INCORPORATING NATURAL/FUZZY BOUNDARIES

Greening the Cadastre

What will future cadastres look like? *GIM International* tackled this question throughout 2010 and 2011. The starting points were six potential design elements: survey accuracy, property objects (including RRRs), 3D/4D capacity, real-time updates, global connectivity and incorporation of natural or fuzzy boundaries. In *GIM International's* November 2011 issue, the authors re-examined 'Survey Accurate Cadastres' and they now discuss the incorporation of natural boundaries in 'Organic Cadastres' here.

For most people, 'cadastres' are synonymous with 'order', conjuring up thoughts of thin black lines on white parchment, of digital parcel boundaries, parcel numbers and owner IDs. These are simplified representations of the real world, idealised workspaces or canvases for land surveyors and lawyers. And in that simplicity lies strength: everybody can appreciate that the recorded lines represent land tenures, land values or land uses. However, is this approach in need of an upgrade? The principles of modern cadastral systems were developed in line with the emergence of capitalism, modern land taxation and the industrial revolution. Land, along with labour and capital, was understood as a means of wealth production. Consequently, cadastres generally treated all land equally. It was merely white space on the map to be identified, carved up and allocated.

GREEN

Societies and their economies are changing. The 'green economy' – sometimes also known as 'natural capitalism' – is coming. This world view emphasises a modified vision of land, one that better captures social and environmental aspects. National land policies and laws are already adapting to reflect these new belief systems. The land administrator might ask: "Do our cadastral systems need to adapt to these changes, and if so, how?" In other words, do we need to add 'green' to our black and white cadastres (Figure 1)? Adaptation could require many changes in boundary adjudication, surveying, demarcation and recordation techniques. New green land regulations often aim to protect or

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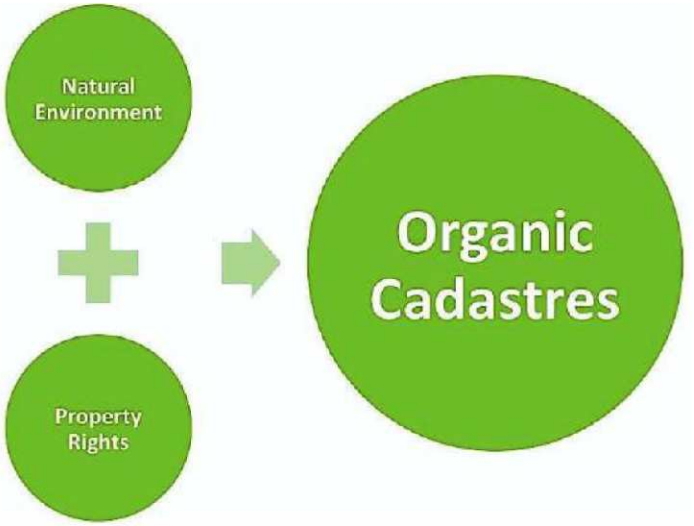

▲ *Figure 1, Do new green property rights require innovative cadastral responses?*

allocate interests in the environment. They do this by creating new, green property rights, restrictions or responsibilities. For maximum efficiency and effectiveness, straight lines will not do: environmental phenomena are fuzzy and often changeable. Therefore, the initial proposal on future cadastres suggested:
"Cadastres will better model the organic natural environment. communities are often vague and require new tools for representation and management".

EXISTING SOLUTIONS

The response in *GIM International* did not generate nearly as much excitement as 'survey accuracy'. Dimitris Rokos and Jurg Kaufman mentioned the design element. Rokos supported the notion, whilst Kaufman highlighted it as an area for future research. Jarmo Ratia provided an example of natural boundaries being captured in Finland's cadastral system:
"In Finland, prerequisites and processes have been defined for forming a cadastral unit with fixed boundaries of, for example, a conservation area. Natural phenomena such as post-glacial rebound or riverbank migration may again mean a cadastral boundary no longer runs along the original shoreline. These sorts of discrepancies can be dealt with in cadastral surveys and in the cadastre. Little or no importance has been paid to the idea of letting a boundary follow a moving geographical feature".

Many systems already possess simple approaches for dealing with natural boundaries

Many new property interests are designed around natural phenomena, rather than the strict bearings and distances or Cartesian coordinates found in traditional land parcels. For example, many interests in the marine environments exhibit fuzzy and changeable boundaries. Moreover, legal controls protecting flora and fauna or the land interests of indigenous

This approach demonstrates the land administrator's inclination to capture the natural environment and make it adhere to a cadastral system. Not all cadastral systems take such an approach with natural boundaries. Many systems already possess simple approaches for dealing with natural boundaries (Figure 2).

FIXED OR GENERAL

Many land administrators will be familiar with the notion of 'fixed boundaries' and 'general boundaries'. Fixed boundaries have been precisely measured and recorded using, for example, a total station. General boundaries approximate the location as descriptions of physical features while locations can change over time. The UK extensively uses the latter: fixed boundaries represented on cadastral maps have played a very minor role in the development of the country's property markets. It is believed that, out of over 18 million registered properties, less than 20 of them feature fixed boundaries.

Australian states provide examples of where fixed boundaries are used extensively. However, they incorporate some flexibility with respect to natural boundaries too. The Registrar General of New South Wales describes how:
"The doctrine of accretion and erosion applies to boundaries of tidal lakes and both tidal and non-tidal streams and waterways where the change in the position of the bank of the waterway is natural, gradual and imperceptible".

In other words, wherever the waterway goes, the boundary goes, regardless of whether a cadastral surveyor is around to measure it. In this way, a new survey is not ▶

▲ *Figure 2, Erosion, accretion or other natural changes often occur in reality; many cadastral systems can already handle such changes.*

▲ *Figure 3, Conservation areas can have fixed outer boundaries, whilst the protected marine species can move.*

required every time a boundary changes, which could be quite often. But the challenge is then, how to keep our cadastral records up to date with reality? More on that later.

Another example of fixed boundaries is the boundary between sea and land. The United Nations Convention Law of the Sea 1994 tackles the problem of the moving waterline by relating territorial zones to the 'baseline', which fixes the boundary between land and sea at 'low water line' level (a hydrographically defined line), wherever that may be.

BUFFER ZONES

Buffer zones are another method used to manage natural phenomena. Buffer zones around nature conservation areas can have a fixed outer boundary, while the natural phenomenon itself can move (Figure 3). Buffer zones are frequently applied in Europe, under the EU Natura 2000 policy. In The Netherlands, analysis of administrative decisions shows that these outer boundaries are visualised as 'general boundaries' and depicted on both topographical maps and Google Maps and Google Earth. However, this approach can needlessly restrict use of large areas.

The use of networks of sensors for administering green boundaries is still in its infancy

Public restrictions regarding soil contamination or noise hindrance are also difficult to capture and record spatially. Moving contamination contours or noise produced by aeroplanes are good examples: while these are sometimes recorded in traditional land administration systems, more often they are not. Whether spatial representations of such phenomena can be captured and maintained cost-effectively requires careful consideration.

LAW VERSUS NATURE

For cadastres, the key issue in all this is the legal status of a given natural boundary (Figure 4). To cite Coan (1996), "Spatial objects – as natural occurrences – have imprecise boundaries that continuously change over time, while spatial objects defined by people are administrative objects with well-defined boundaries, that might change because of discrete changes," or to cite Smith (1995), "Spatial boundaries can exist independently of human cognitive acts or can (or might) not exist independently".

Kaufmann also comments that answers to the question of precise boundary location can be found only within the legal frameworks and respective case law. We believe this is true: where natural objects and

▲ *Figure 4, Complex natural environments in Belgium (left) and Namibia; emerging geospatial tools offer alternative survey, demarcation and recordation.*

administrative objects coincide, there is a need for cadastres to respond. In these cases the management of natural spatial objects requires action by people (to do something or to refrain from doing it) to be enforceable by administrative legitimation (law). The law, and arguably a cadastre, has to define how imprecise natural boundaries and precise administrative boundaries relate at a certain point in time. The UNCLOS solved the moving land-sea boundary by fixing a baseline, buffer zones are delimited to allow nature conservation areas to have changing boundaries, legal boundaries along the riverbanks follow a river's migration, and so on.

NEW SOLUTIONS

But these legal solutions do not always assist on the ground. "Am I allowed to excavate next to this building?" a constructor may want to know, and a farmer may enquire whether he is allowed to drain his lands. In many cases, these practical challenges could do with better tools than those that are currently available. The initial discussion on future cadastres proposed that the geospatial sciences would provide some answers: *"Ambient Spatial Intelligence [see 1] enabled through the use of Wireless Sensor Networks (WSNs) will enable the continuous movement of these boundaries to be measured and presented visually in real time within the cadastral framework".*

A school of bluefin tuna, a protected estuary or a customary grazing route can be tracked, positioned and represented using networks of sensors scattered around the natural resource. Alternatively, regularly updated high-resolution satellite imagery or crowd-sourced information could be used. However, the application of these tools for administering green boundaries is still in its infancy. More investigation is needed. Within jurisdictions, clearer agreement on whether new green boundaries belong in cadastres is required. If they do, determination of low-cost, high-speed, fit-for-purpose approaches for adjudication, surveying, demarcation and recording will be needed. For land administrators, that challenge remains the same as always. ◀

MORE INFORMATION

1. http://ambientspatial.net/amsi/

FURTHER READING

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