10 PLUS REASONS TO REFORM ENVIRONMENTAL RESEARCH

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Abstract

This paper examines the validity of comments as to the suggested inapplicability of ERIC methods for mapping soils using airborne gamma radiation data and the application of the results in addressing dryland salinity. The current status of the comments is addressed and conclusions drawn as to how they arose. Implications for the organisation of environmental research in Australia are discussed.

Introduction

ERIC was established to provide commercial services in the development and application of natural resource information to address land use and the environment. The ERIC capability addresses natural resource management (NRM) but for production as well as the environment. Modern technology is used and ongoing research conducted to improve cost effectiveness and tailor products and services to client needs.

The ERIC capability addresses Australian Government desires for the development of innovation and industry capability in service delivery and the requirements for sustainable and profitable land use. Despite this the ERIC results and methods for soil and salinity mapping have continuously been criticised by a few scientists in federal and state agencies that historically have monopolised such activities. The scientists eventually collaborated in denigrating the ERIC capability[i] and promoting their activities in a consultancy report funded by the Australian Government (Spies & Woodgate 2004, 2005). Ownership of the consultancy report is now attributed to the Department of Agriculture, Fisheries and Forestry (DAFF) and the Department of Environment and Heritage (DEH) [ii] but the contractor remains unnamed.

Material on the ERIC capability was rejected for consideration in the Spies & Woodgate review because of a suggested lack of peer review but the report denigrated the ERIC capability using material that was neither peer reviewed nor publicly available. A request for a right of reply received the fatuous comment from DAFF that the requirement had been met by the provision of an opportunity for public participation in brief workshops. It was inferred that verbal comments could influence the content of the report when a large amount of written material had been rejected. The rejected material included CSIRO reports and publications. A comprehensive list of references had previously been provided to Woodgate due to the disregard of the ERIC capability in a prior review of salinity mapping funded by DAFF (George et al. 1998)[iii].

The commonality in criticisms of ERIC results is that it can't be done. Axiomatically those that say something cannot be done are unable to do it hence such comments identify the limits to the ability of those making them. However, the comments do not identify what is possible for, as science is about developing new capabilities, to suggest something is not possible

simply because it was previously impossible is irrational. The object in science is to make possible things that were previously impossible.

While ERIC expertise in vegetation mapping has been accepted such comments initially arose with vegetation mapping using satellite imagery. A comment by one scientist was that such clear (non-speckled) classified images could not be obtained without filtering when the clarity and resolution arose from the combined use of spectral and spatial statistics in the analysis. This image analysis capability resulted in other scientists making similar comments about the ERIC use of airborne gamma radiation data (radiometrics) to map soils[iv]. This was compounded by the critics perception of what was needed, which related to mineral exploration, without their having any knowledge of soils.

Collaboration between public geophysicists and soil scientists compounded rather than resolved the issues. The understanding of the radiometric data by soil scientists was inadequate as they attempted to map soil types identified by reference to a prior classification of soils, as is traditional. As the prior classification involved pedogenic interpretation there was no reason for the existence of any relationship between their descriptions of soils and the radiometric signals. The approach failed when first applied in the USA around thirty years earlier and will usually continue to do so. It can be applied in specific circumstances, as in parts of the former USSR where recent glaciations have produced a strong relationship between lithology and soil types, but will rarely apply in the highly weathered terrain of Australia.

Technical issues also degraded or negated the results. Univariate analyses were applied to the multi-variate radiometric data. Correlations were sought between an individual airborne radiometric measurement and a point ground sample when such comparisons are effectively negated by the spatial characteristics of the radiometric data.

The criticisms of ERIC mapping methods extended into considerations of the mechanisms for dryland salinity. The ERIC results identified that the rising groundwater model (RGM), presented as the general and official model for dryland salinity, was usually inapplicable. The ERIC considerations were dismissed by unsubstantiated suggestions that the mapping results were invalid.

The criticisms are listed below and summary responses provided in Appendix 1. The discussion examines how such inappropriate comments have arisen and the implications for the conduct of environmental research.

Critical Comments

The sources of the comments are referenced to published articles where possible and otherwise to organisations. Most criticisms relate to unpublished comments by individuals using their position to assert expertise but such comments do not represent the position of any organisation. The one published source represents a compilation of compilations produced by committees mainly comprising public scientists with Spies and Woodgate as the authors. The source of comments is usually undefined hence prime accountability for the comments resides with the authors. However, the publishers also have accountability as they were advised of errors in the final report prior to publication.

Summary responses to the comments are given in the Appendix 1 with references to more detailed information.

Criticisms associated with analysis of the radiometric data

1. Claims made by some vendors have no basis in science. Spies & Woodgate (2004)
2. The only information in the radiometrics derives from K, U and Th in the parent material. Geoscience Australia
3. There is only one way to analyse radiometric data. CSIRO Minerals and Exploration
4. A spatial resolution of one to two pixels cannot be achieved. CSIRO Minerals and Exploration
5. Soils cannot be mapped from radiometrics as there is no relationship between a fundamental soil property and the radiometric signal. Spies & Woodgate (2005)
6. Radiometrics cannot be used to map soils in depositional terrain. Spies & Woodgate (2005) but originally derives from the Bureau of Rural Sciences (BRS)[v]
7. While locally soils can be mapped from radiometrics they cannot be mapped across regions. Spies & Woodgate (2005)[vi]
8. The SoilSelect methodology is unproven. Several state and federal agencies involved in soil and salinity mapping.

Additional criticisms relating to soil mapping include:

9. As the signal derives from the surface it cannot be used to identify subsoil properties. Spies & Woodgate (2005) but derives from CSIRO Minerals and Exploration and Geoscience Australia
10. Radiometrics cannot be used to map salinity. Spies and Woodgate (2005)
11. A reliable soil map cannot be produced with the small number of field samples used by ERIC. CSIRO Soils
12. ERIC does not have a monopoly on developing soil mapping and there are new developments involving diverse data sets including radar. Adelaide University

Additional criticisms on the science include:

13. ERIC cannot say the rising groundwater model is not general. Numerous sources.
14. ERIC cannot say the rising groundwater model has been absolutely negated. University of Western Australia
15. There is no proof that the salt in dryland salinity derives from the soil. Land and Water Australia
16. Addressing dryland salinity through soil structure only addresses symptoms. Land and Water Australia
17. The soil structural degradation explanation for dryland salinity has not been proven. Land and Water Australia

Current Status

The comments have arisen over a period of more than 14 years and most are now generally accepted as being invalid. For example, while the ERIC ability to maps soils from

radiometrics was originally denied the comment has been modified to accommodate results subsequently produced by public scientists. The comment became that soils can be reliably mapped using radiometrics but not across regions as public agencies and research organisations have yet to produce regional maps.

There is no definitive means of determining which comments are still regarded as being valid as the responses provided by ERIC have been met by silence. However, the only points where the criticisms could have any validity are:

a. The RGM is absolutely inapplicable.
b. The signature for SalinityMap derives from cosmogenic ^{24}Na.

The issue with the RGM is as identified in point 14; the conclusion depends on what the RGM is regarded as being. The RGM has been modified over time in attempts to make it applicable to all observed situations. Even so, the logical conclusion when examining the basics of the RGM is that it is physically invalid for dryland salinity except for specific circumstances which have yet to be observed (Tunstall & Gourlay 2006).

The signature for SalinityMap deriving from cosmogenic ^{24}Na represents a hypothesis developed to explain observations and has yet to be tested. However, the observations stand regardless of the validity of the hypothesis. The suggestion that *claims made by vendors have no basis in science* is therefore invalid. The deficient science arises from attempts by critics to use theory to disprove observations.

This highly derogatory comment was based on a highly restricted review (Baddeley et al. 2003). No one has had an opportunity to check the validity of the claims other than those making the derogatory comments (the review did not contain the derogatory comment). The scientist presenting the SalinityMap results (Tunstall) has not had an opportunity to respond to the review or the derogatory comments other than through the ERIC web site (Tunstall 2004d). This is despite a right of reply being part of the agreement associated with the conduct of the review and requests for a right of reply to those presenting the derogatory comments and publishing the report.

The only publicly available information to support the claim that any signal for cosmogenic sodium would be undetectable is based on the sensitivity of the measurement and calculations of the level of ^{24}Na under assumed conditions. The only alternate 'explanation' given for the observations was that they arose by chance (Baddeley et al. 2003). The difficulty is that the probability of the observations arising by chance is much more remote than being able to detect any ^{24}Na signal.

Discussion

Deficient science has been used to criticise the ERIC capability but, given the observation of charlatanry by Passioura (2005), deficient science has become endemic to considerations of dryland salinity. The deficiencies have partly arisen because of the use of peer review to maintain status and position (ERIC 2006b, Tunstall 2006). However, they have also arisen through the use of position to make expert comment without there being any independent assessment of the validity of the comments. The need to use the ERIC web site to provide responses evidences the failure of the system to provide opportunities to respond.

These deficiencies have been highly detrimental to the development of science and its application to provide benefit to the community. The main monetary costs to date have been large expenditures on remedial treatments that at best provide palliative care. Environmental

and social costs have also arisen because activities that could provide solutions involving production and environmental benefits have been suppressed (ERIC 2006). The effective exclusion of the ERIC SoilSelect soil mapping from approved items for addressing salinity under NAP and NHT funding has been of particular consequence. A capability is deemed not to exist until it has been reinvented by public scientists (point 12).

For scientific development the most disappointing outcome is the complete suppression of the development of SalinityMap. Funds are needed to further develop understanding of what is and can be achieved, and how best to routinely produce the results. However, as the technology effectively only has application in addressing issues of public concern the funds must derive from public sources. The failure of public scientists to follow appropriate procedures through using position and restricted reports to denigrate the result has eliminated any chance of the necessary funds being obtained.

The SalinityMap result is of interest in addressing dryland salinity, particularly since it opens a possibility for monitoring salinity outcomes. However, the result has much broader implications as it provides a means of tracing surficial water flows in some landscapes. It provides an opportunity to significantly improve understanding of how systems function and are affected by land use.

The suppression of new developments is antipathetic to science hence there is a need to identify how it has arisen to provide a solution. Defence of status and territory is a standard biological response but science training is meant to raise the conduct of science above self promotion. There have been deficiencies in science training and/or the review process used to address science activities.

The issue does not lie solely with training as the protection of territory is now promoted by organisational and administrative structures. Research organisations have adapted to increase access to research funds that are increasingly being controlled by public administrators with no research experience who need not even have a science degree. Administrators are using funds to lever traditional research funds provided to organisations such as CSIRO hence their influence is greater than indicated by the magnitude of their expenditures.

Where seeking to resolve a problem scientific research addresses defined objectives. However, uncertainty exists as to how a research objective can be achieved, if at all. Uncertainty of success is integral to scientific research, and the Australian Tax Office identifies risk and novelty as being essential ingredients of research. However, with administration it is assumed that the desired objectives can be achieved and that the means exist to achieve them. Any failures reflect badly on the project manager hence administrative solutions are designed to be no risk, and consequently almost invariably have no or low novelty. The priorities of administrators are diametrically opposed to what is needed for the conduct of effective research.

With administrative control of research it is assumed that the achievement of an objective automatically delivers intended benefits to others. Axiomatically the measure of success can then be based on the achievement of an administrative objective, such as the implementation of a procedure or the publication of a report. It need not and usually does not involve an assessment of the realised benefit. This reflects the current situation for addressing salinity and the environment in general but it also occurs in academia where the routine assessment of a scientist's performance is based on the number of publications rather than the solution of a problem.

The status and position of those involved in funding research is inextricably linked with the conduct of the research, and the administrators providing the funds cannot be seen to have failed. A claim by a head of the Murray Darling Basing Commission (MDBC) was that no project they funded had failed. With this example the suggested exceptional level of success could arise through highly conservative selection of projects and/or the use of administrative assessments of success. The assessed level of performance could reverse if it was based on demonstrating the achievement of environmental benefit.

Both the selection of rote projects and use of inadequate performance measures have contributed to the degradation of research. However, the focus of the Cooperative Research Centres (CRCs) on the delivery of practical tools identifies a strong focus on the development of technology rather than research. Control of research activities by administrators has produced a marked shift away from science to technology.

Compared with scientific research the development of technology is simple and has low risk. Moreover, expenditures on technologies can readily be identified as providing benefits regardless of the realised outcomes as technologies are tangible. Advances in research are often intangible, as with the development of concepts, and are then difficult to promote as providing benefit.

To compete for funds CSIRO has developed an organisational structure equivalent to the CRCs by way of Flagships. The CRCs impose an additional administrative structure across organisations and the Flagships do likewise across Divisions within CSIRO. Funds that once built science now build the administration and are being directed at providing 'quick fix' technological solutions through administrators being in control.

LWA programs evidence the administrative overheads and controls. The identified project allocation for the Healthy Soils for Sustainable Farms program is 36% of the AU$5M allocated from the National Heritage Trust fund. However, LWA now also administers research funds for other organisations obtained under statutory provisions from the Australian Government and producers. The LWA program Land Water and Wool represents a joint arrangement with Australian Wool Innovation Limited (AWI). Assuming low administrative overheads for AWI of 10%, and 20% overheads for the organisation actually conducting the research (e.g. CSIRO), then only around 50% of the allocated research funds are actually expended on research.

While the producer's contribution to research is matched by the Australian Government all of the government contribution is consumed in public administration. The only effect of the government contribution is therefore to give public administrators control of the research.

Failures are inevitable even with the best administration but, as administrators cannot afford to be seen to have failed, procedures are used to hide and disguise failures as well as promote position. The use of administrative performance measures is always used to mask any failure in delivering beneficial outcomes but reactionary measures are additionally employed when performance by way of realised outcomes is questioned. For example, CSIRO has sought to control information by increasing support for corporate promotion and restricting comment by scientists to the maximum extent permissible in law.

The Spies & Woodgate (2005) report represents the current extreme for information control where public administrators funded and published a report that promotes the public scientists they support and denigrates alternatives. Public administrators commissioned an expert report from authors that are not expert in the topic being addressed, and the Academy of Science and Academy of Technological Science and Engineering were used to provide a façade of

scientific respectability. General letters of support for research on dryland salinity provided by the heads of the Academies were identified as constituting review.

Research activities are now being determined by committees run by administrators that have developed their knowledge from the scientists they fund where some of the scientists are also on the committees. These incestuous arrangements have completed the demise of independent assessment in the development of research, and they promote the status quo and suppress new initiatives. The system has developed much greater inertia than previously arose with the institutionalised 'boys club' arrangements as science funding is now being directed to promoting the beliefs and status of public administrators as well as their supporting scientists.

The main defence by the public scientists involved with dryland salinity has been to identify that results contrary to theirs have not been peer reviewed and published. Scientists are using administrative procedures in attempts to dismiss alternatives rather than address the substantive content. Setting aside the issue of the value of reviewing publications where the nature of the work was determined by prior review of research proposals, peer reviewed publications are a poor measure of the conduct of effective research. Less than 2% of journal publications were assessed as making a significant contribution before the explosion in the number and scope of scientific journals. A more recent assessment has most journal papers being read by fewer than six people including the reviewers.

An additional adverse consequence of the current administrative arrangements for research funding is that some scientists now expect to directly determine policy. Historically scientists operated through influence with the community deciding which developments were considered beneficial. Nowadays a new breed of environmental scientist considers they know best hence they should directly dictate to the community in specifying policy and regulations through their involvement with administrators. The ultimate development is seen in the NSW Native Vegetation Regulation (2005) identifying that scientific results and decisions by agency scientists cannot be questioned by anyone, including the courts.

The arrangements for environmental research and application in Australia now closely resemble those for agriculture under Stalin (Joravsky 1970). Research is only supported where it promises the rapid delivery of practical benefits. Scientific merit is determined by the delivery of practical outcomes and achievements are identified by the selective presentation of results.

Even the completely authoritarian Soviet regime could not survive the failures consequent on scientists tailoring their results to meet the objectives of the administrators controlling the funds. The return to science occurred with the sacking of the party head Khrushchev due to the failure of the agricultural reforms.

In reflecting on biological research in the USSR Joravsky identified that the status of communities now largely depends on technology derived from science. The conduct of effective science is an economic imperative. He also identified that the conduct of effective science depends on scientists gaining and retaining professional autonomy.

The independence of scientists addresses the need for professional autonomy and relates to the extent to which a scientist's activities are constrained by their environment. The obvious and tangible constraints are organisational, as with the nexus between scientists and the science administrators that control funds. It is imperative that professional research scientists regain control of scientific research.

So who cares?

The use of position by public scientists and administrators to suppress others may only appear to be of concern to those being suppressed. A general community response of 'so what?' could be expected. The reasons why the community should be concerned are identified by Joravsky. Science determines the future for the community and deficient science promotes repressive controls and stifles development. Deficient science appears inextricably linked with the imposition of authoritarian controls as it invokes ideology, and control is necessary to enforce an ideology.

Expenditures on research are only a small part of GDP. However, research determines expenditures on applications that are much more expensive than the research. A small example of wasted expenditure on applications is given by the Pyramid Hill salt works. A costly engineering solution was implemented to remedy a prior mistake with public funds being used to heavily subsidise a 'commercial' operation that produces a very low value product. As for the environment, even the operators of the project acknowledge that it is at best a temporary fix.

Administrators have attempted to benefit from this costly mistake by promoting it as an example of the beneficial expenditure of public funds. They have even assigned salinity credits to a suggested prevention of salt accessions to the Murray River so they can obtain a monetary return. Together with the MDBC, Engineers' Australia has responded similarly in awarding the project it's National Salinity Prize for 2006.

The awarding of a prize to a non-viable project where the profession benefits from its mistakes could reflect a wry sense of humour, but for the community it represents black comedy. It is a costly exercise that does nothing to benefit the environment.

The Pyramid Creek development had a moderate cost at AU$13M and it is effectively benign for the environment and production. Its main detriment arises through lost opportunities. However, *The Upper South East Dryland Salinity and Flood Management Program* (USE Program) near Keith in South Australia demonstrates the damage that can occur when administrators use their control to enforce the application of deficient science (http://usedrains.org.au/ and http://www.dwlbc.sa.gov.au/land/programs/use/). Identified as costing AU$49.3M with AU$11M of this as a compulsory levy on affected landholders, the engineering 'solution' has severely damaged the environment without producing the promised benefits. Landholders are forced to pay for the State to damage their land and this is achieved through the expenditure of public funds.

Deficient science has been used to justify authoritarian controls that damage the environment, and it has all been achieved through the expenditure of public funds. If the community is concerned about the environment and how taxes are spent then it must take an interest in the organisation and conduct of environmental research.

APPENDIX 1

Criticisms associated with analysis of the radiometric data

1. Claims made by some vendors have no basis in science. Spies & Woodgate (2004)

This comment relates to SalinityMap and suggests that observed results cannot exist or that they arose by chance. SalinityMap involves the identification of a distinct signal or signature associated with salinity that is independent of the surrounding geology and can be extrapolated across radiometric surveys.

With this comment theory has been used to in an attempt to disprove observations which is irrational as in science observations are used to test the applicability of theories. The results exist but the critics cannot provide an explanation as to how they arise. The probability of the results arising by chance is of the order of 10^{10} against which effectively identifies that it is impossible.

This comment is based on extrapolating prior understanding through theoretical modeling without new observations to identify the applicability of the assumed constraints. The SalinityMap results logically demonstrate that assumptions made in their theoretical evaluations are wrong. Issues include the assumption that signals cannot be detected below the signal to noise ratio where the validity of this assumption depends on the nature of the signature and the form of analysis. The modeling creates uncertainty as to the applicability of the suggested hypothesis, that the signature derives from cosmogenic ^{24}Na, but does not negate it

The modeling cannot negate the observations and it has not even negated the hypothesis. This comment was omitted from the 2005 version of the Spies & Woodgate report but associated derogatory comments remain.

Tunstall (2004b), Tunstall (2004d)

2. The only information in the radiometrics derives from K, U and Th in the parent material. Geoscience Australia

Statistically the Total Count (TC) band contains information not contained in the other bands which is to be expected as most of the TC signal derives from energy levels below those used to characterise K, U and Th. The information in the TC band is effectively independent of that in the other bands but the amount of information depends strongly on the height of the measurement above the ground.

The SalinityMap result identifies the existence of a distinct signature associated with salinity that is independent of geology, can be extrapolated across radiometric surveys and appears to have a reasonably short life. Logically these attributes identify that the signature does not derive from K, U and Th in the parent material.

This comment reflects the desire to identify minerals by the levels of K, U and Th as well as to assert that the SalinityMap signature cannot exist. With this approach the TC band is considered irrelevant even though it contains the greatest amount of information and has the highest signal to noise ratio. Failure to use the TC band, as is routine in mineralogical

applications, degrades the resolution of an analysis when addressing soils and likely also minerals.

Tunstall (2002), Tunstall (2003b), Tunstall (2004a), Tunstall (2004c)

3. There is only one way to analyse radiometric data. CSIRO Minerals and Exploration

This comment is inapplicable for any form of data but arises because it is assumed that the objective is to identify minerals from the radiometric signature. The objective in mineral exploration has been to obtain absolute values in counts per second for K, U and Th where this is irrelevant when mapping soils.

As normally supplied the radiometric data have been degraded for soil mapping because of the attempt to obtain absolute values for mineralogical applications. The readings are nominally adjusted to remove the proportion of the signal in the band deemed not to be associated with the element in question. As this and other processing techniques routinely applied to the radiometric data degrade their resolution there is likely considerable room for improvement in the analysis of radiometric data for mapping soils.

Tunstall (2002)

4. A spatial resolution of one to two pixels cannot be achieved. CSIRO Minerals and Exploration

The capability has been demonstrated on a number of occasions and is most clearly evidenced by the results for the Cootamundra Shire. The resolution primarily depends on the method used to analyse the image (gridded) data but it also depends on the quality of the gridding. The improved spatial discrimination between two lithologies in the Wildman Formation in 1998 compared to 1997 relates solely to gridding.

Tunstall & Marks (1997), Tunstall et al. (1998), Trethewey & Gourlay (2001), Tunstall (2004b)

5. Soils cannot be mapped from radiometrics as there is no relationship between a fundamental soil property and the radiometric signal. Spies & Woodgate (2005)

The radiometric signal reflects the parent material and its alteration through all components of weathering (decomposition, leaching and accumulation). As soils are a product of the weathering of parent material the radiometric signal strongly reflects patterns of soils.

Radiometrics are particularly suitable for mapping soils because there is no unique relationship between the signal and a 'fundamental' soil property. Similarly to vegetation, soils are characterised by a number of factors hence soils cannot be identified by reference to a single factor such as a particular physical or chemical property. The comment is irrational.

Gourlay & Tunstall (1994), Tunstall & Gourlay (1994), Tunstall et al (1994), Tunstall et al (1998), Tunstall (2005b)

6. Radiometrics cannot be used to map soils in depositional terrain. Spies & Woodgate (2005) but originally derives from the Bureau of Rural Sciences (BRS)[vii]

This comment derives from point 2 where it is assumed that the requirement is for a unique association between minerals and the radiometric signal. It is also sometimes assumed that depositional areas have low emissions that limit discrimination when in some regions sedimentary soils have the highest emissions.

While depositional areas can contain mixtures of materials the radiometrics can discriminate between different mixtures and their alteration through weathering. This has been employed by ERIC in mineral exploration applications to identify different sources of sediments. For soils the analysis can be more difficult than in erosional landscapes and the resolution can be degraded, however, the results are still better than can be obtained by other means.

Tunstall et al. (1994), Tunstall et al. (1998), Tunstall (2005a)

7. While locally soils can be mapped from radiometrics they cannot be mapped across regions. Spies & Woodgate (2005)[viii]

This similarly derives from point 2 as it is assumed a unique relationship must exist between radiometric signals and minerals across the region. Procedures exist that allow the removal of confounding that can arise from the same signal representing different entities to provide regionally reliable results. This is possible because of the strong association between the radiometric signal and the parent material and the usually blocky occurrence of lithologies.

Tunstall (2005a)

8. The SoilSelect methodology is unproven. Several state and federal agencies involved in soil and salinity mapping.

This comment is usually associated with the inference that the Soil Landscape mapping method used by the agencies has been proven and SoilSelect has not when the situation is arguably the reverse. The SoilSelect methodology allows for routine statistical testing of the reliability of the mapped results and with a full implementation the level of testing is the maximum that is scientifically justifiable. Moreover, client consultation is used to identify errors that can be missed with statistical testing due to the inevitable restrictions on sampling.

The occurrence of a significant relationship between soils and classes in a radiometric or Soil Landscape map demonstrates that the method can be used to map some aspect of soils. In this sense both methods have been proven. The main differences relate to the description and mapping of soils. Soil Landscapes map the distribution of mixtures of soil types where a soil type is typically identified by way of a prior pedogenic classification. SoilSelect maps patterns of discrete soils identified by their physical and chemical properties. The reliability of the SoilSelect mapping can readily be determined as the results are spatially explicit and they describe the soils by what is there. The reliability of Soil Landscape mapping is difficult if not impossible to determine because of the mapping of mixtures of soils and the description of soils involves an interpretation of how they developed[ix].

Tunstall & Gourlay (1994), Gourlay & Tunstall (1994), Tunstall et al. (1994), Tunstall (2002), Tunstall (2003a)

Additional criticisms relating to soil mapping include:

9. As the signal derives from the surface it cannot be used to identify subsoil properties. Spies & Woodgate (2005) but derives from CSIRO Minerals and Exploration and Geoscience Australia

While the rule of thumb is that 70% of the signal derives from the surface 30cm of soil the signature that develops in the surface soil depends on the underlying conditions. Statistically the sub and surface soil properties are equally but differently correlated with the radiometric signature. Omitting subsoil properties from an analysis degrades the result.

Radiometrics can be used to map subsurface structures such as fractures, as is also done using aerial photography and satellite imagery. Surface measurements can contain information on subsurface conditions.

Tunstall et al. (1998), Tunstall (2003a), Tunstall (2005a)

10. Radiometrics cannot be used to map salinity. Spies and Woodgate (2005)

Salinity is one soil property and, while it usually exhibits high variability, it can still be mapped from the radiometrics using the SoilSelect method. SalinityMap is a unique situation where a distinct salinity signature has been identified in the radiometrics that is completely independent of the surrounding geology

Trethewey, K. and Gourlay, R. (2001), Tunstall et al. (2001), Tunstall (2003a), Tunstall (2004c), Tunstall (2004d), Tunstall (2005a)

11. A reliable soil map cannot be produced with the small number of field samples used by ERIC. CSIRO Soils

This comment is based on the suggestion that between 1,000 and 2,000 soil samples are needed to reliably map soils for a 1:100,000 map sheet when ERIC would usually employ around 10% of that number[x]. While a source for the comment is known the basis for the number is not. It appears to reflect a general conclusion based on experience without any formal analysis that tests the level of achievement. As that experience relates to Soil Landscape mapping using visual interpretation of aerial photography it has no applicability to soil mapping using radiometrics. Far fewer samples are needed where the image data closely relate to what is being mapped.

The ability to map statistically discrete soils using radiometrics identifies that the field soil sampling is adequate. This statistical assessment effectively cannot be done with the traditional Soil Landscape mapping on which the suggested sample requirement is based.

Tunstall & Gourlay (1994), Gourlay & Tunstall (1994), Tunstall et al. (1994), Tunstall (2002), Tunstall (2003b)

12. ERIC does not have a monopoly on developing soil mapping and there are new developments involving diverse data sets including radar. Adelaide University

The comment on a monopoly applies to everyone and everything. The issue relates to the scientific protocol of acknowledging prior work. The suggested 'new' developments have long been examined by researchers in Australia as well as overseas. For example, the

investigation of the influence of geology[xi] in the application of radiometrics for soil mapping is presented as being new when it has always been fundamental to the ERIC SoilSelect method. It is essential for removing potential confounding that most commonly arises at low signal levels where different entities can effectively have the same signal.

The limited resolution at low signal levels identifies the futility of setting an objective of simply determining the level of association between lithology and the radiometric signal. The result depends on the quality of the data as well as the characteristics of the study area hence the result is only of benefit where it resolves an issue, as with removing confounding.

The investigation of new options is what research is about. However, where multiple data sources are being used to address the same objective, as suggested with the comment, issues arise as to whether it represents a shot gun or 'suck it and see' approach, and whether the data are to be analysed on their merits or the results confounded by the application of the data fusion popular in academia. Data fusion involves combined analysis of diverse data sets to derive a product. It is assumed that diverse data can be integrated and merged into a useful product. The scientifically sound and practical approach is to analyse each data set on its merits. Integration is applied to the products rather than the data and is done to address specific applications.

Gourlay & Tunstall (1994), Tunstall & Gourlay (1994), Tunstall et al. (1994), Tunstall (2005b)

Additional criticisms on the science include:

13. ERIC cannot say the rising groundwater model is not general. Numerous sources.

ERIC and many others before and after have identified exceptions to the RGM hence it cannot be general.

Tunstall (2001), Tunstall (2004a), ERIC (a), ERIC (b), ERIC (2006)

14. ERIC cannot say the rising groundwater model has been absolutely negated. University of Western Australia

The conclusion that the RGM has been absolutely negated is a logical outcome from observations by proponents of the model and can only be countered by identifying where the logic is wrong. However, the conclusion is supported by an analysis of the basic physical constraints for the RGM to apply. The only situation where the RGM could physically apply in lifting sub-soil salt into the above soil is with confined and semi-confined aquifers and this has yet to be observed to apply with dryland salinity.

The conclusion that the RGM is absolutely invalid obviously depends on what the RGM is regarded as being. The conclusion that the RGM is absolutely invalid relates to dryland salinity arising through vegetation clearing on hills and slopes increasing percolation into a groundwater system with the groundwater transporting salt from stores beneath soil on the plains into the soil on the plains.

ERIC (2006), Tunstall & Gourlay (2006)

15. There is no proof that the salt in dryland salinity derives from the soil. Land and Water Australia

There are situations where the salt can only derive from the soil. Moreover, in situations where the salt has been purported to derive from beneath the soil, as at Dicks Creek, the chemistry of the groundwater is very different from that for the soil water causing the adverse salinity outcomes.

ERIC (2006), Tunstall & Gourlay (2006)

16. Addressing dryland salinity through soil structure only addresses symptoms. Land and Water Australia

Dryland salinity has been remediated by improving soil structure and the benefits have been achieved through local and landscape applications. The ability to reverse the damage is a good indication that the cause is being addressed.

ERIC (2006), Tunstall & Gourlay (2006)

17. The soil structural degradation explanation for dryland salinity has not been proven. Land and Water Australia

Neither the RGM nor the soil structural degradation model have been proven, which is normal. However, the RGM has been disproven whereas the structural model has not been.

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[i] The capability of the company GecOz in using airborne radar to map salinity was identified as not being applicable until further researched. It was also suggested that proposals by industry should be vetted by scientists in public authorities and agencies that provide competing services.

[ii] DAFF and DEH jointly administer the National Action Plan (NAP) and National Heritage Trust (NHT) funds that are used to address the environment. Land and Water Australia is solely involved in funding environmental research and is a statutory authority funded through DAFF.

[iii] Peter Woodgate formed teams primarily comprising public scientists to bid for such projects and provided the project management, as with the Australian Greenhouse Office project on mapping native woody vegetation clearing and regeneration.

[iv] The commonality is the numerical analysis of multi-spectral image data. A basic vegetation analysis examines reflectance in the blue, green, red and near infra-red bands of optical imagery. The radiometric bands are indicative of the levels of radioactive potassium (K), Uranium (U), Thorium (Th) and a broad Total Count (TC).

[v] BRS is an environmental research arm of DAFF that obtains around half its funds from 'external' sources (non-appropriation). The 'external' sources include funds jointly administered by DAFF and DEH.

[vi] This is logically inconsistent with point 5 but there are many such logical inconsistencies and errors in the Spies & Woodgate report.

[vii] BRS is an environmental research arm of DAFF that obtains around half its funds from 'external' sources (non-appropriation). The 'external' sources include funds jointly administered by DAFF and DEH.

[viii] This is logically inconsistent with point 5 but there are many such logical inconsistencies and errors in the Spies & Woodgate report (Tunstall 2004c, 2005a).

[ix] The tests of Soil Landscape mapping by Tunstall & Gourlay (1994) and Gourlay and Tunstall (1994) were for Soil Units rather than Soil Landscapes and the soils were described by their physical and chemical properties.

[x] In simple geologies such as around Coonawarra the requirement for field samples is much lower again.

[xi] The comment specified geology but the relationship is with lithology.