Mapping Salt Affected Soils of Australia

J. K. M. SKENE

Victorian Department of Agriculture, Melbourne, Australia

Three major difficulties to the preparation of a map of salt affected soils as proposed at the Budapest meeting in 1967 are seen by Australian soil scientists. These are:

1. Absence of specific definitions for the three categories (saline, alkali, and normal soils) specified at Budapest. Minimum limits for the proposed chemical criteria for these categories are considered essential as reference standards.

2. The relationship between morphological features of the soil profile and analytical values in terms of salts and exchangeable cations is not clearly established.

3. Absence of analytical data over large areas of Australia. In an endeavour to overcome these difficulties the following steps were taken:

(i) Arbitrary limits for salinity, sodicity and alkalinity were fixed in terms of chloride content, exchangeable sodium percentage, and pH.

(ii) A number of classes (27) of salt affected soils were set up representing all combinations of salinity, sodicity and alkalinity as defined.

(iii) Profiles for which chemical data are available were classified into (a) the arbitrary classes, and (b) Principal Profile Forms, the morphological profile unit used in the Atlas of Australian Soils.

(iv) A broad relationship between the arbitrary classification and the morphological classification was established from the two sets of classified data.

(v) The arbitrary classes were mapped from the Atlas of Australian Soils using the established relationship.

(vi) The classes were consolidated to conform to the three main categories laid down by the Subcommission.

(vii) The alkali class was subdivided on the basis of the morphological classification used in the Atlas.

Selection of limits for the criteria

Although two metres had been indicated as the profile depth for consideration, this was considered too deep for Australian conditions and *one metre* was adopted. The maximum analytical value within this depth, irrespective of its position, was taken to be diagnostic. As it was considered better to have too many rather than too few classes for the initial consideration of the data, limits for different levels in each of the salinity, sodicity and alkalinity categories were set as shown below.

Salinity

Chloride has been considered as sodium chloride equivalent for convenience.

A soil profile with more than 0.1% (light texture) or 0.2% (heavy texture) sodium chloride in the surface horizon has been regarded as saline, as has a soil with less than this in the surface, but more than 0.3% in the subsoil. There are, therefore, three categories of chloride status, viz:

Group 0 No chloride salinity in either surface or subsoil.
,, 1 Surface salinity (subsoil salinity may be present also).
,, 2 Subsoil, but no surface, salinity.

Sodicity

The widely accepted ESP value of 15 as reflecting influential sodium has been used, but there is evidence that lower values are associated with adverse soil structure, while the pedogenic influences of sodium salts may be reflected by even lower values. For these reasons, an ESP value of 5 has been selected as the maximum for a non-sodic soil.

Group 0	Non-sodic	ESP, less than 6.
,, 1	Sodic	ESP, 6—14.
,, 2	Strongly sodic	ESP, 15 or higher.

Alkalinity

Although incorporated in the scheme of classification, pH has not been a determinant in the characterization of the soluble salts present.

Group 0 No carbonate or bicarbonate salinity, pH less than 8.
,, 1 Alkaline, pH 8.0—9.5, bicarbonate present.
,, 2 Strongly alkaline, pH above 9.5, carbonate present.

It should be noted that pH has been determined in 1 : 5 soil: water suspensions. Such values for sodic soils may be one pH unit or more higher than in saturated pastes or 1 : 1 suspensions. On the other hand soluble salts depress the pH.

Salt affected classes

The following Table 1. sets out the 27 possible combinations of the above groups.

Relation between principal profile forms and salt affected classes

All profiles for which appropriate analytical data are available were classified in terms of their Principal Profile Form and their Salinity Class. The relationships are set out in Table 2. From this data, the Principal Profile Forms that occur in each salt affected class, are shown in Table 3. The number

Table 1

Salt affected classes

Class	Group			Description	Occurrence
	Cl	Na	pH		
0	0	0	0	Normal soils.	Widespread.
1	0	0	1	Normal alkaline soil.	Widespread.
2	0	0	2	Non-saline, non-sodic, strongly alkaline.	Not recorded.
3	1	0	0	Saline, non-sodic.	Not recorded.
4	1	0	1	Saline, non-sodic, alkaline.	Not recorded.
5	1	0	2	Saline, non-sodic, str. alkaline.	Not recorded.
6	2	0	0	Subsoil salinity, non-sodic.	Not recorded.
7	2	0	1	Subsoil salinity, non-sodic, alkaline.	Not recorded.
8	2	0	2	Subsoil salinity non sodic, str. alkaline.	Not recorded.
9	0	1	0	Non-saline, sodic.	Widespread.
10	0	1	1	Non-saline, sodic, alkaline.	Widespread.
11	0	1	2	Non-saline sodic, str. alkaline.	Locally important.
12	1	1	0	Saline, sodic.	
13	1	1	1	Saline, sodic, alkaline.	
14	1	1	2	Saline sodic, str. alkaline.	Few profiles recorded.
15	2	1	0	Subsoil salinity, sodic.	
16	2	1	1	Subsoil salinity, sodic, alkaline.	
17	2	1	2	Subsoil salinity sodic, str. alkaline.	
18	0	2	0	Non-saline, str. sodic.	Small area.
19	0	2	1	Non-saline, str. sodic. alkaline.	Very widespread.
20	0	2	2	Non-saline, str. sodic, str. alkaline.	Widespread.
21	1	2	0	Saline, str. sodic.	Small area.
22	1	2	1	Saline, str. sodic, alkaline.	Moderately widespread.
23	1	2	2	Saline, str. sodic, str. alkaline.	Not recorded.
24	2	2	0	Subsoil salinity, str. sodic.	Few profiles.
25	2	2	1	Subsoil salinity, str. sodic, alkaline	Moderately widespread.
26	2	2	2	Subsoil salinity, str. alkaline.	Small area.

of PPF's examined is not given, in some cases the number of profiles was many, in other cases, few.

Some overlapping of salt affected classes will be noted. For example, the normal red-brown earths (Dr 2.33, hard setting duplex soils with an alkaline trend in the profile) occur in salt affected classes 10, 16, 19 and 25. However, the general description of "sodic to strongly sodic-alkaline soils, some with subsoil salinity", covers all of these soils as it does most of the cracking clays (Ug soils) which also fall into these groups and in addition into Nos. 1, 15 and 24. The fact that some of the cracking clays are not salt affected makes extrapolation from morphology to the salt affected classification less reliable for the Ug soils.

Compilation of map of salt affected soils

The map units of the Atlas of Australian Soils have been assessed individually in terms of the salt affected classes assigned to the Principal Profile Forms of the component soils. Separation into sub-categories with

Table 2

Relation between principal profile forms and salinity classes

Principal Profile Form	Salinity class	Principal Profile Form	Salinity class
Dr 1.12	24	Db 1.42	9
Dr 1.32	21	Uc 1.11	1
Dr 1.33	19, 22, 25	Uc 6.13	1, 19
Dr 1.42	21, 3*, 6* *No sodium data	Uf 6.11	1
Dr 2.13	19	Uf 6.31	1
Dr 2.33	10, 16, 19, 25	Uf 6.32	10 Few profiles only
Dr 2.42	18	Uf 6.42	9 Few profiles only
Dr 3.43	19	Um 5.11	10, 19
Dr 4.63	20	Um 5.12	25
Dy 1.43	22	Um 6.41	9 Few profiles only
Dy 2.33	25	Um 6.42	1
Dy 2.43	16, 25	Ug 5.14	1
Dy 2.62	9	Ug 5.15	10
Dy 3.41	9, 12	Ug 5.16	1, 10, 15, 19
Dy 3.43	19, 25	Ug 5.2	19, 25
Dy 3.61	9	Ug 5.24	1, 24
Dy 3.72	9	Ug 5.25	1
Dy 3.81	9	Ug 5.28	10, 22
Dy 3.82	18	Ug 5.3	21
Dy 4.43	10	Ug 5.4	10, 19, 24
Dy 5.41	9	Gc 1.1	11, 19, 23, 25
Dy 5.42	9	Gc 1.12	13, 20
Dy 5.43	19	Gc 1.2	10, 16
Dy 5.51	18	Gn 1.13	25
Dy 5.81	9	Gn 2.12	9, 10 Few profiles only
Dy 5.82	18	Gn 2.25	9 Few profiles only
Dy 5.83	19	Gn 2.71	10 Few profiles only
Dd 1.43	19	Gn 2.74	9 Few profiles only
Dd 2.41	18	Gn 3.92	10 Few profiles only

The principal profile forms are described in NORTHCOTE'S A Factual Key for the Recognition of Australian Soils" (second edition) CSIRO, Division of Soils Divisional Reporr 2/65.

Adelaide Feb. 1969

and without a structural B horizon has been on the basis of the described morphology of the Principal Profile Forms.

The first draft map prepared shows the following 9 categories:

A) *Saline soils.*

1. Strong surface salinity. — No analytical data.
2. Surface and/or subsoil salinity, strongly sodic and often alkaline. — Salt affected classes 22, 21 and 24, grading to 25 and 19.

B) *Alkali soils.*

(a) Without structural B horizon — With NaCl

1. Alkaline soils — Salt affected class 1.
2. Alkaline soils grading in part to normal soils and in part to strongly sodic soils. — Salt affected class 1 grading to 0 and to 9, 10, 19, 21, 22, 24 and 25.

Table 3

Principal profile forms in each salinity class

Salinity class	Principal profile forms
0	Many-not recorded
1	Ucl.11; Ug5.25; Ug5.24; Ug5.14; Uf6.11; Ug5.16; Uc6.13; Uf6.31; Um6.42
2—8	Not recorded
9	Dy3.81; Dy3.41; Db1.42; Dy5.81; Dy3.61; Dy2.62; Dy3.72; D5.41; Dy5.42 Small numbers of Gn3.92; Gn2.12; Gn2.25; Gn2.74; Um6.41; Uf6.42
10	Dr2.33; Dy4.43; Gcl.2; Um5.11; Ug5.16; Ug5.4; Ug5.28; Ug5.15 Small numbers of Gn3.71; Gn2.12; Gn3.92; Uf6.32
11	Gcl.1
12	Dy3.41 saline variants
13	? Gcl.12
14	Not recorded
15	Ug5.16
16	Dr2.33; Dy2.43; Gcl.2
17	Not recorded
18	Dr2.42; Dy5.82; Dy3.82; Dy5.51; Dd2.41
19	Dr2.33; Drl.33; Dr2.13; Dr3.43; Dy5.43; Dy3.43; Dy5.83; Ddl.43; Gcl.1; Um5.11; Ig5.2; Ug5.16; Ug5.4; Uc6.13 Small numbers of Uf6.32; Gn2.23
20	Dr4.63; Gcl.12
21	Drl.32; Drl.42; Ug5.3
22	Drl.33; Dyl.43; Ug5.28
23	? Gcl.1
24	Drl.12; Ug5.24;Ug5.4
25	Drl.33; Dr2.33; Dy2.33; Dy2.43; Dy3.43; Um5.12; Ug5.2; Gcl.1; Gnl.13
26	Not recorded

3. Sodic-alkaline to strongly sodic-alkaline, some with surface and/or subsoil salinity.	Salt affected classes 10 and 19 grading to 11, 20, 23, 16 and 25.
4. Sodic-alkaline to strongly sodic-alkaline, some with subsoil salinity.	Salt affected classes 10 and 19 grading to 25.
(b) With structural B horizon.	
1. Sodic-alkaline to strongly sodic-alkaline, some with subsoil salinity.	Salt affected classes 10 and 19, grading to 16, 25 and 20.
2. Strongly sodic to sodic (non-alkaline).	Salt affected classes 18 and 9.
3. Sodic, grading in part to normal soils and in part to strongly sodic varieties, some surface salinity.	Salt affected classes 9 grading to 0 and to 18 and 12.

The Australian Map of Salt Affected Soils presented to the Erevan meeting has been compiled directly from this first draft map by combining the categories within classes A, B(a), and B(b) above, except that the non-saline, non-sodic alkaline category (B(a)1) has been excluded as being comprised

dominantly of soils not salt affected. The soils within the 3 units shown on the map may be described as follows:

A) *Saline* (dominated by chlorides and sulphates). Soils with surface and/or subsoil salinity, strongly sodic and often alkaline.

B) *Alkali* (dominated by exchangeable sodium and/or sodium bicarbonate and/or sodium carbonate).

(a) *Without structural B horizon.*
Sodic-alkaline to strongly sodic-alkaline soils, some with surface and/or subsoil salinity.

(b) *With structural B horizon.*
Sodic to strongly sodic soils, and sodic-alkaline to strongly sodic-alkaline soils, some with subsoil salinity.

The following points should be noted about the map:

1. All of the soils shown as salt affected are sodic. Since sodicity occurs together with chloride salinity, it is not always possible to ascribe dominance to either one or the other characteristic. In such cases, the profiles have been classified in the saline group. On the other hand not all sodic profiles are saline, but these present no problem as they clearly fall into the alkali group.

2. In general, the areas delineated on the map are more than 50% salt affected. However, there are doubtful areas since there has been considerable extrapolation of both morphological and analytical data in some areas where there is a scarcity of information.

3. The map in itself does not necessarily delineate agriculturally salt affected land. For example, salinity in the subsoil has no significance in soils used for grazing pastures in the light rainfall parts of the continent. Subsoil salinity is also unimportant in some cultivated soils.

Subsidiary maps

Secondary salinisation

Secondary salinisation due to the upward and lateral movement of soluble salts has occurred in irrigation areas, and in some non-irrigated areas where the natural vegetation has been removed and the land brought under cultivation. A subsidiary map indicates where secondary salinisation is prevalent, but the scale of the map and the field data available do not allow delineation of specific areas.

Land Use

An associated map illustrating the general picture of land use in Australia enables the present utilisation of the salt affected soils to be visualised.

Acknowledgements

Whilst the author and Mr. K. H. Nothcote, Division of Soils C.S.I.R.O., take responsibility for the Australian Map of Salt Affected Soils, the project could not have been accomplished without the assistance of the following colleagues: Messrs. E. Bettenay, B. E. Butler, F. R. Gibbons, G. D. Hubble, J. H. Hutton, R. F. Isbell and J. M. Rowan.