% from 438 ha to 379 ha. The initial mapping in the Goulburn Broken probably used air photos or 1:25 000 topographic maps as a mapping base. The remapping surveys used a mix of differentially corrected and non-differentially corrected GPS data. Given the different methods used to delineate the extent of saline soil (i.e. marking polygons onto an airphoto or topgraphic map base versus walking the site with a GPS) it is likely that some of the change over time may be due to the different methods used to delineate the extent of soil salinity.

The data was also analysed to determine if there had been any change in the level of severity of soil salinity. The pre 1990 surveys recorded single severity ratings for each area even where multiple severity classes existed for parts of the site. The assignment of the single rating (known as 'Severity')was made according to a set of rules that generally saw the site rated according to the predominant class in terms of area. The post 2000 surveys recorded percentages of the total area for each class (Sev class 1, 2 or 3) at a site. The difference in these classification conventions have to a large part rendered the data incompatible for comparison. This further highlights the need for a consistent and structured approach to monitoring soil salinity. To allow some assessment of change in severity of soil salinity the 'Severity' rating was calculated for the post 2000 mapping. Given the large area (277.0 out of a total 437.5 ha) that was not assessed for severity in the early surveys (Severity class 4), it is hard to draw much from the data. We cannot be confident of the area attributed to each severity class for the pre 1990 surveys. The areas recorded for the pre 1990 surveys are minimum areas as the 277 ha where severity was not assessed would have fallen into either Severity class 1, 2 or 3. Therefore, it is likely that the percentage increase in Severity 1 was not as significant as shown in Table 4, the decrease in the Severity 2 class was greater than recorded, and there may have been a smaller increase or even a decrease in the total area of Severity 3 class soil salinity.

Table 4 Summary of changes in the severity of soil salinity at the saline sites that were originally mapped pre 1990 and remapped between 2001 and 2005 in the Goulburn Broken CMA region

Severity rating	Area (ha) pre 1990 mapping	Area (ha) post 2000 mapping	Area of change (ha)	Percentage change (%)
1 (slightly saline)	14.9	327.3	+312.4	+2092
2 (moderately saline)	145.6	44.6	-100.9	-69
3 (highly and extremely saline)	0.0	6.8	+6.8	NA
4 (saline but severity not recorded)	277.0	0.0	NA	NA
Total saline area	437.5	378.8	-58.7	-13

3.4 Estimates of changes in soil salinity in the North Central CMA region

In 1999 the Mid-Loddon Landcare Group (comprised of the Nuggety Hills, Ravenswood, Upper Spring Creek and West Marong Landcare groups) received funding to implement a local salinity management plan. Prior to commencing work the existing soil salinity data (collected in 1990) was updated to provide a current baseline of the extent and severity of soil salinity in the project area. Both of the 1990 and the 1999/2000 surveys used air photos as a mapping base for the field survey. The remapping survey made a concerted effort to identify all saline sites in the project area, and with the benefit of an active Landcare network a number of new sites were identified. Table 5 summarises the change in the severity and extent of the saline area over time and shows a significant decrease in the total extent of saline areas for the sites that were reassessed. Figure 5 shows the distribution of the remapped areas in the North Central CMA region

The data was also analysed to determine if there had been any change in the level of severity of soil salinity. In similar fashion to the Goulburn Broken CMA region, the original surveys in the North Central region did not record the percentage of each Sev class for each site. Instead a single 'Severity' indice was calculated based on the field assessment and to allow comparison, this same indice was calculated for the data mapped 1999/2000. Table 5 shows that there was a significant decrease in the area of sites class assigned a Severity class of 2 and 3 (moderate and high salinity) while the area of class 1 'Severity' (low salinity) increased significantly. This indicates that the severity of soil salinity probably declined at the sites that were remapped in the North Central CMA region over the monitoring period.

Table 5 Summary of changes in the severity of soil salinity at the saline sites that were originally mapped in 1990 and remapped in 1999/2000 in the North Central CMA region

Severity rating	Area (ha) 1990 mapping	Area (ha) 1999/2000 mapping	Area of change (ha)	Percentage change (%)
1 (slightly saline)	4.5	170.3	+165.8	+3710
2 (moderately saline)	375.0	20.4	-354.6	-95
3 (highly and extremely saline)	349.0	0.0	-349.0	-100
4 (saline but severity not recorded)	11.7	0.0	-11.7	-100
Total saline area	740.1	190.7	-549.4	-74

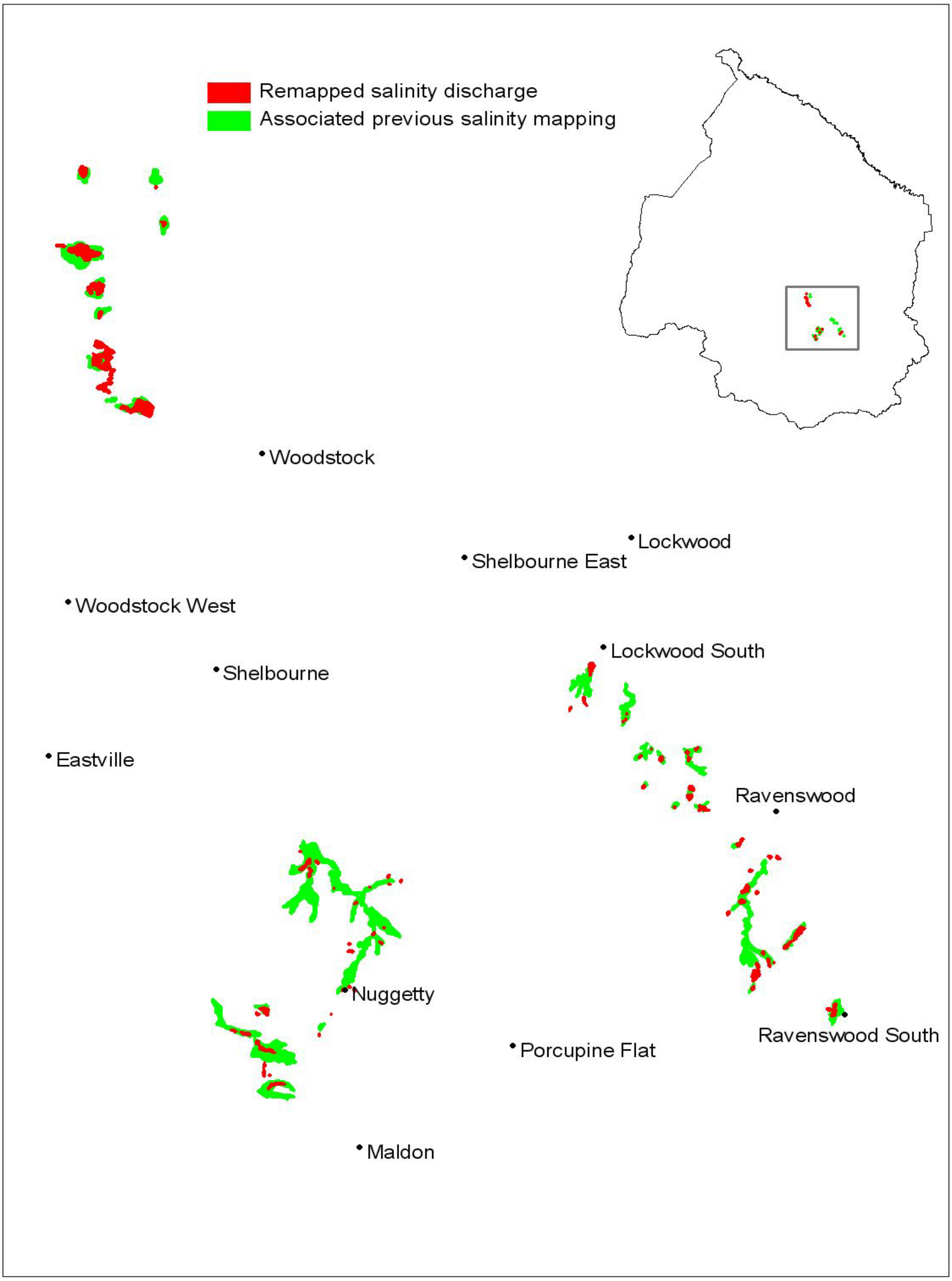

Figure 5 Distribution of the saline areas remapped in the North Central CMA region compared to associated earlier mapping of soil salinity

4 Salinity discharge monitoring sites

The Victorian Soil Salinity Monitoring Project also set-up a statewide monitoring network comprised of more than 50 sites across Victoria to monitor changes in the extent and severity of soil salinity. Clark (2005) developed and documented a standard procedure for assessing change in soil salinity at these sites. At most monitoring sites, estimates of the extent of salt affected ground were based on electromagnetic (EM38) survey and soil analysis. This method is more objective than the vegetation based assessment and provides a more repeatable method of assessing changes in soil salinity over time.

Unfortunately, lack of funding, low soil moisture conditions and changing priorities by investors has meant that monitoring has not continued since 2004. In addition, data from several monitoring sites was not readily accessible due to changes in software and the data format. Given these limitations, data from 21 monitoring sites across six CMA regions were available to provide an estimate of change in the extent of salinity over time. Figure 6 shows the distribution of sites where the available data allowed an estimate of change in soil salinity over time.

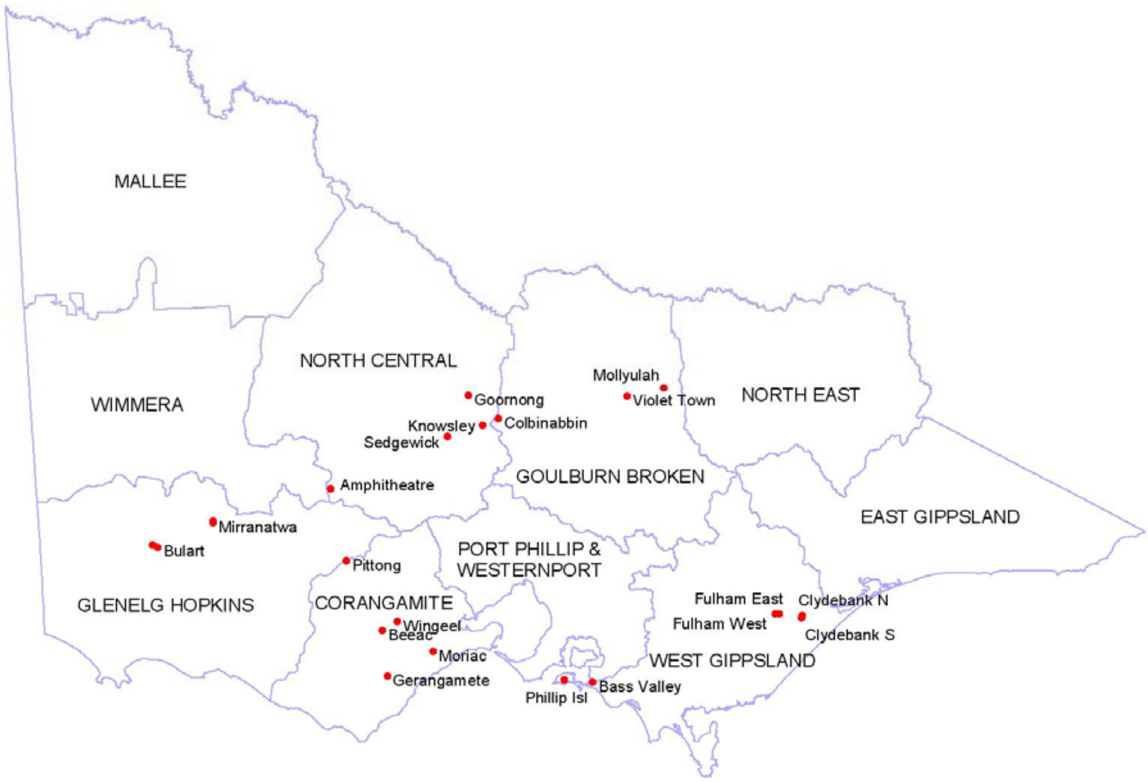

Figure 6 Distribution of sites from the Victorian soil salinity monitoring network used to calculate change in the extent of soil salinity

Like the vegetation assessments, change estimates based on soil conductivity measurements will contain some error, which may significantly affect the estimates of change over time, and results based on soil conductivity mapping may be misleading if the correlation between soil conductivity and effect on vegetation is poorly understood at a specific site. However, in most instances soil conductivity based estimates of soil salinty are accurate and given the more objective and repeatable nature of the assessment (i.e. machine or sensor based measurement), the estimates of change based on the EM38 survey are likely to be more reliable than those derived from the vegetation assessments. In addition, the monitoring network sites were set-up specifically to determine rates of change over time. Nonetheless, some of the monitoring sites are very small (< 1 ha) and it is difficult to extrapolate trends identified at sites of this size across whole regions with confidence.

Table 6 lists the changes in the extent of salinity and Table 7 summarises changes in the severity of soil salinity for each CMA region based on the aggregated results of monitoring sites within each region. These changes are briefly described in the following sections.

4.1 Corangamite CMA region

In the Corangamite CMA region four of the five sites decreased in size. These sites ranged in size from less than 1 ha to around 15 ha. One site at Pittong (around 1 ha in area) went against the apparent trend and more than doubled in size. Other monitoring by Ballarat University in the Pittong region shows similar increases in saline sites (Dahlhaus[1] pers. comm.).

To identify how the severity of soil salinity changed across the region over the monitoring period, data from all sites in the region were aggregated. Over the period 1994 to 2000, soil salinity severity across the sites decreased as the severe and extreme classes (Sev 3 and Sev 4) shrank by 12% and the moderately saline area (Sev 2) shrank by 36%. Some of this area became slightly saline (Sev 1) and this class increased by 6% across all the monitoring sites between 1994 and 2000.

4.2 Glenelg Hopkins CMA region

In the Glenelg Hopkins CMA region, two sites north of Hamilton at Bulart (2-5 ha in area) showed small increases in the extent of salt affected soil. Due to local magnetic anomalies, these two sites were monitored using the standard vegetation assessment instead of the standard EM38 survey used to survey all other sites in the monitoring network. Two sites were established in the Victoria Valley (2-5 ha in area). One showed a small decrease in the extent of salt affected area while the other almost halved in size.

Data from three monitoring sites in the Glenelg Hopkins region was aggregated, and over the period 1996 to 2003 soil salinity severity across the sites decreased as the severe and extreme classes (Sev 3 and Sev 4) reduced in size by 27%, the moderately saline area (Sev 2) shrank by 11%. This decrease in soil salinity at the top end led to an increase in slightly saline land (22% increase) over the period 1996 to 2003 as some of the moderate, high and severly saline land became only slightly saline. The general trend was for a decrease in the severity of soil salinity across the monitoring sites in the Glenlg Hopkins region.

4.3 Goulburn Broken CMA region

In the Goulburn Broken CMA region, two sites showed a decrease while one showed a significant increase in the salt affected area. All of these sites are less than 1 ha in size and the site that increased by 150% (an increase of 300 m^2) covered an area less than 0.1 ha. It is hard to use data from sites of this size to estimate likely rates of change across a whole CMA region.

To identify how the severity of soil salinity changed across the region over the monitoring period, data from three sites in the region was aggregated. Over the period 1995 to 1998, soil salinity severity across the sites decreased as the severe and extreme classes (Sev 3 and Sev 4) disappeared entirely, the moderately saline area (Sev 2) shrank by 80% and the slightly saline class (Sev 1) decreased by 8%.

4.4 North Central CMA region

In the North Central CMA region, three of the four sites decreased in salt affected area by more than 50% (these sites were 1-5 ha in size) while the fourth site (around 2 ha) did not change.

To identify how the severity of soil salinity changed across the region over the monitoring period, data from all four sites in the region was aggregated. Over the period 1995 to 2000, soil salinity severity across the sites decreased as the severe and extreme classes (Sev 3 and Sev 4) shrank by 19%, the moderately saline area (Sev 2) shrank by 48% and the slightly saline class (Sev 1) decreased by 67%.

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4.5 Port Phillip CMA region

In the Port Phillip/Westernport CMA region, both sites (both around 10 ha in area) increased marginally in extent.

To identify how the severity of soil salinity changed across the region over the monitoring period, data from both sites in the region was aggregated. Over the period 1998 to 2001, the severity of soil salinity across the sites increased at the upper end of the spectrum as the severe and extreme classes (Sev 3 and Sev 4) grew by 11% and the moderately saline area (Sev 2) by 13%. Over this time the slightly saline class (Sev 1) decreased by 10%, indicating that some of the slightly saline soil probably became more saline as the change in extent was almost nil.

4.6 West Gipsland CMA region

In the West Gippsland CMA region, one site (7 ha in area) shrank slightly, two sites (both >15 ha in size) remained virtually unchanged and the fourth site (around 12 ha) increased in area slightly. Taking measurement error into account it is unlikely that any of these changes in extent were significant.

Analysis of the aggregated site data showed that over the period 1996 to 2001, the severity of soil salinity across the sites decreased at the upper end of the spectrum as the severe and extreme classes (Sev 3 and Sev 4) shrank by 18%. The moderately saline area (Sev 2) increased by 27% while the slightly saline class (Sev 1) decreased by 9%. It is likely that some of the S3 and S4 land became less saline over the monitoring period and was reassessed as moderately saline (Sev 2) thus accounting for the increase in that class.

Table 6 Summary of changes in the extent of soil salinity at monitoring sites in the Victorian soil salinity monitoring network

CMA region	Site	Initial mapping date	Mapped area (ha)	Remapping date	Mapped area (ha)	Change in area (ha)	Change (%)
Corangamite	Moriac	1995	0.39	2000	0.28	-0.11	-30
	Gerangamete untreated	1994	1.50	1999	0.39	-1.11	-74
	Wingeel	1995	15.40	1999	12.30	-3.10	-20
	Pittong	1996	0.75	2000	1.70	+0.95	+128
	Beeac	1996	16.20	2000	14.10	-2.10	-13
	Aggregate		34.24		28.77	-5.47	-16
Glenelg Hopkins	Mirranatwa treated	1995	5.21	1998	4.92	-0.29	-6
	Mirranatwa untreated	1995	2.67	1998	1.28	-1.39	-52
	Bulart treated*	1997	1.95	2004	2.05	+0.10	+5
	Bulart untreated*	1997	3.24	2004	3.54	+0.30	+9
	Aggregate		13.07		11.79	-1.28	-10
Goulburn Broken	Mollyulah	1995	0.79	1998	0.58	-0.21	-27
	Violet Town	1995	0.07	1998	0.06	-0.01	-10
	Colbinabbin	1995	0.02	1998	0.05	+0.03	+150
	Aggregate		0.88		0.69	-0.19	-22
North Central	Amphitheatre	1995	1.80	1999	1.80	0	0
	Knowsley	1995	1.60	1998	0.70	-0.90	-56
	Goornong	1996	4.96	2000	0.10	-4.86	-98
	Sedgewick	1996	4.80	2000	2.07	-2.73	-57
	Aggregate		13.16		4.67	-8.49	-65
Port Phillip	Bass Valley	1998	9.88	2001	10.04	+0.15	+2
	Phillip Island	1998	9.60	2001	9.95	+0.34	+4
	Aggregate		19.48		19.99	+0.51	+3
West Gippsland	Clydebank North	1996	7.40	2001	7.05	-0.35	-5
	Clydebank South	1996	17.30	2001	17.40	+0.10	+1
	Fulham East	1998	16.60	2001	16.57	-0.03	0
	Fulham West	1998	11.29	2001	12.05	+0.76	+7
	Aggregate		52.59		53.07	+0.48	+1

* Data based on vegetation assessment rather than EM38 survey

Table 7 Summary of changes in the severity of soil salinity at monitoring sites in the Victorian soil salinity monitoring network

	Corangamite	Goulburn Broken	Glenelg Hopkins*	North Central	Port Phillip	West Gippsland
First survey non-saline area (ha)	18.17	7.18	2.02	22.65	5.97	19.86
First survey slightly saline area (ha)	7.68	0.65	4.08	11.29	8.44	16.62
First survey moderately saline area (ha)	11.26	0.21	4.83	1.79	5.65	18.36
First survey highly and extremely saline area (ha)	15.32	0.00	1.50	0.11	5.40	25.79
Second survey non-saline area (ha)	23.69	7.39	2.99	31.07	5.47	20.89
Second survey slightly saline (ha)	8.12	0.60	4.96	3.74	7.59	15.19
Second survey moderately saline area (ha)	7.16	0.04	4.31	0.93	6.39	23.25
Second survey highly and extremely saline area (ha)	13.49	0.00	1.09	0.09	6.01	21.23
Change in non-saline area (ha)	+5.53	+0.20	+0.98	+8.42	-0.50	+1.03
Change in slightly saline area (ha)	+0.44	-0.05	+0.88	-7.55	-0.85	-1.43
Change in moderately saline area (ha)	-4.10	-0.17	-0.52	-0.86	+0.73	+4.89
Change in highly and extremely saline area (ha)	-1.84	0.00	-0.41	-0.02	+0.62	-4.56
Change in non-saline area (%)	+30	+3	+48	+37	-8	+5
Change in slightly saline area (%)	+6	-8	+22	-67	-10	-9
Change in moderately saline area (%)	-36	-80	-11	-48	+13	+27
Change in highly and extremely saline area (%)	-12	-100	-27	-19	+11	-18

* Data based on vegetation assessment as well as EM38 survey

5 Conclusion

A coordinated, comprehensive mapping of dryland soil salinity has never been funded and so the database is not able to provide a complete picture of soil salinity across Victoria at one time. The Victorian dryland soil salinity data base held on the CSDL is a compilation of almost all Victorian soil salinity surveys and provides the most current record of the mapped extents of dryland soil salinity. This database indicates that over 260 000 ha of soil salinity (this includes over 110 000 ha of primary salinity) has been mapped in Victoria.

This data base was not specifically designed to estimate the rate of change of soil salinity over time, but some areas have been remapped. Based on limited data, it appears that there has been a decrease in the extent of the salt affected area in the Goulburn Broken region (pre 1990 compared to post 2000), although it is hard to determine if there was a change in the severity given the available data. In the North East CMA (1995 compared to post 2001) and the North Central (1990 compared to 1999) CMA regions both the extent and severity of salt affected areas declined. In the Corangamite CMA region (pre 1992 compared to 2001) a slight increase in extent was accompanied by a decrease in severity. All changes should be interpreted in conjunction with other available data including rainfall, groundwater levels and land use. Some surveys show that change was not consistent across the remapped area, but the total change across a survey area is the figure that has been quoted.

The Victorian Soil Salinity Monitoring Network was set up to identify rates of change in the area and severity of salt affected soil, and some of that data is presented here. Unfortunately, lack of funding, low soil moisture conditions and changing priorities by investors meant that monitoring has been erratic and has not continued since 2004. In addition, data from several monitoring sites was not readily accessible due to changes in software and the data format. Given these limitations, data from 21 monitoring sites across six CMA regions was available to provide an estimate of change in the extent and severity of salinity over time.

Data from the monitoring network was variable and to gain a feel for how the soil salinity was changing across each CMA region sites were aggregated. In general terms, based on the available data, it is possible to say that:

In the Corangamite CMA region, contrary to the soil salinity layer, the monitoring network sites showed a decrease in extent over the period 1994 to 2000 (down by 16% or 5.52 ha) accompanied by a decrease in severity.

In the Glenelg Hopkins CMA region two sites grew slightly (1997–2004) while two others decreased (1995–2003), but the total saline area across all sites decreased by 9% (0.98 ha) accompanied by a decrease in the severity of soil salinity across the monitoring sites.

In the Goulburn Broken CMA region two sites shrank while one very small site increased slightly in area (although the change in terms of percentage is significant) over the period 1995 to 1998. The change in extent across all sites was a decrease of 24% in extent but this should be considered in the light of the small size of the sites as the total decrease in extent was only 0.2 ha. This does support the available data on the soil salinity GIS layer. At the same time there was a general decline in the severity of soil salinity.

In the North Central CMA region three sites decreased in extent significantly while the fourth did not change (1995–2000). Taking all the sites together there was a 64% (8.42 ha) decrease in the extent of the salt affected area in the North Central CMA region accompanied by a general reduction in the severity of soil salinity across all classes.

In the Port Phillip/Westernport CMA region the two sites grew only marginally by 3% (0.5 ha) over the period 1998–2001, and the affected area tended to become more saline.

In the West Gippsland CMA region, one site shrank slightly (1996–2001), two sites (both 15-20 ha in size) remained virtually unchanged (1996–2001) and the fourth site (around 12 ha) grew slightly (1998–2001). The aggregate change across all sites in the West Gippsland CMA region was only a decline of 2% or 1.03 ha.

Over this same period, the sites tended to become less saline as 18% of the high and extremely saline land improved to become only moderately saline.

It is hard to give a concise answer as to the rates of change of soil salinity for the whole of Victoria. While the results were not totally consistent across the whole state and across both methods (the vegetation based data held in the soil salinity GIS database and the EM38 based surveys monitored as part of the discharge monitoring network) we can say that both datasets tended to show an overall trend of decreasing severity (i.e. translation of severe to less severe and generally a reduction in mapped area) since the early 1990s. Specific local factors such as climate, topography, soils, geology and land use mean that different processes are driving the expression of soil salinity. In the light of this it is reasonable to expect that there will be variation in rate of change from region to region. To gain a full appreciation of changes in any one area, these local drivers need to be included in an analysis. The rates of change will also vary depending on the period for which data is collected, that is, an estimate of change based on surveys in 1985 and 1996 may show a significant increase in salinity, but an estimate of change for the same area based on surveys in 1985 and 2006 may show no change or a relatively small change.

In summary, the available data appears to indicate a general decline in extent and severity of soil salinity, but it is difficult to say how much of this trend is related to variation in method of assessment and mapping technique.

Further research could be undertaken to attempt to establish the influence of measurement technique and operator error by applying repeat surveys (different measurement, different operators) to sites within the same timeframe. The results of this research would potentially remove one of the unknowns and thereby assist in the current and future data interpretation. Finally, this exercise has highlighted the need to re-design and properly resource the soil salinity monitoring system to allow meaningful reporting of changes in the extent and severity of saline soil so that useful feedback can be provided to funders, land managers and the community. Until then estimates may not be sufficiently reliable.

References

Allan M (1996) Method for assessing dryland salinity in Victoria. Department of Natural Resources and Environment, Victoria.

Clark R (2005) The salinity monitoring site network in Victoria, standards and procedures. Department of Primary Industries, Victoria.

Clark R (2006) Remapping soil salinity in 2003 in the Gardiners Creek sub-catchment. Department of Primary Industries, Victoria.

Clark R, Fawcett J (in prep) Method for field assessment of dryland salinity in Victoria using GPS technology. Department of Primary Industries, Victoria.

Gardiner B (2001) Salinity discharge mapping in the Corangamite region. Department of Primary Industries, Victoria.

Grinter V, Mock I (2007) Mapping the Mallee's saline land using available spatial data. Investigations into sustainable landscape management. Final report. Agriculture Victoria Services Pty.Ltd. (unpublished).

Macreadie K (2007) Salinity discharge mapping in North East Victoria. Department of Primary Industries, Victoria (unpublished).

Matters JM (1987) Dryland salinity component: criteria and methodology of assessment. Land Protection Division, Victoria.

Matters JM, Boruvka V (1987) Field Guide to Plants Associated with Saline Soils of Victoria. Department Of Conservation Forests and Lands.

Matters JM, Bozon J (1989) Spotting Soil Salting. Department of Conservation Forests and Lands

Matters JM, Bozon J (1995) Spotting Soil Salting (Second Edition). Department of Conservation and Natural Resources.

Miller L (2006) Salinity discharge mapping across priority areas in the Surfcoast, Colac Otway, Golden Plains and Corangamite shires. May 2006. Department of Primary Industries, Victoria.

Milner J, Hale M (2002) Global Positioning System Handbook. GPS data collection for integration with Geographic Information Systems. Standards, specifications and best practice field guide. Department of Sustainability and Environment, Department of Primary Industries, Victoria.

SPPAC (1989) Goulburn Dryland Salinity Management Plan (Draft). Salinity Pilot Program Advisory Council, Salt Action Victoria.