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CARBON PROPERTY RIGHTS IN SOIL

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ABSTRACT

The commodification of soil to permit carbon sequestration and hence trading in the resultant carbon rights is examined as an emerging facet of climate change management. As the developed world moves towards carbon offsets and decarbonisation, the Australian continent provides a capacity to be a land based repository of carbon in either select species of vegetation grown specifically for this purpose, or where soil is conserved to sequestrate carbon. A presumption exists that carbon is sequestrated differentially in various soil landscapes, which typically comprise a mixture of different soil types. Diffuse boundaries between soil landscapes and significant differences assigned to same soil landscapes, albeit in different areas, significantly impacts sequestration of carbon.

In some Australian states, there has been partial crystallisation of legal rights in carbon. Whilst distinguishable from the elemental land property right, these "rights in carbon" remain part of the land based property right. Carbon rights in soil remain conceptually part of the legal bundle of rights held by the proprietor of the land property right. This legal maxim is explored as the core issue to be resolved if carbon property rights in soil are to be conceived.

KEYWORDS

Carbon sequestration, property law, property rights, soil science.

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Introduction

Rights to land-based carbon, in order to be legal rights as well as economic rights, need to be based on the amount of carbon being sequestered[3] by vegetation or soil. The amount of carbon being sequestered and its legal status is crucial to enabling accurate descriptions of worth to be made of the carbon asset. However, the notion of a carbon property right remains problematic and the Australian Property Institute (NSW and Queensland Divisions) recently noted that:

> *A carbon property right has not yet been clearly defined in Australia. A clear, coherent definition is essential to provide traders in carbon assets with certainty about the nature and worth of what is being traded.*[4]

Property rights require a satisfactory answer to the question of territoriality, whether by placement of an individual property right on the cadastre or on some other form of spatial information vehicle. Some emerging property rights such as native title, water and biota require the convergence of professional, technical and scientific knowledge and skills residing in particular in the spatial and valuation professions. There is also a need to garner crucial support from other disciplines such as botany, zoology, anthropology, hydrology, and a raft of other sciences in specific cases.

The conceiving of these rights also requires attention as stated earlier to the issue of territoriality (definition) and hence worth ascription (valuation), because these newly emerging rights have not only economic value but demand the status of legal private rights. Barzel usefully distinguishes economic rights from legal rights in the following manner:

> *Legal rights are the rights recognised and enforced, in part, by the government. These rights, as a rule, enhance economic rights, but the former are neither necessary nor sufficient for the existence of the latter. A major function of legal rights is to accommodate third-party adjudication and enforcement, in the absence*

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[3] To make metabolically unavailable without destroying the compound.

> *of these safeguards, rights may still be valued, but assets and their exchange must then be self-enforced.*[5]

Hence, mere economic rights asserted over natural resources such as water and biota (including carbon) lack the security of legal ownership in much the same manner as squatter communities cannot enforce their economic rights as titled legal landowners.

This focus on property rights in natural resources such as water and carbon is not unexpected especially in Australia where there is a deference towards private property[6]. Indeed, the drafters of the Australian *Constitution* ensured that the new Commonwealth Government could not commute private property rights except on *just terms.*[7] This guarantee of private property is a rare Constitutional right in a text evidencing:

> *…[a] shortage (as it is now perceived) of explicit statements of ideals and guarantees of rights, and of descriptions of essential human or national attributes.*[8]

The Australian continent comprises 7,741,220 square kilometres[9], and it is reasonable to posit that most carbon sequestration endeavours will be land based, and will have as their core either select species of vegetation grown specifically to sequestrate carbon, or soil conserved for this purpose. As regards soil, the authors identify in the following section of this paper a knowledge gap in soil science which places considerable doubt upon current efforts to conceive carbon rights in soil, especially rights which are property rights.

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[4] Australian Property Institute (NSW and Queensland Divisions) (2007) *Conceiving Property Rights in Carbon: A Policy Paper* (Sydney: 26 July), 4.
[5] Barzel, Yoram (1997) *Economic Analysis of Property Rights* 2nd ed. Political Economy of Institutions and Decisions series (Cambridge: Cambridge University Press), 4.
[6] Irving, Helen (1997) *To Constitute a Nation: A Cultural History of Australian's Constitution* (Cambridge: Cambridge University Press), 96.
[7] s.*51 (xxxi)*, Australian *Constitution.*
[8] Irving, 162.
[9] *The World Guide: Global Reference Country by Country* (2007) 11th ed. (Oxford: New Internationalist Publications Ltd), 90.

Carbon in Soil

Carbon within the soil profile is a complex and dynamic measure of chemical attributes, including nett plant biomass[10], decomposing humic[11] material, microbial content and inorganic complexes. Estimates by the Soil Science Society of America[12], reveal that nearly 75% of global terrestrial carbon content is currently sequestered subterraneously, with a potential for this figure to increase dramatically if soil management focus shifted toward sequestration. According to Six et al.[13], globally soils have lost 25% of carbon from the soil profile due to heavy till agricultural practices, while the Soil Science Society of America has suggested that this figure could be up to 50%[14].

At a molecular level, the capacity of soil to sequester carbon varies greatly, dependent upon soil taxa[15] and management regime. Furthermore, the interaction between these attributes occurs in ways only just beginning to be understood, adding great variability to how carbon is retained in soil. As a result there is significant scientific conjecture in any suggested application of a 'carbon sequestration value' to specific parcels of land.

The largest established pool of carbon occurs as soil organic matter (SOM), sequestered through a series of complex reactions within the soil matrix, and primarily consisting of decaying plant and organic compounds. Concentrations of carbon typically peak within the first metre of the soil profile, echoing the distribution of soil micro biota and plant root mass. SOM carbon includes structures such as carbohydrates, fats or oils, proteins,

[10] The total weight of living organisms (or organic matter consisting of, or recently derived from living organisms) in a given area.
[11] Derived from plant remains.
[12] SSSA (Soil Science Society of America) Ad Hoc Committee (2001) 'Carbon Sequestration: Position of the Soil Science Society of America'. http:// www.soils.org/pdf/pos_paper_carb_seq.pdf (22 October)
[13] Six, J., Frey, S.D., Thiet, R.K., Batten, K.M. (2006) "Bacterial and Fungal Contributions to Carbon Sequestration in Agroecosystems", *Soil Science Society of America Journal*, 70 (2), (March-April), 555-569.
[14] SSSA, see also Jones C (2006) "Soil Carbon and Carbon Credits – Aggregate or Aggrevate? Creating Soil Carbon" Paper presented at YLAD Living Soils Seminars, Euronglilly (14-15 February). http://www.soilcarboncredits.blogspot.com/ (22 October 2007)
[15] a systematic classification of soil by rank or class.

alkanes[16] and humic substances, and according to Pettit[17] may contribute 2-8% of all carbon in the upper soil profile.

Limited scientific understanding of carbon within SOM complexes is such that it is not possible to accurately describe the chemical structure and composition of humic substances[18], nor even accurately quantify carbon concentrations in the soil[19]. Indeed, very recent developments in soil carbon science have revealed carbon fractions within soil profiles which have never before been identified and are yet to be fully explored.[20]

Currently, carbon sequestration figures within varying soil classes are usually based on generalised analytical results using various diagnostic methods.[21] Such sequestration figures typically base average potential carbon content of soil on textural grade, however the premises underlying such relationship assertions are problematic.[22]

For example, sandy loam soil has a generally low level aggregate structure and a relatively poor ability to retain carbon, typically revealing a low carbon value of between 0.3% and 0.6%[23]. Conversely of the textural grades within soils, clay has a far higher

[16] Saturated hydrocarbons such as methane.
[17] Pettit R.E. (2006). "Organic Matter, Humus, Humate, Humic Acid, Fulvic Acid and Humin: The Wonderful World of Humus and Carbon' http://www.humusandcarbon.blogspot.com/ (22 October 2007)
[18] Pettit.
[19] So, H.B., Dalal, R.C., Chan, K.Y., Menzies, & N.M. Freebairn, D.M. (2001), in Stott, D.E., Mohtar, R.H. and Steinhardt, G.C. (eds) *Sustaining the Global Farm: Selected papers from the 10th International Soil Conservation Organisation Meeting (1999*) (Purdue University and USDA-ARS National Soil Erosion Research Laboratory, May 24-29); see also Jones C (2006) "Soil Carbon and Carbon Credits – Aggregate or Aggrevate? Creating Soil Carbon". Paper presented at YLAD Living Soils Seminars: Euronglilly (14 -15 February) http://www.soilcarboncredits.blogspot.com/ (22 October 2007).
[20] Jones, C.
[21] So; see also, Jones DL, & Willett VB (2006)." Experimental Evaluation of Methods to Quantify Dissolved Organic Nitrogen (DON) and Dissolved Organic Carbon (DOC) in Soil" *Soil Biology and Biochemistry* 38, 991-999; see also Zinn YL, Lal R, Bigham JM, & Resck DVS (2007). "(b) Ediphiatic Controls on Soil Organic Carbon Retention in the Brazilian Cerrado: Soil Structure" *Soil Science Society of America Journal*, 71 (4), (July-August), 1215 -1224.
[22] Zinn YL, Lal R, Bigham JM, & Resck DVS (2007). "(a) Ediphiatic Controls on Soil Organic Carbon Retention in the Brazilian Cerrado: Texture and Mineralogy" *Soil Science Society of America Journal*, 71 (4), (July-August), 1204-1214.
[23] Macdonald, A.J., Murphey, D.V., Mahieu, N., & Fillery, I.P. (2007) "Labile Soil Organic Matter Pools Under a Mixed Grass/Lucerne Pasture and Adjacent Native Bush in Western Australia" *Australian Journal of Soil Research* 45, 333-343; see also Hati KM, Swarup A, Singh D, Misra AK, & Ghosh PK

affinity for carbon aggregation and hence sequestration[24], although the inherent heterogeneity[25] of clay makes any data difficult to extrapolate. Ranges noted by Wang et al. [26], indicated that total organic carbon content in a south east Queensland vertisol[27] averaged across various management techniques were between 20.5t/ha to 22.3 t/ha within the top 10 centimetres of the soil profile, however there was a high degree of variability with regard to treatment and seasonality. Importantly, the NSW Government has commissioned significant studies of clay carbon content in endemic[28] soils to assess how improved management practice will impact upon carbon sequestration in specific localities[29].

Given that SOM determines the quantity of soil organic carbon, soils high in detritic material such as marshlands and swamps and high productivity old growth forests, would be expected to contain far higher nett quantities of sequested carbon, than lands of low fertility. Unfortunately, the majority of Australia's land mass falls within the categories of relative poor to moderate potential for sequestration, Flannery soberly observing:

> *[c]urrently, 22 million hectares of arable land is being used in Australia. Much of this land would be considered marginal agricultural land on other continents. Yet it is by far the best of our arable land. The rest is decidedly marginal even by Australian standards, and is largely untested. Already, after less than 200 years of use, 70 per cent of that 22 million hectares is degraded and in need of soil restoration programmes.*[30]

(2006)."Long Term Continuous Cropping, Fertilisation and Manuring Effects on Physical Properties and Organic Carbon Content of a Sandy Loam Soil" *Australian Journal of Soil Research* 44, 487-495.

[24] Zinn (a)

[25] The quality of being diverse in kind or nature.

[26] Wang W, Dalal R, Moody P (2004) "Sol Carbon Sequestration and Density Distribution in a *Vertosol Under Different Farming Practices. Australian Journal of Soil Research*, 42, 875-882.

[27] A clayey soil with little organic matter found in regions having distinct wet and dry seasons, characterised by deep wide cracks when dry and an uneven surface.

[28] Habitually present in a certain area as a result of permanent local factors.

[29] NSW Department of Environment and Climate Change "Carbon Sequestration Under Summer/Winter Response Cropping in Northwest New South Wales" http://www.greenhouse.nsw.gov.au/home_page/whats_new/latest_items_added_to_greenhouse_nsw/carbon sequestration_under_summer_winter_response_cropping_in_in_northwest_nsw (22 October 2006).

[30] Flannery, TF (1994) *The Future Eaters: An ecological history of the Australasian lands and people* (Sydney: Reed Books) 367.

However, in attempting to determine the capacity of soil to be carbon sequestrative, one of the crucial governing factors is microbial colonisation[31], and yet this indicator is possibly the most unstable for determining carbon retention. There are a range of variables which affect microbial populations, notably substrate or organic matter changes[32], variable composition of flora within the immediate surrounds[33], or even temperature increases associated with climate change[34].

Whilst these variables may all greatly affect the capacity of microbes to retain carbon within the profile, the nature and magnitude of these fluctuations will also vary with the species biodiversity and colony composition. This dynamic factor is heavily intertwined with site-specific conditions, an issue not easily determined or tabulated.

Further, there has been significant debate over the impact of management factors such as fallow practice and fertilizer application in attempts to present carbon sequestration in soil as a viable carbon property right and hence tradable. The Australian Greenhouse Office has commissioned research into the impact of tillage on soil carbon density[35], and it is reported:

> *…higher levels of soil disturbance in combination with stubble burning will result in greater carbon losses from soil than less intensive tillage regimes with stubble retention/ incorporation. However the effects of tillage on soil carbon densities are complicated by climate, soil type and the nature and timing of specific management actions within the broad groupings of management practices.*[36]

[31] Six et al.
[32] Six et al.
[33] Chen CR, Xu ZH, & Mathers NJ (2004) "Soil Carbon Pools in Adjacent Natural and Plantation Forests of Subtropical Australia" *Soil Science Society of America Journal.* 68 (4) (January-February), 282-291.
[34] Rasmussen, C., Southard, R.J. & Howath, W.R (2007). "Soil Mineralogy Effects Conifer Forest Soil Carbon Source Utilisation and Microbial Priming". *Soil Science Society of America Journal*. 71 (4) (July-August), 1141-1150.
[35] Valzano, F; Murphy, ; and Koen, T (2005) *The Impact of Tillage Changes in Soil Carbon Density with Special Emphasis on Australian Conditions*, National Carbon Accounting System - Technical Paper No. 43 (Canberra: Australian Greenhouse Office, Department of the Environment and Water Resources).
[36] Valzano, 42.

Management factors may bear significant complications for carbon retention at a molecular level. Current best management practice within the agricultural industry fosters carbon retention within the soil profile through the adoption of zero till production. Carbon has been shown to decrease proportionally with increases in the rate of till and soil disturbance[37], as increased interfaces between the atmosphere and soil matrices accelerate diffusion of carbon dioxide[38].

Interestingly, it has been shown by So et al.[39] in modelling that if all 47 million hectares[40] of cultivated land within Australia were to undergo a single till rotation it is estimated that 9.4 million tonnes of carbon dioxide would be released into the atmosphere. However, Chen et al.[41] found that the content of total carbon in soils was unaffected by harvesting practices in a short term context.

A limiting factor in any discussion on carbon sequestration in soil is the inherent poor fertility of Australian soils which ordinarily require the addition of lime as a basic remedial practice to enable productive yield. Aridity and poor structural development of many Australian soils would hinder the ability of the more rudimentary landscapes to successfully retain carbon. The addition of lime results in carbon dioxide precipitation, and hence the loss of carbon from the soil profile, and as a result soil becomes a nett source of carbon dioxide loss to the atmosphere rather than a sink.

Further, exposure of bare earth to air can also foster carbon loss according to Jones,[42] and this fact has major implications for agriforestry and cropping management in a sequestration context. The impact of land use on carbon sequestration remains largely

[37] So, et al.
[38] So, et al.
[39] So, et al.
[40] It will be noted that the figure of 47million hectares used by So et al is greater than the figure of 22 million hectares adopted by Flannery, however Flannery does refer to other lands which are also even more marginally arable, and presumably comprises the additional 25 million hectares that in total is adopted by So et al.
[41] Chen et al.
[42] Jones.

unresolved, Macdonald et al.[43] observing that some land uses such as cropping did not have a significant impact on the total amount of carbon in the soil in contrast to native woodland.

Such findings are contrary to research by Chen et al.[44] and Dalal and Mayer[45], who found differences in soil carbon concentrations relative to changes in land use and vegetative cover. Again, contributing factors to the high variability of results are climatic and pedological issues such as texture and clay mineralogy which would bear heavy influence on the outcome, and further scientific clarification is warranted.[46]

The foregoing discussion reveals that carbon soil science is yet to elucidate a scientifically viable description of how carbon is sequestrated in soil. In particular, at a level of certainty they can be utilised by property theory and law to conceive carbon property rights in soil. By combining soil science, property theory and property law perspectives, the following final section of this paper identifies research gaps relating to this agenda.

Conceiving property rights in soil

The commodification of natural resources such as water and carbon has largely raced ahead of the need to provide a coherent economic and legal framework for these emerging property rights. Unsurprisingly, Butt observes that the need to conceive carbon sequestration rights raises the question of whether such rights constitute a new landed interest, given that:

> *[t]he categories of interests in land are not closed. They change and develop as society changes and develops. The past few years has seen the slow emergence of an interest not previously known to the law, the "carbon sequestration right".*[47]

[43] Macdonald et al.
[44] Chen et al.
[45] Dalal, R, Mayer, C (1986) as cited in So et al.
[46] Macdonald et al.
[47] Butt, P. (1999) "Conveyancing and Property: Carbon sequestration rights – a new interest in land?" *Australian Law Journal* 73 (4) (April), 235.

However, the complexity of the biophysical *milieu* within which specific natural resources such as carbon exist is poorly understood, and much existing legislation provides stark evidence of the scientific misinterpretations within which drafters are often operating.

For example, in NSW carbon sequestration rights in forests are legislated to be *profits `a prendre*, and hence a property right[48]. However, Butt points out that *profits `a prendre* are a quite limited legal right:

> *[a] profit `a prendre (or, more simply, a "profit") is a right to enter another person's land and take away part of the soil or the natural produce of the soil. The thing taken may be, for example, crops, timber, soil, minerals, or animals running on the land. A profit may exist over a given area but with the precise location left for the grantee to choose.*[49]

Where a forestry right exists for the purposes of carbon sequestration, *s.88AB Conveyancing Act 1919* (NSW) states that:

> *If a forestry right consists in whole or in part of a carbon sequestration right, the profit `a prendre deemed to exist by subsection (1) in relation to the carbon sequestration right consists of the following:*
> *(a) the profit from the land is taken to be the legal, commercial or other benefit (whether present or future) of carbon sequestration by any existing or future tree or forest on the land that is the subject of the carbon sequestration right,*
> *(b) the right to take something from the land is taken to be the right to the benefit conferred by the carbon sequestration right.*[50]

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[48] cf *s.88AB Conveyancing Act 1919* (NSW)
[49] Butt, P. (2001) *Land Law 4th Ed* (Sydney: Lawbook Co), 422.
[50] *s.88AB (2) Conveyancing Act 1919* (NSW)

Butt points out that these provisions creating carbon property rights out of forestry rights were included in amendments in 1998 to the *Conveyancing Act 1919* (NSW) to encourage carbon trading[51]. In earlier comments Butt also notes:

> *[t]hese "forestry rights" the Act characterises as profits `a prendre (s.88AB),which (like other forms of profit a prendre) can be registered. This allows them to get onto the Torrens register and enjoy the benefits of indefeasibility of title. In particular, if the land over which the registered forestry right exists is transferred, then the forestry right survives as against new owners of the land.*[52]

Importantly, the *Conveyancing Act 1919* (NSW) also interweaves the carbon sequestration right with the notion of a *forestry covenant* which is defined *inter alia* at *s.87A* as:

> *…a covenant that is incidental to a forestry right and includes any such covenant that imposes obligations requiring…*
> *(d) the provision of access to or the maintenance of trees or forests on land that is the subject of any carbon sequestration right, or*
> *(e) the ownership of any tree or trees on land that is the subject of a forestry righto be vested in the person who owns the forestry right,*
> *or imposes any term or condition with respect to the performance of or failure to perform any such obligation.*

Butt further points out that the vesting in an individual of *the ownership of any tree or trees on land*[53] raises novel legal issues and:

> *…poses the intriguing possibility of one person "owning" trees which stand on another person's land. Arguably, such an arrangement was possible at common*

[51] Butt, 427.
[52] Butt (1999), 235.

> *law, but the potential complexities to which it could give rise would make the title to the land intricate in the extreme.*[54]

Indeed concern has been expressed recently by the Australian Property Institute[55] regarding the adequacy of such legislative provisions given the rising value of carbon offsets, and the resultant need to create a more comprehensive definitional and titling regime for any carbon property rights. The Institute soberly noting:

> *…[its] deep concerns over the apparent headlong rush by industry and promoters to secure carbon offsets. Unfortunately, the NSW and Queensland Divisions of the Institute believe that the multitude of private schemes, which anecdotal evidence suggests could number in excess of 300 nationally, are reminiscent of the entrepreneurial activity that could more expectedly occur in an undeveloped or developing country elsewhere.*[56]

Clearly, the notion of separating vegetation and soil from the basic land property right is a difficult conceptual task legally, and it may be that the venerable *profit `a prendre* is not the appropriate vehicle to be utilised for this purpose in all cases.

Furthermore, the manner in which *profits `a prendre* are notified on existing land property titles is crucial to any trading that might subsequently occur. If *profits `a prendre* are nevertheless to be utilised as a vehicle to create a carbon right, it is critical to understand the various existing State land titles registration requirements that sever the legal nexus between vegetation and land.[57] As stated earlier, there are concerns regarding the adequacy of such legislation covering land based sequestration, and even with the specific process of carbon capture and storage (CCS), Minter Ellison pointing out:

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[53] s.*87A Conveyancing Act 1919* (NSW)
[54] Butt (1999), 235.
[55] Australian Property Institute (NSW Division) (2007) Letter to the Hon PC Koperberg, Minister for Climate Change, Environment and Water in Sydney (20 September).
[56] Australian Property Institute (NSW Division) 2.

…[t]here is no current legislative regime in Australia that expressly deals with the entirety of the CCS process through capture, transportation and injection and storage of carbon dioxide.[58]

Yet, as Bredhauer observed in 2000 despite *the issue of incomplete information*[59] on carbon sequestration, trading in carbon is occurring nationally and internationally. An indication of the local value of carbon offsets is the 1999 intent expressed by the NSW Government:

…to establish a planted forest between 10,000 to 40,000 hectares, with up to $100 million predicted as potential investment…[60]

This paper has identified the knowledge gaps that currently exist in carbon soil science, which as a result invites a more sophisticated analysis of the prospect of carbon property rights in soil. Given the change in potential carbon retention between soil classes and the relative high variability of carbon accumulation within the profile itself, it is the view of the authors that concentrations of carbon cannot be tabulated to a level suitable for a generalised system of credits based upon relevant scientific governing factors.

If such a system were to be initiated, criteria such as tillage and management practice, rainfall and biota content within the immediate area (both terrestrial and sub-terrestrial) would be crucial for the quantification of a carbon quotient. Currently, the level of scientific understanding required to devise an appropriate management system applicable nation-wide is still developing.

Soil science is also still developing appropriate numerical ranges to describe the influence of both biotic and abiotic factors on sequestration. Current research commissioned by the

[57] Bredhauer J, (2000) "Tree clearing in Western Queensland – a cost benefit analysis of carbon sequestration" *Environmental and Planning Law Journal* 17(5), (October) 391.
[58] Minter Ellison (2005) *Carbon Capture and Storage: Report to the Australian Greenhouse Office on Property Rights and Associated Liability Issues* (Canberra: Australian Greenhouse Office: Department of the Environment and Heritage Australian Greenhouse Office) 94.
[59] Bredhauer, 388.

Australian Greenhouse Office, seeks to quantify residual soil carbon stocks within contrasting land management regimes continent wide. Although this information will be integral for establishing a scientific framework for any future trading scheme, further research is required to understand the additional impact of those additional factors identified earlier in this paper. Such research is a crucial precursor to any attempt to conceive carbon property rights in soil.[61]

Confounding such research needs is the current ineffectiveness of computer aided modelling of projected sequestration in forecasting concentrations of carbon at a field level, requiring heavy manipulation for local circumstances[62]. Although allowing inputs for the governing criteria discussed earlier, the inherent variability of soils make such estimations wrought with error according to Rasmussen et al.[63]. Individual parcels of land may be subject to area-specific carbon testing, however in practice, this process is slow and grossly ineffective in quantifying carbon on a geographical scale to be of any use as a tradable commodity.

Furthermore, there is a paucity of established data relating on nett retention of carbon within the soil profile. Given the potential for carbon retention is not infinite, an "equilibrium maximum organic C content"[64] will be reached, the boundaries of which are yet to be defined experimentally. The absence of historic knowledge on sustainable carbon retentive capacity in the soil profile limits any practical application of forecasting future carbon stocks within the soil profile.

[60] Bredhauer, 389.
[61] : Harms, B and Dalal, R (2006) "Paired Site Sampling for Soil Carbon (and Nitrogen) Estimation – Queensland, Part A. Technical Report Number 37.
http://www.greenhouse.gov.au/ncas/reports/pubs/tr37final_a.pdf)
[62]Causarano, Shaw, Franzluebbers, Reeves, Raper, Balkcom, Norfleet,& Izaurralde (2007), "Simulating Field-Scale Soil Organic Carbon Dynamics Using EPIC". *Soil Science Society of America Journal*, 71 (4) (July-August), 11-12.
[63] Rasmussen et al.
[64] So et al.

Conclusion

Without question there is a significant rising global demand for pathways whereby carbon can be satisfactorily sequestrated. Such endeavours are intended to produce tradeable carbon offsets which will be the future engine of development, or the future constraint on development. Indeed, business interests such as the Investor Group on Climate Change (IGCC) reveal increasing concern over investment risk arising from carbon emissions, the recent IGCC Carbon Disclosure Project (CDP) report on Australia and New Zealand stating:

> *…France is proposing a trade tax in the European Union which would penalise states which have not ratified the Kyoto Protocol or states which do not meet their Kyoto obligations. Such an initiative would impact Australia as well as New Zealand should they fail to meet their Kyoto obligations…*[65]

Disquiet has also arisen regarding the absence of a financial accounting standard for carbon credits, given the International Accounting Standards Board (IASB), withdrew its carbon emissions standard in March 2005, reportedly:

> *…as a result of pressure from the European Union and other international bodies, expressing concern that the document was unworkable.*[66]

Adding to the current unease is the different accounting methods for carbon emissions and critically how carbon emissions are actually calculated, *The Australian Financial Review* reporting as follows:

> *[a]side from the lack of clarity and consistency with the way accounting treatments can be – and are- used to record carbon emissions, another key issue involves how carbon emissions are measured.*[67]

[65] IGCC (Investor Group on Climate Change) (2007) *Carbon Disclosure Project Report 2007 Australia and New Zealand.* (Melbourne) 47.

[66] *The Australian Financial Review* (2007) “Accounting for carbon credits is still a grey area” (26 September) Special Report Sustainable Investments, 8.

The Australian Accounting Standards Board (AASB) is required to follow the direction given by the IASB, and the Chairman of the AASB David Boymal has stated:

> *… measurement is the only thing that will enable an emission right to be traded because every item requires a value in order to be traded.*[68]

Reinforcing the critical issue of measurement of carbon sequestration, Boymal further observes that the carbon offsets market:

> *…is just like a stock exchange that estimates the value of the carbon credits. That…[is] why some kind of measurement is critical.*[69]

With the election of the Rudd Federal Labor Government in November 2007, Australia subsequently ratifying the *Kyoto Protocol* and achieving *Protocol* obligations, raises the real issue that tradeable carbon offsets sourced in Australia will most likely arise from sequestration in vegetation or in soil, which are the two most available avenues for the conceiving of such offsets if they are to be land based. As stated earlier in this paper, established international markets for carbon credits already exist, and importantly in September 2007 the CDM Bazaar was created, being:

> *…a web portal established by the UN Framework Convention on Climate Change, (part of the 1997 Kyoto Protocol) to encourage an exchange of information between buyers and sellers of carbon credits.*[70]

Notwithstanding that Australia had not ratified the *Kyoto Protocol,* the current worth of carbon offsets in NSW alone has reportedly reached a value of $500 million[71], however the inadequacy of State legislation is such that:

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[67] *The Australian Financial Review*
[68] Boymal, David cited in *The Australian Financial Review.*
[69] Boymal.
[70] *The Australian Financial Review.*
[71] *The Sun Herald* (2007) "$500m and growing up", (9 September) 25.

> *[c]ritics of carbon offsetting say there is no guarantee the money is being spent as it should be or is delivering value, and stricter accreditation is required to regulate the sometime anarchic industry.*[72]

Finally, it is in this broad context, this paper has undertaken a sober analysis of any potential for sub-terrestrial carbon sequestration, revealing that the huge potential carbon sink in Australian soil cannot as yet be assured scientifically. Indeed whether this pathway is a sustainable solution for carbon sequestration and trading in the future is at best problematic[73]. Although the effects of carbon in soil is well reported in the scientific literature, paradoxically an understanding of carbon sequestration continues to develop albeit much more slowly than emerging property theory and law.

[72] *The Sun Herald*.
[73] SSSA.

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