

Representing Carbon Property Rights

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SUMMARY

The reduction of carbon emissions is considered fundamental in the mitigation of a global rise in temperature and severe climate change events. A market approach has been adopted by several countries to efficiently reduce national carbon emissions and fulfil Kyoto Protocol obligations, and emergent sequestration rights in carbon have gained distinction from the archaic bundle of rights metaphor. In this respect, rights in carbon follow rights in water and biota as emerging property rights that must be independently managed, measured and represented visually. The distinction of carbon from rights in land, biota and water does not preclude the necessity of managing all *land system* rights as interdependent entities.

We suggest that key to managing land and property rights holistically is an adequate representation of the relationships and interdependencies between land elements, the rights, obligations and restrictions, and the multiple stakeholders with an interest. Existing methods, such as Geographic Information Systems (GIS), fail to display systems holistically and comprise only visual elements with limited interactivity that risk compromising understanding and uptake by amateur users.

In addressing the above, this paper will first explore areas of contested meaning significant to the unbundling of rights in real property and the management of land at the system level. These areas comprise land and property, representation and visualisation, and property rights themselves. We will then introduce the key requirements and base design of our proposed virtual representation of complex real property rights, specifically designed for a better interpretation of carbon property rights.

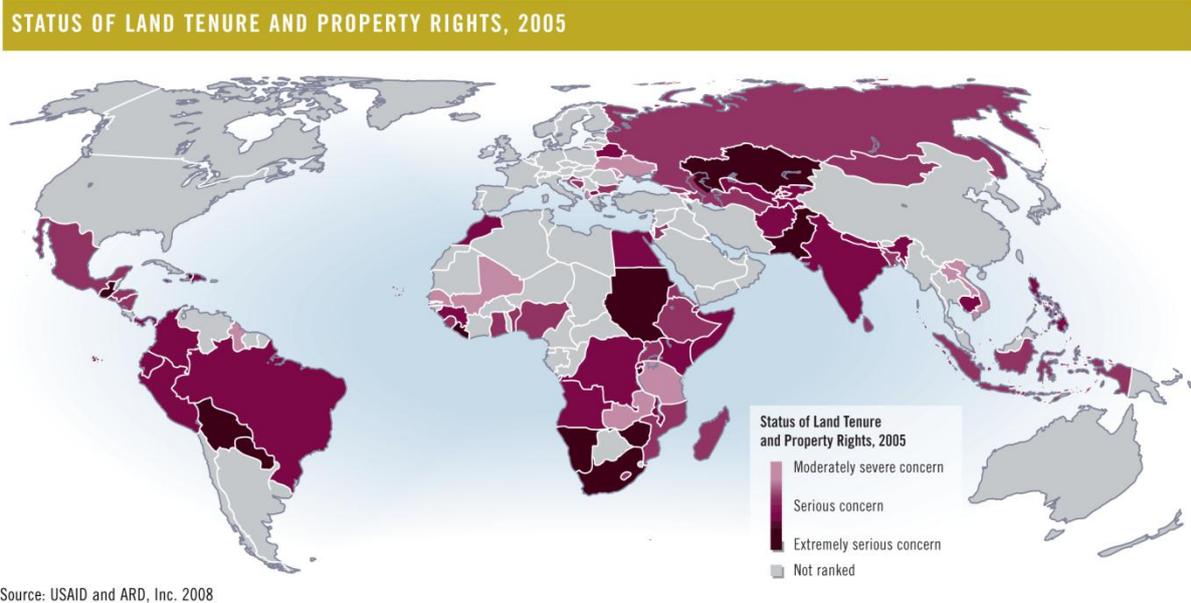
This research is a work in progress, and is presented as a merging of ideas and concepts to provoke thought and cooperation on a subject that is integral to climate change discussions.

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1. INTRODUCTION

In his presentation to the MAP World Forum in India in February 2009 the FIG President, Professor Stig Enemark, made a number of visual representations about interests in land, property rights and property systems. One is particularly significant - the USAid and ARD, Inc. 'Status of Land Tenure and Property Rights, 2005' (see Figure 1).



Source: USAID and ARD, Inc. 2008

Figure 1: Status of and Tenure and Property Rights (source http://www.wri.org/image/view/10105/_original)

We present this paper in Sydney, Australia. In Figure 1 Australia, as with much of the developed world, is shown in grey and not ranked – the status of land tenure and property rights is seemingly of little concern. We find this curious, given that the feudal radical title of the Crown is a point of significant contestation from the perspective of the aboriginal community. We raise this point as we will illustrate the complexity of understanding the indigenous context is fundamental to expanding our view of carbon (for an exposition of indigenous carbon property rights, see Sheehan 2010). When we focus on property rights in *carbon* – ‘property’ but not land – Australia and many other countries should be remapped as the darkest shade in Figure 1, as the status of property rights relating to carbon is an extremely serious concern. The surveying adage *you can't manage what you can't measure* is particularly germane in the case of emergent property rights. By this we refer to not the quantitative measurement of carbon, but the qualitative and spatial measurement of carbon property rights.

Carbon property rights have emerged from an understanding that climate change events are the result of ever-increasing greenhouse gas emissions due to population and western lifestyle demands on agriculture and industry. Carbon dioxide emissions have been particularly targeted, such that internationally individuals through to major companies and industries are encouraged, or legally compelled, to monitor and reduce carbon dioxide emissions. To reduce emissions a market-led approach has generally been adopted, whereby rights to emit carbon dioxide are limited and tradeable, requiring secure and well-defined property rights in carbon (Barnes and Quail, 2009; Boydell et al., 2009b).

Barnes and Quail (2009), Boydell *et al.* (2009) and Sheehan and Small (2005) further relate the problems that arise from the conception of property rights in relation to the permanent storage of carbon in trees and forests to offset carbon emissions – that is, the difficulties in separating rights to land from rights to trees and other elements of the land. Our focus for this paper is carbon property rights at the local to national scale, excluding international programmes such as the United Nations Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).

In our view, Figure 1 highlights the contested meanings that occur in land and resource management, particularly in what is now considered a carbon-constrained world. In this paper we explore three specific themes related to these contested meanings - land and property, visualisation and representation, and the complexity of property rights themselves.

In addressing these three themes, we do not set out to specifically provide solutions, but rather raise a collection of important questions that require answers for the holistic management of our contemporary environment. Our questions go beyond the limitations of Henry Maine's (1861) explanation of property rights as a 'bundle of sticks' ... indeed, our starting point goes beyond unbundling the bundle of rights, the continuum of rights or web of interests, to the visualisation of a *constellation* of property rights (see Table 1). Specifically we invite debate on the suitability and design of current visualisations of land systems, in particular the visual tools that enable planning, governance and decision making with regards to land and property rights in a carbon constrained world.

In discussing the importance of accurate and relevant representations, specifically important to emerging 'unbundled' rights, we offer the foundation concepts for the metaphor of a constellation in a new virtual representation of complex real property rights. This virtual representation will integrate GIS and spatial components alongside social, economic and legal information – emphasising data about the relationships and system interdependencies. To enhance appreciation of the complexity associated with land and property relationships in the context of carbon, we propose to achieve this unbundling and progress towards a constellation by engaging the development of interactive multimodal representation (interactivation).

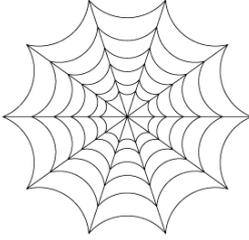
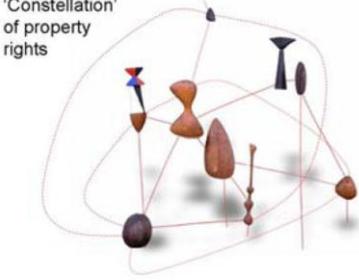
Bundle of rights	Web of Interests	Constellation of property rights
		
<p>Property as a bundle of abstract legal rights – using the ‘bundle of sticks’ metaphor with each right taken in isolation (Maine 1861)</p>	<p>Acknowledges that a property right exists as a relationship between many entities with respect to a central property object (Arnold 2002; Zellmer & Harder 2007)</p>	<p>Acknowledges the continuity of property elements such as land, and the relationships that exist between people, between people and objects and that these relationships may interact (Boydell, Sheehan & Prior 2009; Boydell et al. 2009a; von Benda-Beckmann, von Benda-Beckmann & Wiber 2006)</p>

Table 1: Evolving metaphors for property rights (adapted from sources as shown)

We have arranged this paper in six parts. Following this introduction, we offer some discussion on the notion of land and property, the prudent stewardship of which is the underlying focus of FIG. The third section provides a summary of recent interpretations beyond the bundle, through the web and into a constellation of property rights from a carbon perspective. The fourth section discusses representation and visualisation; visualisation means many things to many people - we ask you to look beyond embedded preconceptions to question the meaning of what you see. This sets the scene for the fifth section where we look at designing property representations. We introduce a number of disparate issues which we integrate in the final section where we offer possible directions and invite wider collaboration.

2. LAND & PROPERTY

2.1 Land and Property in the context of culture

What does ‘land’ mean to you? And what is your understanding of ‘property’? Our response to meaning in the context of land is determined by our perspective and culture, resulting in either a high-context or low-context interpretation (or aspects of each). It may be helpful for us to elaborate on this, and one of the better distinctions to be made between low-context and

high-context cultures is offered by Burgess and Burgess (1997) in explaining conflict management and land. Whilst our focus in this paper is not on conflict, where land is concerned conflict can arise all too easily when we engage the *wrong* context.

There are major challenges to conflict management when a straightforward low-context (US, Canada, Western Europe, Anglo-Australian) approach is applied to a culturally sensitive high-context society (traditional, collectivist, honour based cultures e.g. Japan, China, Latin America, and Pacific Islands). The western approach identifies conflict as a struggle between competing interest and something to be addressed in a businesslike way. Language is explicit and the conflict is tackled head-on, adopting competitive (positional) bargaining or integrative (problem-solving) negotiation.

This brash approach contrasts harshly with the high-context identification of conflict as a problem of relationships as well as interests. In such circumstances, a relationship-oriented process must encompass indirect and non-verbal communication to protect stakeholders and face. Accordingly, traditional societies often prefer locals to act as intermediaries, even though they may be party to the conflict and partial to one or other side, based on their community trust and respect. Such individuals are seen to have a longer-term interest in enduring solutions for the greater good of the society than impartial outsiders do.

To demonstrate this, we will contrast two examples. First, below, a Western low-context (albeit gender biased) example:

“WHO AM I? I am the basis of all wealth, the heritage of the wise, the thrifty and the prudent. I am the poor man's joy and comfort, the rich man's prize, the right hand of capital, the silent partner of many thousands of successful men. I am the solace of the widow, the comfort of old age, the cornerstone of security against misfortune and want. I am handed down to children through generations, as a thing of great worth. I am the choicest fruit of toil. Credit respects me. Yet I am humble. I stand before every man, bidding him to know me for what I am and possess me. I grow and increase in value through countless days, though I seem dormant, my worth increases, never failing, never ceasing. Time is my aid and population heaps up my gain. Fire and the elements I defy, for they cannot destroy me. My possessors learn to believe in me: invariably they become envied. While all things wither and decay, I survive. The centuries find me younger, increasing in my strength. I am the foundation of banks, the producer of food and the basis of all wealth throughout the world. Yet I am so common that thousands, unthinking and unknowing pass me by. Who am I? ‘I AM LAND’.” (Anonymous)

In contrast, a high-context indigenous relationship to land is articulated through our colleague Larissa Behrendt's recollections of her father's description of the cultural relationship to land:

“We bond with the universe and the land and everything that exists on the land. Everyone is bonded to everything. Ownership for the white people is something on a piece of paper. We have a different system. You can no more sell our land than sell the sky. Our affinity with land is like the bonding between a parent and a child. You have responsibilities and

obligations to look after and care for a child. You can speak for a child. But you don't own a child." (Behrendt 2003, p.33).

As this quote illustrates, land can be perceived beyond the westernized and masculine, to represent a number of issues, such as rights, obligations and restrictions that will be developed below. We have heard an economic (or at least land economist) western notion of land as an absolute and passive backdrop to development – low-context. We have contrasted this with an indigenous perspective of sentient land (as demonstrated also in: Backhaus & Murungi 2005; Hercus et al. 2002). Neither perspective presents a rounded and full definition of land, yet together, if such contrasts can be integrated, they contribute to a whole.

Cultural views of land define not only legal and economic characteristics but the use and ultimate management of land and land elements – emphasising space over place. For example, being high-context, the Australian Aboriginal cultural attributes of land and the relationship between space and place are spatially narrated by dreamtime stories – offering a different interpretation to the high technology yet low-context geospatial representations of space and place afforded by, for example, GoogleEarth. *"It is through the cultural processes of imagining, seeing, historicising and remembering that space is transformed into place, and geographical territory [transformed] into a culturally defined landscape."* (Coetzee 1987).

2.2 Questions regarding land versus property definitions

Concepts of land do not only differ across cultures. Within the English language, we define land as distinct from 'soil', 'ground' and 'earth'; similarly, we define as separate space, place, and location. Each word is both distinct and interrelated. What do we mean when we state, 'this land is mine'? Land (as a noun) is defined as the solid portion of the earth's surface, as opposed to sea (water); in addition land may also refer to a unit of local government in Austria and Germany; whilst land may also form a verb meaning to come to land or to come ashore (OED 1989). Interestingly, the first and last define land as distinct from the alternative 'surfaces' – air and water – implicitly placing 'ground' and 'soil' as subsets of land. Land as a unit of local government, however, implies that boundaries are inherent in human precepts of land, and emphasises land as property. The notion of property is not so much the management of land, but the management of relationships between people and place.

The emphasis of land as 'property' is an important distinction. Property implies 'ownership'. As Gray and Gray (2005, p.100) remind us, few concepts are quite so fragile, so elusive and so frequently misused as the notion of property. They continue, 'Our daily references to property therefore tend to comprise a mutual conspiracy of unsophisticated semantic allusions and confusions, which we tolerate - frequently, indeed, do not notice - largely because our linguistic shorthand commands a certain low-level communicative efficiency'. Property is not so much a thing as a legally enforced collection of rights that are guaranteed by the state. One does not own land or property, but rather a collection of right, obligations, and restrictions, or an individual right, over a plot or parcel of land. In low-context societies where the emphasis is on an ever increasing gross domestic product, it is not land itself or the resources thereon (or therein) that hold value - it is instead the legally enforceable property

rights associated with a plot or parcel of land that form the basis of its economic worth. The realisation that economic value is associated with real property rights over land serves to undermine the anonymous 'I Am Land' quotation provided above.

2.3 The Carbon Property Right Conundrum

No mention is made in these definitions of trees or potential constituent elements of land, such as soil, minerals, groundwater and carbon – yet in a legal context (for example in the UK and Australia) a tree is often considered to be part of the land from the perspective of real property. This raises challenges to the management of carbon forestry from a legal and property perspective. This distinction is not universal - the converse possibility of individual tree ownership in Nigeria, Uganda and Tanzania contrasting with the land ownership claim that may follow tree planting in Kenya (Fortman 1985). Such examples demonstrate that concepts of ownership become more complex when the interdependencies of ecological systems are contrasted against individual rights across land elements. A tree cannot exist in separation from soil and water, and in turn facilitates the spread of nutrients through soil and may impact the depth and flow of ground and surface water. In the context of carbon, carbon may be 'captured' by trees in the process of photosynthesis – yet it cannot be separated from the tree whilst the tree is alive.

Butt (1999) notes the possibility of one person owning trees on another's land for the purposes of carbon sequestration – but how can such individual rights in carbon be managed as distinct from trees, soil and other gases in the air? There is growing recognition of an interconnectedness between less familiar forms of property and even archaic property rights such as native title (Sheehan & Small 2005). Adequate representation of this interconnectedness of rights and the actions of right-holders is necessary to predict conflict, and manage land systems. In our earlier work (Boydell, Sheehan & Prior 2009) we highlight that obligations and restrictions need to be equally acknowledged and represented alongside rights.

The emerging right in carbon and its sequestration role within an emissions trading scheme is perhaps best described as an 'object-based' concept – in contrast to existing rights which define a set ownership space in three dimensions (such as strata or condominium title) or two dimensions, but with 'reasonable use' of the third (see, for example, Gray 1991). This 'object-orientation' is overlooked in both economic and legal systems, with the relevant attributes of a property object discarded in favour of information pertaining to the right and right-holder (Zellmer & Harder 2007). This view is supported by Arnold (2002), who also suggests the need for 'object-regard' in relation to property; however Boydell *et al.* (2009) relate High Court findings that negate the legal view of property as object. Kalantari *et al.* (2008) add weight to the potential of the property object (albeit extra-legally) to describe a spatially referenced legal property that may exist for representational and understanding/governance purposes but may not require legal acceptance as a new property definition.

Having introduced high- and low-context cultural interpretations of land and provided an interpretation of the fragile and elusive concept of property, the next section will focus on

property rights and engage with the carbon conundrum associated with bio- and geo-sequestration.

3.

3. PROPERTY RIGHTS

Property rights research has emerged from a broad range of disciplines including archaeology (Earle 2000), anthropology (von Benda-Beckmann, von Benda-Beckmann & Wiber 2006), ethics, sociology and anthropology (Sorensen 2000; Swedberg 2003), psychology, law (Arnold 2002), geography, history, philosophy, economics, planning and business studies.

The transdisciplinary approach to property rights promoted by the Asia-Pacific Centre for Complex Real Property Rights (APCCRPR) has recently been influenced by research emerging from within the disciplines of law (Arnold 2002), sociology and anthropology (von Benda-Beckmann, von Benda-Beckmann & Wiber 2006). Anthropological research into property does not differ in the main from that of the sociological and has from the beginning drawn heavily on legal traditions, which under the broader jurisprudential level is indistinguishably part of the social sciences (Sheehan & Small 2006, p.389). The established interdisciplinary relationship between these fields is exemplified by recent research undertaken by the legal pluralism group at the Max Plank Institute for Social Anthropology (von Benda-Beckmann, von Benda-Beckmann & Wiber 2006).

We aim to go beyond such an interdisciplinary approach and expand on the APCCRPR transdisciplinarity in another paper being presented at this conference (see McDermott & Boydell 2010). We draw on Nicolescu (2006, p.143), who highlights that ‘Transdisciplinarity concerns itself with what is *between* the disciplines, *across* the different disciplines, and *beyond* all disciplines’

3.1 A bundle of new metaphors

As we identified in the introduction to this paper, for more than a century the ‘bundle of rights’ identified by Henry Maine in *Ancient Law* (1861), has provided some common ground for interdisciplinary dialogue on property (see Boydell 2007 for a useful summary of these rights). More recently there have been moves to develop more complex metaphors and models for understanding contemporary property rights arguing that the ‘bundle of rights’ is conceptually limited (see for example Arnold 2002; Gluckman 1965; von Benda-Beckmann, von Benda-Beckmann & Wiber 2006; Zellmer & Harder 2007). These critiques have sought to question the existing image of the bundle, promoting instead new metaphors and models that establish the building blocks from which to visualise, imagine, understand, and problem-solve contemporary property. These critiques share the view that visualising property through the bundle of rights is too narrowly conceived, that it brings up the image of exclusivity and separation. The bundle approach does not adequately reflect the increasing sense of interconnection and co-existence that marks contemporary property rights such as those associated with carbon (Boydell, Sheehan & Prior 2009) or water (Zellmer & Harder 2007).

These new models and metaphors promote the use of such terms as ‘interests’ and ‘relations’ rather than just ‘rights’, to support a more fluid articulation and understanding of contemporary property. Most importantly for this paper is the unbundling of carbon, water and other biota in the move towards a constellation metaphor of property rights. The distinct definition of property rights in carbon, land, water and other biota necessitates that land system representations appropriately represent, articulate, negotiate and otherwise visualise the multiple stakeholder influences and aspirations relating to a constellation of rights, obligations and restrictions/responsibilities. An understanding of the cultural elements of land is crucial to engaging community support in land management decisions, and needs to be correlated with environmental, legal and economic elements to enable sustainable land systems. In an object-based approach to representing the legal and economic components of property rights, environmental considerations, as well as non-spatial elements such as low/high context culture, the interconnectedness of land system elements and the relationships between right holders and stakeholders needs to be engaged, represented, and visualised to meet these criteria.

In the next section we expand on the notion of visualisation and representation and set the scene for modelling a constellation of carbon property rights.

4. REPRESENTATION AND VISUALISATION

Do you see what I see? How can I help you to see what I see through my eyes or in my mind’s eye? Having briefly explored concepts of land, property and property rights, in this section we investigate representation and visualisation – specifically, what we mean by these terms and how they can be engaged to facilitate our understanding and management of land systems, particularly in the context of carbon.

The word visualisation conjures up a multitude of variants. These include, but are not limited to, creative visualisation, flow visualisation, illustration, information graphics, interactive visualisation, music visualisation, scientific visualisation, software visualisation, and one that is more familiar to in FIG audience, i.e. geo-visualisation, or geospatial visualisation. Visualisation has a long heritage that can be traced back to the philosophy of Plato. Plato believed in the reality of abstract forms perceivable only through the mind's eye and imperfectly represented in everyday life (Plato 1937). Interestingly, Plato argued that we see *through* the eyes, not *with* them (Jay 1993, p.27).

It is our intention to represent the constellation of property rights – as it exists in the minds’ eye of experts and researchers – in a visual and workable interactive representation that has no preconceptions with respect to culture or space.

This representation of property rights is motivated by carbon constraint and must engage interactivation, digital architecture and geospatial science to construct a constellation of legal, economic and spatial data that incorporates environmental considerations as well as non spatial elements relating to culture and context.

4.1 Origins of ‘representation’

We are offered some guidance on representation by Pitkin (1972) who attributes its origins to the Roman *repraesentare*, which was used in the literal sense ‘re-present’: to bring something previously absent into presence, or to create an abstraction of an object. Adding depth to Plato’s argument, she offers the example of the embodiment of courage in a human face or in a piece of sculpture. The concept of abstract embodiment is particularly pertinent in that it demonstrates the potential to depict intangible entities or concepts in another, not necessarily related, form. In other words the representation of land does not necessitate a map.

A representation can further be a reproduction in some material or tangible form, the action of presenting to the mind or imagination, a clearly conceived idea or concept (OED 1989). Representation engages concepts of sight and visibility, reproduction, mind, and imagination – all critical to the management and future planning of land and property.

Representation as conceptualisation also evokes description and symbolism. This is not merely to re-present, for example by resemblance or reflection, but also to express connection with reality in a different manner. This can be achieved through the amalgamation or high level view of elements to define causality and comprehend complex data (Staley 2002).

Placing this back into the context of property rights, the Australian Property Institute (API 2007, p. 7) suggests that “the appropriateness and resilience of conventional land titling systems to deal with these newly emerging property rights has raised fundamental issues... 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”. Going beyond Figure 1, what means of representation are suitable and appropriate to display and explain property rights?

4.2 Traditional representations of land

Building on the notion of representation, we will first review some traditional depictions of land and property to determine the potential and most suitable method to transfer understanding across peoples. One of the oldest tangible examples can be traced to the agricultural settlements along the Tigris, Euphrates and Nile Rivers where Egyptian land registers dating to as early as 3000BC were used for land taxation purposes (US NRC 1980). Such representations appear similar to the present day examples, yet maps have not been the only representations of land throughout history.

The aboriginal tribes of Australia transferred their understanding of land and culture through songs and dances, which, in our research terms, form a theoretical interactivation basis for engaging with both haptification (touch) and sonification (sound). Each tribe has its own songs, representing navigational and historical knowledge (Nelson 1998), as well as methods to explain how to best manage the land and live in balance with the environment. The songs combine historical relationships tying individuals, tribes and history to the land by describing the *Dreamtime*. Dreamtime is the creation story of the aboriginal peoples and it explains how

the topography of the land was formed by the actions of totemic ancestors, such as the rainbow serpent who carved the mountains and gullies of the Australian continent (Dourish 2007). Through this approach, the spiritual and material connections of the aboriginal people are visualised on the topographic features of the land (Brazenor, Ogleby & Williamson 1999). These ancestral songs are dynamic, as an interesting ‘first contact story’ (cited in Jacobs 1983) demonstrates. The song recounts that the first contact that an Aboriginal tribe has with a white settler is marked by a small round hill in Port Augusta, representing the pudding that was shared on their meeting. In this way, a musical phrase can be interpreted as a map reference.

Performance-based representation of land and property is similarly expressed in other cultures relationships with land. For example, the *Lienzo de Quauhquechollan* is the first known map of Guatemala. It is significant not as a map for individuals to read in silence, but rather to be performed by an experienced narrator at community rituals (Restall 2006). This narration is the only known indigenous account of the conquest of Guatemala (Restall 2006). The map was created on fabric, with square sections stitched together, and emphasises historical accuracy over spatial data. Some towns appear more than once during the narration of battles, migration, conquests and warriors (see <http://lienzo.ufm.edu> for an online digital version).

These examples highlight the importance of culture in capturing historical knowledge in land management. The representations visualise beyond existing two-dimensional maps (and three- and four- dimensions where these include height and time). They engage traditional ‘performance-methods’ of transferring land knowledge, facilitating memory by understanding interactivation... and introduces us to the idea of performance based property rights.

4.3 Bringing present-day, Western representations into the future

Waldron (1988) comments that the primary objects of real property have traditionally been physical and generally immovable, such as arable soil and solid surfaces. However, the ‘unbundling’ of water as a distinct and separate right, and the acknowledgement that one can have rights in carbon credits has radically moved our conceptions beyond the limitations of Henry Maine’s ‘bundle’. To transcend our current understanding of property then, we need similar radical changes in our representations of property, and in doing so can learn from both technology and traditional methods.

Existing visualisations of property rights data are dominated by legal words and ‘titles’ – which may be two dimensional on paper, or three- (sometimes four-) dimensional in software, often available online. Within Australia, for example, there are significant variations in national and state cadastral systems, and these are independently represented as the sole ‘visualisation tool’ for property rights data (Kalantari et al. 2008; Rajabifard et al. 2007). Wallace and Williamson (2006) highlight the emergence of complex land markets and their continual evolution, with the need for dynamic systems to manage such varied commodities. We contend that such a system does not yet exist. In Australia, for example, we have to navigate between the seven discrete legislative frameworks of the States and Territories, where each has evolved land law slightly differently.

Data elements identified by Kalantari *et al.* (2008) in the cadastre include: land parcel, property, third dimension, public, individuals, rights, responsibilities, restrictions, land value, and land use. The land parcel is typically the foundation of the data model – however increasingly this is less relevant in describing or relating to emerging property interests (Kalantari *et al.* 2008; Sheehan & Small 2002; Sheehan & Small 2005). Kalantari *et al.* (2008) identify that historically public and private interests in land were maintained in separate registers, and in the state of Victoria in Australia leases are not required to be registered. If emerging interests in property such as carbon, water and biota are to be integrated with land administration systems then a holistic treatment of all forms of related property is required. This is arguably slowly improving in the context of water rights in Australia, albeit that water is treated as ‘personal’ as opposed to ‘real’ property.

Additional community forms of representing property rights data have emerged in the form of social interaction tools such as virtual earth explorers (GoogleMaps and GoogleEarth, ArcGis Explorer, NASA WorldWind etc.), which each cater to a different community (ranging from more the social/public to the scientific). These have enormous potential to facilitate not only a wider understanding of spatial data, but increased stakeholder and community interaction with regards to land management (the growing emphasis and research on participatory planning is evidenced in EU Directives - see for example Bremner 1998; Lange & Bishop 2005).

We commented above on the need to conceptualise property objects, particularly for the representation and understanding of emerging (natural) rights in real property. Conceptually, we need to represent the property objects to which a right applies (for example, land) because the reality is often too large to view in completeness at once, and in any case is often located some distance away from centres of governance and decision-making. Secondly, we need to represent the relationships between property objects and people, and between the property objects and people themselves, in order to make such concepts more tangible and to improve understanding. We now briefly explore this conceptualisation.

5. DESIGNING PROPERTY REPRESENTATIONS

‘Inherent intricacies in creating carbon property rights derive from the need for security and tradability, the broader socio economic impact (such as the existing land property market), and cognizance of land use zoning and environmental management regimes’ (API 2007).

So far we have explored the need for greater acknowledgement of cultural understandings of land, the role representation and visualisation have to play, and a brief background on how existing knowledge in specific property rights is analysed and communicated. This synergy provides the basis for a new representation not just of land, but of land systems, to enhance our ability to manage and communicate land and land knowledge (and of course, property in terms of property rights).

In designing the foundations of such a representation, we draw from previous ‘visualisations’ and metaphors in property – notably Arnold’s (2002) ‘web of interests’, Zellmer and Harder (2007) who evolve this with a view to determining if property exists, the constellation of property rights (Boydell, Sheehan & Prior 2009; Boydell et al. 2009b; von Benda-Beckmann, von Benda-Beckmann & Wiber 2006), and Kalantari *et al.* (2008) who propose a system founded on the ‘legal property object’. We propose a synthesis of these, adopting the constellation concept for its emphasis on dynamic relationships, and its potential for relating non-spatial data, and the object-oriented approach to allow ‘the character of the thing in question’ (Zellmer & Harder 2007) to be adequately represented.

Such a dynamic representation will facilitate transdisciplinary collaboration across scientific, legal, financial, visual, and social disciplines, allowing communication and potential contributions from stakeholders and community organisations alike. Bennet *et al.* (2008) comment on the significance of Australia’s lack of an overarching land policy (given the statist interpretations of federalism) with regards to copious legislation to counter and manage Australia’s environmental problems. The overlapping legislative framework is rarely understood by all stakeholders, but could in the future be better understood through a standard representation. GoogleEarth has in essence brought Geographical Information Systems (GIS) to the masses, and as a global tool is paving the way for property rights, including by way of example those to in carbon, to be better represented and understood. Many national level land information systems have already emerged, and our intention is not to recreate these, but to expand their functionality to better represent the complexity of property rights over any given parcel of land.

Building on the key requirements of the emergent metaphors in property documented by Arnold (2002), Zellmer and Harder (2007) and von Benda Beckmann et al. (2006), and the specific requirements of carbon bio-, geo- and soil sequestration documented in Barnes and Quail (2009), Boydell *et al.* (2009) and Sheehan and Small (2005), our representation would require the features outlined in Table 2.

Obviously constraints limiting the effectiveness and implementation of land information systems impact on the proposed requirements (detailed in Table 2), and must be managed. These include support for dynamism, ensuring currency and accuracy of data (and recording such metadata) and autonomy for repeated functions. Research in spatial data infrastructure (SDI), semantics, cloud computing and the ‘networked aspect of data’ (Chalmers 1997) should further be investigated to enable data sharing at a national level.

In this paper we stress the need for the integration of non-spatial and cultural understandings relating to land and property, into existing technological representations of land. We do not propose a new representation of *land*. Rather we advocate an augmentation of current land information systems to enable greater provision within those systems for the comprehension of property rights, particularly as they emerge in elements such as carbon. Through a multimodal and transdisciplinary approach (Max-Neef 2005; Nicolescu 2006), we intend to interactively represent property-object information, object-object relationship information and

person-object relationship information, and integrate this information with existing spatial information data models.

World View + Relationships View	<p>Our representation would be in the style of GIS for familiarity, but could allow for the interrogation of property rights relationships.</p> <p><i>E.g. a query on a property object could reveal web strands spreading from the object to demonstrate relationships between entities with respect to that object.</i></p>
Interconnectedness	<p>It must be possible to demonstrate how actions (or inaction) with relation to one property object, may affect other, not-necessarily-neighbouring property objects and rights.</p> <p><i>E.g. the impact and spread of seepage from a carbon geo-sequestration site; the impact of carbon bio-sequestration on water rights in the same catchment.</i></p>
Time and multi-modality	<p>Already integrated into many GIS, time is particularly pertinent to carbon sequestration projects whereby the storage of carbon is to <i>permanently</i> or temporarily offset other emissions.</p> <p>Multi-modality stresses the need to move beyond visualisation to incorporate multiple dimensions in sound, touch and vision intelligently, resulting in representations that are interactive with improved user comprehension.</p>
Acknowledgement of different stakeholder roles	<p>Private and public stakeholders play different roles in management processes.</p> <p>DiBiase (1990) acknowledges the different requirements of a representation for analysis, and a representation for communication, proposing a two-phased process of</p> <ul style="list-style-type: none"> - visual thinking stages (exploration and confirmation) - visual communication stages (synthesis and presentation)

Table 2: Representation components for carbon property rights - developed for this research

6. CONCLUSION

In this paper we have introduced some of the challenges confronting the visualisation of emergent property rights, such as those relating to carbon. We have offered an interpretation of land from both a low-context and a high-context perspective. This allowed us to engage in the contested notion of property and the property rights upon which economic and legal understanding of space is determined. From this foundation, we developed the discussion into

the nature of visualisation and representation. We then propose a tentative model of what must be incorporated in property rights representations.

Decisions with respect to property are most often made remote from the site in question. It is important that information used in making such decisions is complete, accurate and unbiased. The unbundling of carbon, water and other emergent rights in property requires a holistic, *systems* approach to land administration and property management. This places particular emphasis on the attributes of property elements, and the relationships between people and property, which we explain as a ‘constellation’ of real property right, obligations and restrictions.

By taking a transdisciplinary review of traditional concepts and representations of land, we have demonstrated that existing two- and even multi-dimensional maps can be improved to incorporate cultural ties to land. This will enhance communication and facilitate understanding of complex concepts through user interaction with abstracted datasets. In doing so, we stress a multi-modal approach to representation.

In designing a representation to encompass multiple conceptualisations in a constellation of complex real property rights, we propose to incorporate requirements such as dynamism, multiple stakeholder roles, support for display of relationship data, and autonomy. Whilst such requirements are not new concepts, they have yet to be applied in the realm of property rights, particularly with respect to incorporating the multiple complex relationships defined by property rights in carbon.

Our research is obviously a work in progress. The ideas we have presented here are offered in the anticipation of provoking reaction and promoting support for the development of a collaborative constellation model to represent contemporary property rights in a meaningful and visual way. We identify this enquiry as being of significance to all involved in the stewardship of land and the wider FIG community. By engaging in such an endeavour, we appreciate that we are embarking on a transdisciplinary journey of great complexity. It is not a journey that can be undertaken in isolation, and as with any complexity paradigm requires the input, engagement, and counsel of multiple perspectives. To this end, the authors particularly welcome suggestions and feedback from interested readers.

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BIOGRAPHICAL NOTES

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