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Te Rōpū Kairūri o Aotearoa

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EDITORIAL

BRUCE MCFADGEN

Christchurch – once a heritage vision, now a vision of destruction, severely damaged by a series of earthquakes and aftershocks that struck what was considered to be one of the least hazardous parts of the country. The impact of the Canterbury (Darfield) and Christchurch earthquakes, from our present vantage point only months later, seems wholly negative.

Yet the history of tectonic events and their impact on humankind globally has, overall, been surprisingly positive for humans, both physically and culturally. Consider Lisbon. The Lisbon earthquake of 1755 was perhaps the most destructive natural event in the history of Europe. Its magnitude is estimated to have been possibly around 8.5. The devastation was not confined to the city. The earthquake affected the whole region, as far away as North Africa, Spain and France. In Lisbon alone more than 10,000 people were killed outright, and many more later died of injuries.

The earthquake was accompanied by a tsunami and followed by fire. Unconsolidated sediments, unreinforced masonry buildings, and narrow streets contributed to the devastation. The aftershocks continued for months. Some 85 per cent of the 20,000 houses in Lisbon were destroyed. The city's cultural heritage – art works, libraries, and records of Portuguese exploration – were all destroyed.

The Marquis of Pombal, to whom the King gave sole authority to lead the recovery, made good use of the opportunity to modernise Portugal. A new city arose from the ruins of the old one. Its narrow streets and tightly-packed vulnerable buildings were replaced by wide boulevards and buildings designed to withstand future shaking. What might have been an unmitigated disaster was turned into an opportunity to modernise Portugal – commercially, economically and politically.

The earthquake brought about social change. The influence of the church and nobility in the country declined as Portugal left the Middle Ages and entered the Age of Enlightenment. Significantly, it dawned on the Portuguese that disasters, which they had previously considered to be Acts of God, were in fact natural events, deadly to those who failed to understand and adequately prepare for them.

This realisation is as pertinent today as it was in 1755. Considering our modern habit of building not only in earthquake-prone areas, but also on the flanks of volcanoes, on river banks vulnerable to flooding, and on shorelines vulnerable to tsunami inundation, storms, and coastal erosion, it behoves us to prepare for the worst. Most importantly, the Lisbon earthquake led to a search for its scientific causes, and ultimately to the birth of modern seismology.

It was not only Europeans whose understanding of earthquakes was changed. It has recently been suggested that calamitous events – those that severely damaged or destroyed towns and cities, such as fires, floods, storms, tsunamis, and earthquakes, have played an important role in the development of the United States by providing opportunities to re-examine values, change direction, and rebuild in ways more appropriate to modern conditions. In modern times, cities in different parts of the world have quickly and successfully recovered from catastrophic events through the opportunities the events have provided for renewal and progress. In New Zealand, after the 1931 earthquake, Napier emerged from the Depression two years before the rest of the country. It was rebuilt as a city redesigned for the times, without the benefit of large amounts of insurance money, but funded mainly by the New Zealand Government.

Humans are tectonic animals. We and the civilisations we have created are the fruits of living on a tectonically active planet.

A brief history will suffice. Significant fossil remains of our hominin ancestors have been found along the African Rift Valley, an active tectonic plate boundary. Recent research suggests that the valley environment, shaped by tectonic activity over millions of years, played an important role in human development, by providing a complex environment where a slow, weak, biped could survive the ravages of large, fierce, four-legged predatory animals.

The advantages of living on plate boundaries have also been argued for later Palaeolithic times. In the eastern Mediterranean, the juxtaposition of resources resulting from horizontal fault movement made fault boundaries desirable places for people to live. And in the early Neolithic, many early cereals originated on plate boundaries. These examples, however, demonstrate only a passive interaction between tectonic environments and humans, where plate boundaries benignly provided advantages. With the advent of civilisation, the interaction intensified. The disadvantages of living close to plate boundaries become more evident.

Early civilisations from the Mediterranean to China and in South America were strung along plate boundaries and continental deformation zones like beads on a string. Despite the ravages of large earthquakes that flattened them from time to time, many cities rose again on the same sites, some several times. How long a civilisation lasted depended on how close it was to the plate boundary, with a mean distance of about 75 km.

Those civilisations furthest away survived longest, and the relationship is logarithmic, which suggests that earthquakes played an important role. Trade routes often followed plate boundaries, so they can be seen as important conduits for communication. For reasons that are still not entirely clear, plate boundaries have played an important and active role in the development of civilisation.

The outcomes of tectonic activity: fertile soils, safe harbours, valuable minerals, we use to our advantage. From time to time we pay the price in the destruction of property and loss of lives. The trick is to ensure we are prepared for the worst, to minimise the loss of life while at the same time making the most of the advantages.

For New Zealand, with its tectonically-active environment, understanding earthquakes and our geological environment is essential. That is why we fund GNS Science and the Natural Hazards Reasearch Platform. Yet our understanding is far from complete. Many large earthquakes in New Zealand since European settlement have been, like Christchurch, in areas deemed to be not particularly hazardous. The same can be said for earthquakes in many other parts of the world, including Japan.

Our survey system can now cope, at least in part, with tectonic movement of the landscape (see Blick et al, this issue). This will be essential to the rapid recovery of Christchurch. Surveyors played a vital role in the days and weeks following the 2011 earthquakes, monitoring damaged buildings, and later assisting with their assessment. Rebuilding Christchurch, whether it is on the same site, or one more appropriate for a modern city, presupposes a well-defined land title system, and skilled and equipped practitioners to use it. That is our task as surveyors.

The settler founders of Christchurch came to this country from a tectonically benign landscape. Unlike Maori, who occupied buildings better suited to a tectonic environment, the Europeans built with their traditional materials of brick and stone in places at risk from shaking. A century and a half later, we should know better, and before we rebuild Christchurch, take heed of what science and history tell us about the conditions where we wish to rebuild.

We need to remember that tectonic events of the kind that struck Christchurch have two sides, adversity and growth. We can therefore expect that good will eventually come from the destruction and loss that 'Christchurch' now signifies.

SPLITTING THE ATOM OF COMMUNAL LAND TENURE, WITH SPECIFIC REFERENCE TO MAORI FREEHOLD LAND

Abstract This article begins by contextualising Māori Freehold Land (MFL) within a wider global debate about communal land that is in transition to more individualised forms of tenure. A comparison is made between Ngai Tahu MFL and a case of transitional communal land in Zimbabwe. It is concluded that for many Ngai Tahu Māori, general land and the State now cater for shelter, sustenance and other functions formerly supported by MFL, while remaining MFL now handles disproportionately more of the cultural functions and interpersonal ties that are generally divorced from 'western' tenure forms. This raises the question of whether MFL should now be managed with an emphasis on fulfilling those functions not met by formal, individualised tenure, and if so, how this should best be achieved in practice.

Keywords Communal land, individualised tenure, Māori Freehold Land.

INTRODUCTION

Communal land tenure, so called to reflect the socially embedded nature of its rights, still dominates right-holding in many parts of the world. This includes the Pacific, where the majority of land is held under customary land tenure systems (Ward and Kingdon 1995) and Africa, where between two and ten percent of land only is covered by formal tenure (Cotula 2006; Cousins 2007; Berry 1993). Much of this so-called customary land is in fact no longer held under pure custom, but is in transition as tribal authority structures give way to national systems of government and as familiarity is gained in dealing with registered and commoditised land under western tenure models in urban centres (Chauveau and Colin 2006).

Māori Freehold Land (MFL), amounting to about 6% of land in New Zealand (Grant 2000), also sits somewhere in the continuum between pure customary tenure and registered title, veering closer to the formal registered title end since completion of the Māori Freehold Land Registration Project (MFLRP) in 2010. 'Unlocking' Māori Freehold Land has been the subject of considerable debate in New Zealand (e.g. Hutchings 2006), and balancing productive and cultural uses of communal land in transition is also an issue of wider, global significance. Cultural uses of such land are often downplayed as countries take steps to bring customary land onto the formal register with the stated aim of increasing land rights security, increasing productivity, alleviating poverty and securing access to land for cultivation, industry and shelter (Deininger and Binswanger 1999; Williamson 2001). An agenda that is not always made explicit, however, is that of bringing more land onto the market, and this and other issues (Cotula et al. 2009) make individualising communal tenure a complex undertaking that all too often has ended tragically (Vanuatu land boom 2011). This underlines the need to better understand the cultural significance of land that is in transition between communal tenure and formal 'Western' tenure. This article begins by summarizing key points of a research project that used a case study approach to learn more about transitional land, and to situate Māori Freehold Land in a global context of communal land in transition. The focus is then narrowed to the particular case of Māori Freehold Land, especially the practical issues inherent in achieving a balance between productive and cultural uses of MFL.

A RESEARCH PROJECT TO LEARN MORE ABOUT COMMUNAL TENURE IN TRANSITION

The research for this article, undertaken in 2005 as part of a PhD study, drew on 88 semi-structured interviews roughly divided between two contrasting cases of customary land, namely Ngai Tahu Māori Freehold Land in New Zealand, and Shona and Ndebele Communal land in Zimbabwe. The object was to use a case study comparison to ascertain what

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land tenure custom has persisted, and why. The interviews went some way towards updating the rich anthropological literature on land custom, which exists for both countries, to reflect current issues and imperatives. Early on it became apparent that strong points of similarity existed between the two African tribes on the one hand and Māori and Pacific land on the other. In both cases, persisting land tenure customs were found to include not only ceremonies linking people and land, but also ceremonies linking people to people. These links are exemplified below with reference to four attributes of communal tenure from the African case study:

- ***Investment in a belonging group***. One mechanism for investing in a belonging group was by what might be called 'rates and taxes' parties. For Shona and Ndebele, this took the form of *chiutsi* (= 'smoke') or *mabiko* (= 'cooking') parties to formally launch new homesteads, and also *nhimbe* work parties. Such parties are often accompanied by a ceremonial variety of beer, which may be brewed in a special way and with place-specific ingredients (Goodwin 2008). These are not just housewarmings and 'working bees'; the ceremonies are tantamount to paying rates/taxes, and are even comparable with long leases in giving rise to real (praedial) rights. In the words of one interviewee: 'It is that ceremony which gives you 'title deeds', as it were, to that land, because a ceremony was held, and nobody can take it away from you. It's the title deed.' These 'parties', perhaps better than anything else, underline a central element of communal tenure, namely socially based security (including security of land rights). Parallels exist with the positive facet of *utu* in Māori custom; reciprocity that helps to build a web of ties between people (Metge 1976: 15, 16, 67, 68).
- ***Forging land links at birth***. Burial of the umbilical cord (*rukuvhute* (Shona) *nkaba* SiNdebele) is still widely practised. For many it is still a requirement of 'title', a 'need to have' rather than a 'nice to have', probably to a greater degree than in New Zealand, although burial of the placenta (*whenua*) still occurs quite often among Māori today as individuals search for meaningful tradition to give due ceremony to the miracle of birth and place. The African ceremony is adapted pragmatically to suit contemporary life. For example, for clinic births, soil may be brought from rural homes (*kumusha/ekyaya*) and rubbed on a newborn baby's navel to avoid the complexities inherent in taking a birth cord home for burial (although the latter does occur, and carries its own adaptive custom).
- ***A combination of land links and interpersonal links on occupying a new homestead***. For Shona and Ndebele, the *kurova hoko* and *utshaya ihlahla* ceremonies are still important. The former is putting in a peg to indicate a homestead site, and the latter laying a branch, also to mark a homestead site. However, neither ceremony is merely about territorial markers. The ceremonies also serve to bind families, and are a declaration of commitment to help in trouble and an affirmation of authority (father, headman, chief) (Vijfhuizen 2002; Goodwin 2008).
- ***A locus of belonging and of renewing family ties***: Just as the hearth for Europeans may be the symbol of home, the kitchen has special significance in African tradition. A wealth of symbolism and ceremony is bound up with kitchens, and in a polygamous marriage, each wife has her own kitchen. Within are low benches (*chiguva*) containing symbolic grave apertures in which ancestors are invited to come and live, and on which food beer and snuff are placed to 'feed' the ancestors. Kitchens also have low doorways so that people have to bow to gain access, birth cords are often buried in the floor or doorstep, the dead are often laid out in a kitchen and it is here that living members congregate to spend time together.

It is clear from the above points that at least two intertwined strands exist in communal land tenure. The first is the strand of interpersonal or 'belonging' links. Cousins et al. (1992) note that: '…individualised property rights are still hedged in by a wide-ranging set of social obligations in which the interests of the group are articulated. Individual ownership is embedded in a larger 'communal' tenure system in which rules governing access to and use of the commons are still important'. The second strand, closely bound up with the first, is that of people-to-land links. By contrast, individualised ('Western') tenure plays down interpersonal links and emphasises land 'holding' (in the sense of 'holding a fort' to the exclusion of others). Words like 'private' property are employed, and 'seisen', which has the same root as 'seize'. In fact, the English Common Law Ceremony of 'feoffment with livery of seisen' may have been used in the early European history of New Zealand (McRae and Baldwin 1997:16). In Western tenure there is a strong emphasis on land rights (e.g. rights to cultivate land, reside on land and bequeath land), and these rights are largely separated from interpersonal ties and from responsibilities towards a community.

The contrast between communal land holding and individualised tenure is shown diagrammatically for Māori Freehold Land in Figures 1 and 2.

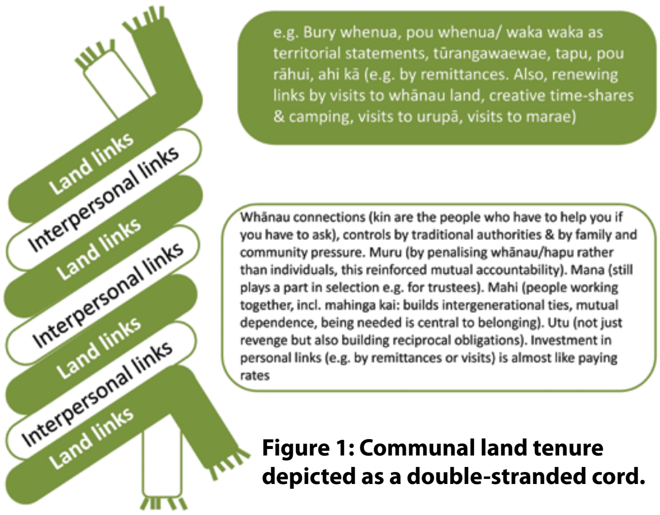

Figure 1: Communal land tenure depicted as a double-stranded cord.

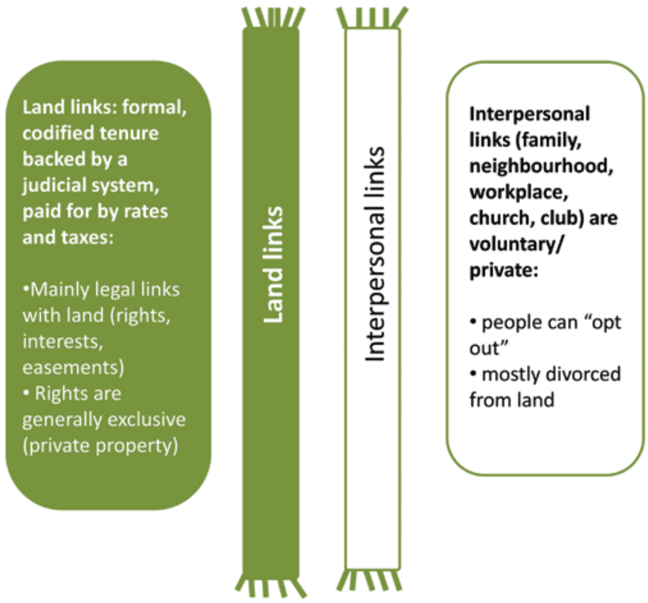

Figure 2: Western tenure as two separate strands.

Many issues connected with customary tenure can be traced to customary land being in transition, between a system where interpersonal links were inseparable from land links, and a system where land rights are treated in isolation. The following section considers in more detail some implications of separating the strands.

IMPLICATIONS OF SEPARATING THE STRANDS

This section focuses on some of the changes that may currently take place when 'separating the strands' of communal tenure.

Table 1. Changes observed when land passes from communal to individual tenure.

Rights -

Before separating the strands: Land rights are only secure if people remain part of an integrated community. A survival incentive exists to cooperate for hunting, cultivation, fighting etc.

After separating the strands: Land rights are secure even to uncooperative and antisocial individuals, and welfare benefits are an automatic right of citizenship (i.e. State security is more important to survival than either whakapapa or teamwork).

Duties -

Before: Duties to family, community (including retrospective and prospective community: ancestors and children), and the spirit world are bound up with rights to land. Survival is also tied to sound relationships with the natural world. E.g. narrative accounts of the Māori world implied not only rights but environmental cautions: the Taieri taniwha winding down the central Otago hills and wriggling through the plain is not just a water right but a caution about a captive monster capable of breaking out in flood.

After: Duties to family, community, posterity and also to the natural world become voluntary, personal and, with the direct link to survival removed, and sometimes excluded from busy schedules.

Authority -

Before: Discipline is possible because excommunication from the group is a real (possibly even fatal) threat.

After: Being able to 'opt out' dilutes traditional authority. National and local political leaders have more authority than cultural heads, and discipline becomes problematic without either the incentives of kinship and being needed, or the controls of ostracism/excommunication.

Group Membership and Land Management -

Before: Equitable benefits and group membership pass to all (i.e. no member of the group will ever be denied shelter and food) but management is passed either to individuals or families according to need, *mana*, *ahi kā* etc.

After: In the absence of a will, tenancy in common (established under the Maori Land Court) conveys not only joint land rights but management of that land. This often results in 'large committee' issues and inefficient utilisation. Bottom-line food and shelter benefits are tied to citizenship, not to the land.

Group Cohesion -

Before: Belonging groups share a common history and usually common ancestor/s, and comprise kinship units bound by love and affection.

After: Through treaty and naturalisation, nations are larger groups with more disparate members having diverse histories and experiences. Enhanced unity is sometimes brought about in times of war (and sometimes sporting contests), and conversely unity may be eroded by globalization. Strong cohesion is today found is typically associated with smaller groupings and blood lines (families) rather than tribes.

Collectively, these changes suggest that the breaking up of a communal mode of existence is not trivial. Holleman (a Southern African anthropologist) wrote the following lines about the breaking up of a communal mode of existence:

> If you have learnt to look upon a dunhu community not merely as a loose collection of individual people and families, but as something that grows and lives as a single organic body, you can understand why the headman cried that his country and people had 'died' when his villages were scattered over two or three different dunhus. It meant, indeed, that a living thing was snuffed out, or left helplessly bleeding to death (Holleman 1958:208).

This is echoed by a South African lawyer, who writes that:

> ... at the heart of the African socio-political order lay the family, a unit that was extended both vertically and horizontally to encompass a wide range of people who could be called 'kin'. This large, accommodating group

> provided for all an individual's material, social, and emotional needs, and loyalty to it was a cardinal value (Bennett 1995).

To be cast out of such a group is perhaps unimaginably appalling to most Westerners. Rian Malan tells the story of the 'hammer murderer' in South Africa who, like Maxwell (of the silver hammer in the Beatles song), commenced a succession of gruesome murders using a hammer. When apprehended, psychologists attempting to get to the bottom of this individual's fixation concluded that he had been cast out of his belonging group for an unforgiveable sin (the crime of incest; he married a first cousin, which was forbidden) and that, unwilling to take his own life but with life no longer worth living, he embarked on deliberate course to earn the death penalty (Malan 1990).

The strength of the belonging force was no different for Māori hapū (sub-tribes) in New Zealand, as shown by the following observation by a Maori interviewee:

> When the land was sold, and reserves were created, what actually happened was that families were crammed on the land and they soon realised it was too small. And they had to move away and break up the customary ways, to eke out a living … I think an awful lot of issues that affect the people arose from that time. The adjustment to that reality. The loss of their whole fabric of society was starting to break down. I think a lot of our ills come from there (Interviewee M6:5 in Goodwin 2008).

Dr. James Knight of the Otago District Health board is attempting to counteract some of those ills by contriving quasi-communities that 'reconnect antisocial individuals to wider society in more positive ways'. He writes that:

> … anatomically modern humans have been around for 200,000 years, and for most of that time we have probably lived in tightly knit kinship groups. I think human nature is designed for living in village-sized groups, and in those sorts of groups we maintain personal relationships with perhaps several hundred individuals, and how we maintain personal relationships with those individuals determines our fate. ... human survival is more or less contingent upon the extent to which humans are interconnected (Knight, 2007 & 2002).

The above comments give us a picture of a potent force binding communal groups, a force that is unleashed, as land tenure becomes more individualised, in a way that is almost reminiscent of splitting the atom. When considering moves to unlock MFL, or to balance better the productive and cultural uses of that land, developers, social engineers, politicians and law-makers need to factor this in.

MĀORI FREEHOLD LAND (MFL)

The scope of this article is now narrowed down to MFL, beginning with a summary of some key issues both for Māori right holders and for administrators of that land.

Frustrations of right-holders: The majority of MFL in New Zealand today is effectively managed by a large committee. Only 10% of titles have a single owner, the average is 62 owners per title and the highest 10% has an average of 425 owners each (Grant 2000). This leads to difficulties in gaining consensus, and can encourage 'passengers' seeking benefits but not prepared to work for these. This 'committee' management is at variance with original custom, where ornaments and heirlooms might be inherited[1] but where 'there was no system of succession to lands in general because of the communal nature of the title' (McHugh 1980:12), and management went to individuals or families. The proliferation of multiple owners also cuts across the *ahi kā* principle whereby there was an expectation of continued investment in land links even by absentees to 'keep the fire burning', and where failure to occupy would let that fire die out (McHugh 1980:6). In the opinion of some MFL right-holders, *ahi kā* has today been trumped by inclusivity, so that rights can now generally be retained passively. A common complaint was that of 'born again Māori' resurfacing when they perceived an advantage (Goodwin 2008). MFL right-holders also bemoaned the dilution of the *mahi* (work) principle in that today people can retain rights without work (or cash as symbolic of work). Another grievance is that of unsatisfactory access to MFL for many families who wish to maintain links with that land (e.g. planning regulations that permit no higher accommodation density than farmland), and the lack of income generating options from the land.

Frustrations for administrators: Regional authorities also voice frustrations over MFL, some of which appears untidy and poorly maintained and where there is frequently difficulty in contacting owners and gaining consensus. There is also significant defaulting on rate payments, with one reason being that the symbolic value of the land has endured while its practical potential for generating revenue has been eroded. The Local Government Act 2002 requires Local Authorities to adopt a policy on the remission and postponement of rates on Māori freehold land. Finally, with a possible connection to MFL, there is a disproportionately high level of Māori offenders and of welfare and health issues (Durie 1998). Mason Durie writes that 'young Maori are facing a greater range of health and mental health problems than at any time in the past' (Durie 2003:144), which raises the question of whether links with MFL can be used more effectively to foster a sense of self-worth and identity.

In short, a number of issues connected with MFL have been singled out as needing change of some form. A strong consensus of those interviewed (Goodwin 2008) pointed towards the fact that many right-holders of MFL now have access to other land for shelter (for example in urban centres), and to sustenance from off-land employment and from social services. Together these meet needs formerly met by customary land, and remaining MFL is therefore regarded by many as having a primary function of fulfilling cultural functions not met by formal, individualised tenure. However, a number of impediments stand in the way, including inadequate access opportunities for visits to renew links to MFL, and the inability of the land to generate adequate revenue to maintain it (e.g. fencing, and control of invasive plant species) and develop it (e.g. building *papakainga* housing, timeshares or camping grounds). This adds up to the conclusion that a key function of MFL today is to fulfill cultural functions not met by western tenure, and that revenue generation should, at least in some instances, not be a primary focus, merely play a secondary role of funding maintenance and development of the land (or part of the land) to better serve Māori right-holders. Three issues stem from this conclusion; first, technical issues, second, ways of optimising what formal tenure omits and third, funding. These are considered in order:

i) Technical issues (neutral) to do with improving management and decision making

The Māori Freehold Land Registration Project (MFLRP) was established in 2005 to meet registration requirements of Te Ture Whenua Māori Land Act[2] and to bring all MFL onto the formal register held by Land Information New Zealand (LINZ). Of a total of 27478 blocks of MFL (Tangaere, 2011), about 99% are now registered with LINZ (NZ Government 2010), with a few remaining blocks still being processed. This stands in contrast with the 2005/2006 position when 10139 blocks were unsurveyed (Tangaere 2011). With inputs from Google and Terralink, it is thus now possible to search Māori Land Online and to link a graphical representation of land with owners and interests, excluding non-registerable information such as Māori Land Court decisions, land use activities, some leases and encumbrances and histories of blocks (Tangaere 2011).

ii) Ways of optimising what the formal tenure system omits

As outlined above, needs for sustenance and shelter are now largely met by general land, commerce, and the State, and MFL has special importance in retaining some functions of land before the 'strands of communal tenure' were separated. In particular, MFL is still viewed as a place to visit for defining occasions such as birth, death and marriage, *ahi kā* still carries weight, *mahi* is still viewed as important in retaining rights, *tūrangawaewae* is still significant and intergenerational ties continue to be revered. Conceptually at least, it seems possible to institute a deliberate policy of maximizing the cultural use of the *taonga* portions of MFL as the locus for *tūrangawaewae*, reaffirming interpersonal but land-rooted belonging links, engaging in work/*mahi*, *mahinga kai* etc. It could also be a place for regaining an appreciation of survival through mutual dependence, re-establishing contact with the natural world, and fostering creativity.

iii) Funding

In one sense, fallow land is productive, for example as a wildlife species reservoir or for carbon sequestration. Even gorse, though vilified, may be viewed as a colonizer that, in the very long term, provides a nursery for native plant species. However, in brittle environments fallow land does not invariably improve and may even regress (Savory 1988), and a common frustration voiced by Māori right holders in interviews was that the land was hamstrung and for a variety of reasons could not be used to generate funds for paying rates bills and for development. A pragmatic stance was evident among Māori right-holders, with certain (not all) commercial enterprises being viewed as necessary, acceptable and as opportunities to exercise *kaitiakitanga* and to provide funds to maintain and develop the land while protecting its cultural functions. This leads on to the question of what options might be desirable and also practicable for MFL.

A DISCUSSION OF OPTIONS

McHugh gets to the root of the problem when he argues that MFL 'must be freed from the administrative disability caused by fragmentation yet the owners should still be able to retain their identification with the land' (McHugh 1980:35). One suggestion for doing this, from a Māori interviewee, was to set aside a symbolic square metre for *tūrangawaewae*, transfer all ownership rights to this symbolic *tūrangawaewae* 'patch' and free the rest of the block for leasehold or freehold. This suggestion carries an elegant simplicity, but glosses over some important details. For example, Māori irked by insufficient access possibilities to *taonga* (treasured) land are unlikely to be satisfied with merely symbolic rights to an arbitrary square metre. A more realistic option mooted by Strack and Rosie is to set aside a *whānau* or *hapū* centre such as a *marae* for *turangawaewae*, and to hold the rest of the land in trust (Strack and Rosie 2001). Rankilor (2011) provides details of how *wāhi tapu* and *wāhi taonga* could be separated from non-*taonga* land (see figure 3).

Figure 3: Categorising blocks of Māori land: Category 1, *Marae/Pa, ūrupa, tūāhu*; Cat. 2, Historic *Pa* sites, historic places; Cat. 3, Special features, karaka trees, rock outcrops, mountain tops, beaches, streams, rivers etc.; Cat. 4, Areas potentially needed to expand or enhance categories 1-3; Cat. 5, Balance Māori land (surplus) (Rankilor 2011).

Clearly, to realise such a plan in practice, changes would need to be orchestrated on a wide front including alterations to regional plans to permit higher concentrations of housing than are normally permissible on rural land[3] and taking a fresh look at rates rebates for heritage land and native bush areas (as species reservoirs and wildlife preserves, for instance). From a legal perspective, possibly tenancy-in-common could be retained for whole blocks but with access rights by co-owners limited to core *taonga* land. The most important requirement for the balance of the land would be to bring it under the management of fewer individuals. This might be achieved by the tried and tested devices of incorporations (Maori Land Court (Incorporations) (2002)) or else one of the trust options, in particular, *ahu whenua* and *whānau* trusts (ss214,215 Te Ture Whenua Maori, Maori Land Act; TTWMLA (1993); pp19-21 & 26,27, Māori Land Court (Trusts) 2002). Incorporations permit somewhat more flexibility than do trusts in respect of share redistribution. There is a legal requirement for an incorporation to keep a share register, but all that happens if shares are transferred is that the secretary for the incorporation makes a note of the change (Māori Land Court (Incorporations) 2002:17). In contrast, if shares in a trust are gifted or sold, an application for a share transfer needs to be submitted to the the Māori Land Court, signed by both parties to the agreement.

One further alternative that would be interesting to try is a more traditional management model, perhaps selecting individuals or families for extended leases using criteria of *mana*, *mahi, ahi kā*, need and strength of business plan. This might also succeed in bringing the remainder of land (which would remain MFL) under the management of fewer people, with a primary objective of generating revenue for the *taonga* component. The greatest challenge might be to gain consensus on questions such as 'who gets to use the land?', 'what for?' (especially given that a majority of the land is remote from markets) and 'where could working capital be sourced, if needed?'.

CONCLUSIONS

This paper suggests that, in separating the twin strands of communal tenure, shelter and sustenance have tended to be catered for by the individualised tenure sector, using General land, while MFL retains special importance for its embedded cultural functions. It therefore proposes a deliberate policy of maximising cultural functions of MFL as part of any moves to 'unlock' Maori Freehold Land, and suggests that this be achieved by separating out *taonga* areas of land and making provision for access, accommodation and future expansion. By one means or another, the less treasured parts of the land could then be brought under smaller management groups; either trustees, elected representatives of corporations or else individuals or families under a more traditional management model. It is seen as important that solutions be non-coercive, and further work is planned to gauge how acceptable this would be to Māori, through a variety of case studies.

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References

Bennett, T. W. 1995. *Human Rights and African Customary Law*. Cape Town, Juta.

Berry, S. 1993. *No Condition is Permanent: the Social Dynamics of Agrarian Change in Subsaharan Africa*. University of Wisconsin Press, Madison.

Chauveau, J.-P. and Colin, J-P. 2006. Changes in Land Transfer Mechanisms: Evidence from West Africa. *In*: Cotula, L. (Ed), *Changes in 'Customary' Land Tenure Systems in Africa*. Rome, FAO.

Cotula, L, (Ed). 2006. *Changes in 'Customary' Land Tenure Systems in Africa*. Livelihood Support Programme (LSP) Working Paper: Access to Natural Resources Sub-Programme. Rome, FAO.

Cotula, L., Vermeulen, S., Leonard, R., and Keeley, J. 2009. *Land Grab or development opportunity? Agricultural investment and international land deals in Africa*. London/Rome, FAO, IIED and IFAD.

Cousins, B., Weiner, D. and Amin, N. 1992. Social Differentiation in the Communal Lands of Zimbabwe. *Review of African Political Economy*, 53: 5-24.

Cousins, B. 2007. More Than Socially Embedded: The Distinctive Character of 'Communal Tenure' Regimes in South Africa and its Implications for Land Policy. *Journal of Agrarian Change*, 7(3): 281-315.

Deininger, K., and Binswanger, H. 1999. The Evolution of the World Bank's Land Policy: Principles, Experience, and Future Challenges. *The World Bank Research Observer*, 14(2): 247-76.

Durie, M. 1998. *Te Mana, Te Kawanatanga. The Politics of Maori Self-Determination*. Oxford University Press, Auckland, New Zealand.

Durie, M. 2003. *Launching Maori Futures*. Huia, Wellington.

Goodwin, D. P. 2008. Belonging knows no boundaries: Persisting land tenure custom for Shona, Ndebele and Ngāi Tahu. PhD Thesis, Departments of Anthropology and Surveying, University of Otago. 428pp.

Grant, J. A. 2000. Maori Land Development: Survey and Title., Department for Courts, Te Tari Kooti. August 2000.

Holleman, J. F. 1958. *African Interlude*. Nasionale Boekhandel BPK, Cape Town.

Hutchings, C. 2006. Unlocking Maori Land. *Te Karaka* 2006 (Winter/Makariri): 22-27.

Knight, J. 2002. Antisocial Behaviour: A Developmental Perspective. M.Sc Thesis, University of Otago.

Knight, J. 2007. Personal communication following his address to the Ashburn Psychiatric Clinic on 12th November, 2007.

Malan, R. 1990. *My Traitor's Heart*. Vintage, London.

Maori Land Court (Incorporations), 2002. *Maori Incorporations, a guide*. Ministry of Justice, Wellington.

Maori Land Court (Trusts), 2002. *Maori Land Trusts, a guide*. Ministry of Justice, Wellington.

McHugh, P. G. 1980. *The Fragmentation of Maori Land*. Legal Research Foundation Inc., Auckland.

McRae, J. A., and Baldwin, A.J. 1997. Title to land: its origins and development of the land transfer system. In: *Law for Surveyors*, Chapter 3. Department of Surveying, University of Otago; New Zealand Institute of Surveyors, 77pp.

Metge, J. 1976. *The Maoris of New Zealand Rautahi*. Routledge and Kegan Paul, London.

NZ Government, 2002. Local Government Act 2002.

NZ Government, 2010. Project draws to a successful close. Retrieved 14th June, 2011, from http://www.beehive.govt.nz/release/project-draws-successful-close.

Rankilor, David, 2011. Presentation to the New Zealand Institute of Surveyors' hui on Māori land tenure. Rotorua, 14 and 15 February, 2011.

Savory, A. 1988. *Holistic Resource Management: A New Framework for Decision Making*. Gilmour, Harare.

Strack, M., and Rosie, D. 2001. Maori Land: Kicking around the Football. *New Zealand Surveyor* 291 (April): 15-19.

Tangaere, J. 2011. Presentation on the Maori Land Court to the New Zealand Institute of Surveyors hui on Māori land tenure. Rotorua. 14th and 15th February, 2011.

Te Pouwhenua, 2005a. Registration Project underway. TE POUWHENUA, Te Kooti Whenua Maori, April (28): 6-7.

Te Pouwhenua, 2005b. Update on the Maori Freehold Land Registration Project. TE POUWHENUA, Te Kooti Whenua Maori, December (31): 3, 5, 6.

Te Pouwhenua, 2007. Update on the Maori Freehold Land Registration Project. TE POUWHENUA, Te Kooti Whenua Maori, January (37): 5.

TTWMLA 1993. Te Ture Whenua Maori, Maori Land Act, New Zealand Government. 4/1993.

Vanuatu land boom. http://www.youtube.com/watch?v=5g5kFi-_zcw Journeyman pictures. Accessed 20th June, 2011.

Vijfhuizen, C. 2002. *The People you Live With: Gender identities and Social Practices, Beliefs and Power in the livelihoods of Ndau women and men in a village with an irrigation scheme in Zimbabwe*. Weaver Press, Harare.

Ward G R & Kingdon E, Ed. 1995. *Land, Custom and Practice in the South Pacific*, Cambridge University Press.

Williamson, I., P. 2001. Land Administration 'Best Practice': providing the infrastructure for land policy implementation. *Land Use Policy* 18(4): 297-307.

(Endnotes)

1 Cf. Shona custom where moveable possessions such as a knobkerrie or tsvimbo (walking stick) could be inherited, some having a symbolic burden, but where land rights remained vested in a tribal or sub-tribal group (Goodwin, 2008:355).

2 e.g. s17 and Part V, TTWMLA; Te Pouwhenua, 2005a, 2005b, 2007; NZ Government, 2010.

3 For example, Rapaki, on the Lyttleton harbour, has worked very successfully with Regional Authorities over papakainga housing.

USING AND STOPPING UNFORMED LEGAL ROADS

Abstract This paper describes the role of unformed legal roads (paper roads) in providing for public access to and through land. With increasing demands for more access to land, the Walking Access Commission has identified unformed roads as a convenient and secure way of enhancing public use of land for access. The new mapping system (WAMS) provides an effective way of informing the public and promoting access. But adjoining land proprietors may seek to stop these roads to acquire private control of them and councils may wish to dispose of them as surplus to requirements. A recent Environment Court ruling examines the arguments for and against stopping unformed legal roads, and determines that such decisions should not be based on reasons for stopping, but on potential public benefits of retention.

Keywords Walking access, road stopping

INTRODUCTION

Roads provide a vital physical link between people and the land. The communication and movement needs of our society have always been of paramount importance. 'Rural roading is the historical foundation of rights of access to the outdoors in New Zealand, and appropriately, the Crown has always been its guardian' (Hayes 2008:140). In the early years of settlement when land parcels were granted (and most particularly in relation to Maori land parcels), provision was made for land to be taken for roads without requiring compensation. Furthermore, roads are readily taken under the Public Works Act 1981, being perhaps the least contentious public work. The requirement to extend public access continues in the provisions to set aside Marginal Strips under the Conservation Act 1987 and Esplanade Reserves under the Resource Management Act 1991 (again without compensation), and in developing government policy and legislation like the Walking Access Act 2008. Generally, roads are the most permanent land use category, and they are not easily stopped or disposed of in spite of the stopping process established under the Local Government Act 1974. A recent Environment Court decision in Central Otago has reiterated the legal priority of the public interest in roads which contributes to public access to and through land.

UNFORMED LEGAL ROADS FOR ACCESS

There is an extensive network of unformed legal roads (often colloquially referred to as paper roads) throughout New Zealand: by the reckoning of the Ministry of Agriculture and Forestry (MAF), about 56,000 kilometres of them (Hayes 2008). This amounts to 112,000 hectares. Most of this area will be occupied and used by adjoining landowners, providing a significant windfall benefit for those proprietors – free use of land, not subject to rates charges. Since an amendment of the Counties Amendment Act 1972, this land is vested in the territorial authorities, but they are usually relieved of the practical duty of caring for that land – they have no responsibility to form such roads, and only vaguely defined responsibility to keep them clear of obstructions. Unformed legal roads, therefore, have significant value attaching to them, and while it may be convenient for the landowner to support the *status quo* and retain the unencumbered use of the land, it is possible that local authorities could capitalise on the land value, undertake to stop these roads, and sell the land to adjoining owners. However, the difficulty of this course of action is that unformed legal roads provide a very valuable public access resource in the current era of calls for more public access to and through public and private land.

The Walking Access Commission is charged under the Walking Access Act 2008 to promote walking access to public land that is free, certain, enduring and practical. One of the major issues identified in previous public consultation[1] was the problem of identifying public land that could be utilised for walking access. This was partly a mapping problem – there were no maps that satisfactorily distinguished between public and private lands. The Commission has therefore established a Walking Access Mapping System[2] (WAMS) to serve the public need to identify public access. This system overlays cadastral, topographic, and photographic data and usefully illustrates the legal status of land, the nature of the topography, land occupation and use,

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and the nature and extent of any formation. From a survey point of view this is hardly accurate in defining boundaries between private land and a legal road, and the use of handheld GPS, while being a useful approximate guide, is not decisive in differentiating between public and private, but it does illustrate the existence of legal access routes.

Unformed Legal Roads become very obvious on the WAMS and indeed they have been identified by the commission as the most productive way to enhance public access. The legal rights over this land are exactly the same as for any formed road. The public have the right to pass and repass for unobstructed access (Hayes 2007: 4). Now that the public can more conveniently identify the existence of an unformed road across open farmland, there is every chance that user conflicts will escalate. Farmers, who to date have probably enjoyed uninterrupted use of the road, will perhaps feel that their farming operations (safety of stock and equipment) are threatened, while assertive countryside walkers, newly aware of their public rights, may more aggressively assert their rights of access. The Walking Access Commission has therefore also prepared a Code of Conduct to guide appropriate and considerate behaviour by everyone. This code is sensible and logical, and provides useful advice about rights and responsibilities. Even more practical, concise and relevant to actual behaviour while enjoying outdoor recreation is the Department of Conservation's New Zealand Environmental Care Code.[3] Application of, and compliance with both these codes should mitigate potential conflicts.

Rural proprietors have enjoyed the benefits of the use of unformed legal roads through their land, and have often expected that that longstanding occupation and management of the land has developed into a set of exclusive or protected rights, but recent legal and policy clarifications have dispelled such expectations. However, that is not to say that farmers do not have legitimate and understandable concerns about freeing up and indeed promoting public access over unformed legal roads. Such roads may have been imperfectly delineated in early compass and chain surveys, so their actual location may indeed be doubtful. They are unlikely to be identified on the ground by survey pegs or even fences. They are also very likely to pass over difficult terrain and not correspond to convenient pathways. The intrusion of the public onto these lands may well disrupt farming operations. Stock may be disturbed, fences may obstruct access and be damaged when crossed, there may be bio-security risks from invading organisms, and rubbish and debris may be left behind. For all these reasons several attempts to have such roads stopped have come before the Environment Court: a recent example follows.

STOPPING UNFORMED LEGAL ROADS – THE CENTRAL OTAGO CASE

In a recent Environment Court case; *In re Central Otago District Council,* the Court heard an appeal by a party interested in outdoor access – Central Otago Recreational Users' Forum (CORUF), against a district council decision to stop an unformed road traversing Moutere Station just north of Alexandra. It is informative to examine the issues and arguments made both for and against the stopping.

Presumably, the Moutere Station applied for the stopping of several roads in order to formalise their longstanding use and occupation of the roads. This would allow them to purchase the road reserve from the council, formally incorporate the land into the farm, and be assured of the privacy and protection of the farming operations on that land. Among the claimed private benefits were included; the integrity of farming operations especially the separation of groups of animals; the ability to exclude biosecurity risks; the protection of stock from disturbance (e.g. the risk of mis-mothering); and the reduction of fire hazard caused by smoking by potential users.

The council defended their decision to stop the road by asserting that it would rationalise the regional roading infrastructure; remove council responsibility for maintenance (e.g. weed control); and provide some income from the sale of the land to the adjoining proprietor.

The Council followed the process for road stopping as set out in the Tenth Schedule of the Local Government Act 1974; having a survey plan prepared showing 'Road to be Stopped'; providing justification for the road stopping including provision of alternative access; notifying affected parties; and advertising (on the land and in public notices) the intention to stop the roads. The council considered that the roads in question were no longer a necessary part of the roading network; the road in question was never used; no one would be denied access to their property; the council would never form the road; there were appropriate alternatives for recreational users; and other land could better provide for recreational needs. The council subsequently confirmed a decision to stop the roads.

The access group (CORUF) objected to the stopping, and it was referred to the Environment Court to confirm or decline the road stopping proposal. In the event, there seemed to be some uncertainty about which roads were included in the objection, so two sections of road stopped by the council were not considered and they remain stopped. The remaining section of road therefore needed examination by the Court.

The approach of the court followed precedent,[4] but is particularly instructive now that there is such a strong policy-driven focus on the use of unformed legal roads to cater for the increasing demands for more and better public (walking) access to the outdoors. In spite of all the logical reasons and benefits accruing to both the council and the adjoining proprietor for the road stopping, the Court made it quite clear that 'the issue is the need for the road, not the stopping' (para15), and:

> 'Therefore the effects of the road on the operations of [the adjoining proprietors] are of little relevance in the

consideration of this road stopping. If there is a reason and purpose for the road to remain, then an inconvenience to them is not the Court's concern. The roads themselves are the important consideration and for the road stopping to be appropriate those roads must be able to be seen as serving no public purpose.'[5]

In response to the various arguments that were brought to support the stopping, the Court decision has highlighted the following issues:

Lack of past use. It is likely that most unformed paper roads are used and occupied by adjoining owners; they are likely to be fenced off and apparently as publically inaccessible as the surrounding private property. For this reason, non-use in the past is to be expected, especially given the barriers to access; the land presents as if it is private, with no ground marking or other evidence of its public character, and therefore "there is no indication of any public right of users" (para 27), and a lack of readily available public records to indicate public rights. The record now available, notably the online WAMS, has highlighted these public roads, both for the benefit of the public user, and also to the apparent concern of the adjoining owners. Thus, future use patterns are likely to be very different from past use.

Access to property. There is every likelihood that all adjoining 'ownership blocks'[6] have practical, reasonable and legal access,[7] so the stopping of an unformed legal road through the land will have little impact on other ownership blocks, and the council may consider that therefore, an unformed legal road serves no purpose. That situation may change, however, in the future, if or when individual parcels or titles within an ownership block are separated from the block in some future subdivision.

Rationalising council roading infrastructure. Council responsibility for its roading network is a considerable concern for most district councils. For example, it was stated in this case that roads accounted for 21.5% of the council's budget (para 31). It is unlikely that council will consider adding to that burden by forming more roads, unless there is a strongly identified need. Unformed legal roads usually do not unduly burden councils; 'expenditure on unformed roads is confined to addressing issues relating to access when they are raised by road users or ratepayers and spraying noxious plants when these are identified by the Otago Regional Council' (para 32). Furthermore, the value of the stopped road is likely to be relatively low and will not contribute significantly to council income (in this case the proposed stopped road was worth $12,000). There would only be one possible purchaser of the land, and while that purchaser may have increased security of tenure over the road space and enable the owner to enforce his/her exclusive use, it would merely confirm and settle the existing (informal) use and occupancy, and contribute little to the farming operation's financial position. A council's evidence about the need for, or likelihood of, future formation is irrelevant to retaining the road for walking access. It may be argued that too much access may impose too high a cost on councils, but in most situations the cost is not high and 'the public benefit of retaining the road for recreational purposes is greater than the public cost of doing so' (para 44).

Recreational use of the road. Roads remain the most secure way to provide for public rights of use and passage – more secure than walkways, marginal reserves, easements, and the like. Formed roads serve vehicular traffic well, but are often dangerous, noisy, and far from relaxing for a walker. The outdoor walking access experience is usually enhanced by being in natural surroundings (open grasslands, or varied green landscapes – i.e. on unformed legal roads) rather than built environments, although some level of amenity may be beneficial (including boardwalks, stile, and trimmed vegetation). Except where unformed roads are draped over very intimidating landscapes (like canyons, cliffs, swamps), there is every likelihood that they will provide for recreational use, especially so if they link to other accessways, lead to special places or form a convenient recreational circuit. It is the unformed road network that provides the best opportunities for walking access (a point made clear by the Walking Access Commission's policy). The availability of alternative routes, that may suggest that a road is non-essential and should be stopped, is not necessarily an argument to support stopping – in fact, as the Environment Court highlighted in this case, the existence of choice and variety of routes may protect and enhance the public purpose by adding to 'the variety of opportunities available, particularly for those seeking gentler exercise off formed roads and in a clearly rural setting' (para 42).

Negotiating new road alignments. It is certainly true that many unformed legal roads may not provide the most direct, convenient or easiest route through the land, and it may be possible for landowners to provide more convenient routes (for both the land owner and for public passage) in exchange for stopping an inconvenient route. This would be acceptable when the road alignment could be shifted from a position bisecting a working landscape to a perimeter alignment especially if the way was more user friendly, and entry, exit and way points were more conveniently traversed, but this would best be achieved by negotiation with local interested parties to avoid objections to any road stopping. There are also many routes and places to get to (landmark features, viewing sites, or places of historic or scientific interest), which are not accessible by the existing road network. If proprietors can offer additional access through their land to such sites, then they may think they have a bargaining tool to facilitate the stopping of other roads. However the Court may not accept such an exchange if there appears to be too great a separation between what is being gained and what is being lost, and again if there is any objection then the court has no power to enforce or offer alternatives, make deals, or impose conditions (para 45) when confronted with a road stopping case. This concept of environmental compensation (e.g. accepting some compromise to public access in return for the provision of more valuable access elsewhere) is similarly beyond the scope of the court's jurisdiction although it may feature between owners, councils and public stakeholders. Indeed the Walking Access Commission reports that this type of negotiated exchange is often done. In the Ruapehu District, in substitution of an overgrown unformed legal road, a landowner has provided practical access that is acceptable for the farming operations, serves the public need, and the Walking Access Commission has funded construction of a stile and access signs (NZWAC 2011b). Such alternative access is, however, not protected by any mechanism within the title, so cannot be viewed as providing any legal rights or adverse possessory claims.

CONCLUSION

In response to the arguments discussed above, the Court reversed the council's decision to stop the unformed legal road. Recent decisions of the Environment Court, including the case described herein, indicate that it is unlikely that any stopping of unformed legal roads will be successfully applied if any objector can support the future utility of the road for recreational use, even if vehicular use will never be available. In other words, it does not matter if the road has never been used before, the Court will protect the public roading infrastructure despite landowner or council desires to stop roads.

Unformed legal roads will continue to be promoted by NZWAC to enhance public access to the outdoors. Roads are increasingly likely to be further protected in the future for the recreational benefits they can provide. Free, certain, enduring and practical access is likely to be further enhanced.

References

Hayes, B.E. 2007. *Roading Law as it Applies to Unformed Roads*. Policy Publications MAF. Wellington.

Hayes, B.E. 2008. *Roads, Water Margins and Riverbeds: The Law on Public Access*. Faculty of Law University of Otago, MAF. Dunedin.

Land Access Ministerial Reference Group. 2003. Walking Access in the New Zealand Outdoors. MAF Policy. Wellington.

NZWAC. 2011a. New Zealand Walking Access Commission. *Guidelines for the Management of Unformed Legal Roads*. NZWAC. Wellington. 2011.

NZWAC. 2011b. New Zealand Walking Access Commission. *News* No 6. July 2011. "River access agreed in Ruapehu District."

Walking Access Consultation Panel. 2006. Outdoor Walking Access Consultation Document. MAF. Wellington.

Case Law:

In re Central Otago District Council. [2010] NZEnvC 364

Re an application by Waitaki District Council C74/2006

Proposal by Matamata County Council [1998] NZTA 411

New Zealand Legislation

Conservation Act 1987 No 65 (as at 01 April 2011), Public Act.

Counties Amendment Act 1972 (since repealed).

Local Government Act 1974 No 66 (as at 20 June 2011, Public Act.

Public Works Act 1981 No 35 (as at 01 May 2011), Public Act.

Resource Management Act 1991 No 69 (as at 01 October 2011), Public Act.

Walking Access Act 2008 No 101, Public Act.

(Endnotes)

1 Land Access Ministerial Reference Group 2003, and Walking Access Consultation Panel 2006.

2 http://wams.org.nz/wams/

3 http://www.doc.govt.nz/upload/documents/parks-and-recreation/plan-and-prepare/environmental-care-code/environmental-care-code-checklist.pdf

4 Previous Town Planning Appeal and Environment Court cases have reached similar conclusions. E.g. *Proposal by Matamata County Council* 1998 and *Re an application by Waitaki District Council* 2006.

5 Para 17 – quoting *Re an application by Waitaki District Council* C74/2006

6 Land held under single ownership which may nevertheless be in multiple parcels and/or multiple titles.

7 If that was not the case then the Property Law Act provides a remedy for landlocked land.

THE IMPACT OF THE 2010 DARFIELD (CANTERBURY) EARTHQUAKE ON THE GEODETIC INFRASTRUCTURE IN NEW ZEALAND

Abstract On 4 September 2010 a magnitude ~7.1 earthquake struck 30 km west of Christchurch near Darfield in the South Island of New Zealand. This was, then, the most damaging earthquake to affect New Zealand in almost 80 years. The earthquake produced a ~30 km long surface rupture with up to 5 m of horizontal displacement and 1 m of vertical movement. The shallow depth of the earthquake produced some of the strongest ground shaking ever recorded in New Zealand and resulted in areas of liquefaction and severe ground damage locally.

The area affected by land movements greater than a decimetre consists of the flat alluvial plains of Canterbury and includes the city of Christchurch and several smaller surrounding towns. The rural area is highly developed with peri-urban lifestyle blocks and intensive rural farming. The ground deformation associated with the earthquake caused damage to utilities such as water and sewerage, particularly in areas of liquefaction, and has had a major impact on the cadastre, especially near the fault rupture. Changes in levels have also raised concerns about the potential hazard of increased flooding due to the low lying nature of the topography.

The earthquake has also had a major impact on the geodetic infrastructure used to fix the positions of cadastral boundaries, utilities and flood management projects. Geodetic surveys were undertaken immediately following the earthquake and in the subsequent months to quantify the ground deformation caused by the earthquake, and its impact on the geodetic and cadastral infrastructure in the area.

Subsequent major earthquakes in the Christchurch area on 22 February 2011 and 13 June 2011 resulted in further movement of the geodetic infrastructure.

Keywords Darfield Earthquake, geodetic infrastructure

INTRODUCTION

Canterbury (Darfield) earthquake

The Canterbury region of New Zealand's South Island experienced a magnitude 7.1 earthquake on 4 September 2010. The earthquake was centred near the town of Darfield, about 40km west of Christchurch, the South Island's main city (Fig. 1). Christchurch, with a population of 390,000, is the second largest city in New Zealand. The Canterbury region surrounding Christchurch is principally alluvial plains with small townships as residential commuter towns for Christchurch or supporting agricultural or horticultural activities on the Canterbury plains.

The depth of the earthquake was relatively shallow at about 10 km. It caused substantial damage to property and

Figure 1. Location of Greendale fault and the CORS station MQZG relative to Christchurch City

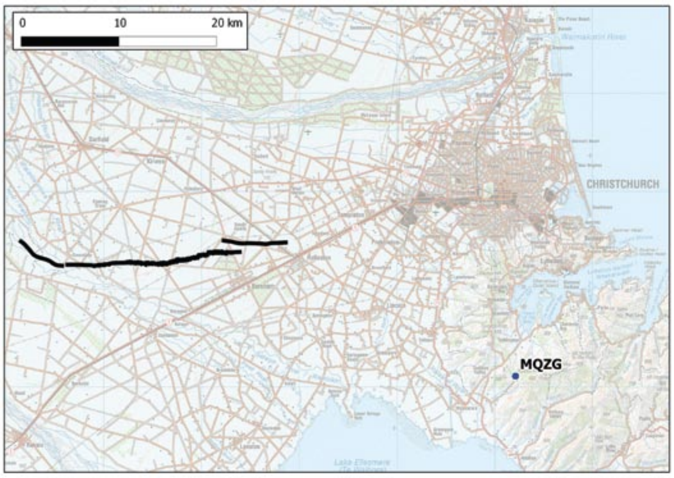

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Figure 2. Trace of the Greendale fault displacing a water canal (Photograph by: Richard Jongens, GNS Science)

infrastructure, but no loss of life. Across parts of Christchurch, liquefaction caused localised areas of subsidence and lateral spreading. The earthquake occurred in an area that has previously had few earthquakes relative to other parts of the South Island. A fault rupture associated with the earthquake, named the Greendale fault (Figs 1 and 2), occurred along a previously unknown fault and resulted in a surface rupture of several metres in an east-west direction.

On the 22 February 2011, the city was hit by the Christchurch earthquake, and on 13 June 2011 by yet another large aftershock. These earthquakes, both 6.3 on the Richter scale, are considered to be aftershocks of the Darfield quake. Although smaller in magnitude than the Darfield earthquake, their locations very close to Christchurch resulted in massive property damage and loss of life. Particularly notable with these events were the extensive areas of liquefaction and ground damage.

The New Zealand Geodetic Infrastructure

New Zealand lies across the obliquely convergent Australian and Pacific plate boundary. In addition to the plate motions, New Zealand experiences the effects of other deformation events such as large earthquakes, volcanic activity, and more localised effects such as landslides. To accommodate the effect of crustal motion, Land Information New Zealand (LINZ) implemented a semi-dynamic datum, New Zealand Geodetic Datum 2000 (NZGD2000), in 1998 (Blick et al. 2003). This datum includes a deformation model to convert geodetic observations made at different times to a common reference epoch of 1 January 2000 to accommodate the effect of crustal kinematics. The impact of events such as the Darfield earthquake are managed using a patch (Jordan et al. 2007) to ensure that the effects of the earthquake can be modelled and the accuracy of the datum maintained.

The New Zealand Survey Control system is divided into a number of networks, each of which serves a different purpose (Donnelly and Amos 2010). LINZ also maintains a national global navigation satellite system (GNSS) network of 34 continuously operating reference stations (CORS) which is used to monitor the kinematics of New Zealand and provide real time positioning services to users.

New Zealand cadastral boundaries are defined by survey. For about 70% of parcels, principally in urban and peri-urban areas, the cadastre is connected to the geodetic network and is referred to as survey-accurate – this could be termed a geodetic cadastre. Geodetic, cadastral and title data are managed in an automated digital database called Landonline (www.landonline.govt.nz). Landonline is an observational database that enables the readjustment of coordinates as new or improved data come to hand.

Since the introduction of NZGD2000 there have been substantial earthquakes that have compromised the accuracy of the datum. However, to date these earthquakes have been located in isolated parts of the country, where population levels are so low that substantial efforts to re-establish the control system have not been deemed necessary.

The Darfield and two Christchurch earthquakes changed this, centred as they were in a major agricultural area and city. Thousands of geodetic marks and millions of cadastral marks are estimated to have moved by significant amounts.

This article outlines the impact of the Darfield earthquake on the spatial accuracy of the geodetic infrastructure and cadastre and the steps that were proposed to update their accuracy. It briefly comments on the effects and implications of the more recent Christchurch earthquakes.

PRE AND POST EARTHQUAKE SURVEYS

An extensive network of geodetic survey marks existed prior to the earthquake across the Canterbury region. Donnelly et al. (2011) provide detailed descriptions of the surveys undertaken pre and post earthquake.

Pre-earthquake high accuracy survey data from the 1990s were collected as part of the establishment of NZGD2000. A particularly dense network of marks was available across Christchurch city. In addition, one of the LINZ CORS stations (Fig 1) operated close to Christchurch. These data were supplemented by data collected from other agencies including private surveyors.

An immediate post-earthquake survey was undertaken by GNS Science to determine the extent and magnitude of co-seismic displacements. The data were used to determine the initial extents of both horizontal and vertical deformation associated with the earthquake. This and differential Interferometric Synthetic Aperture Radar InSAR data were used to determine a preliminary source model for the earthquake (Beavan et al. 2010). The results showed that the deformation resulting from the earthquake was able to be well modelled by displacement occurring on the strike-slip Greendale Fault and several other fault segments (Fig. 3).

Once subsequent surveys confirmed that post-seismic movement was subsiding, work commenced on more

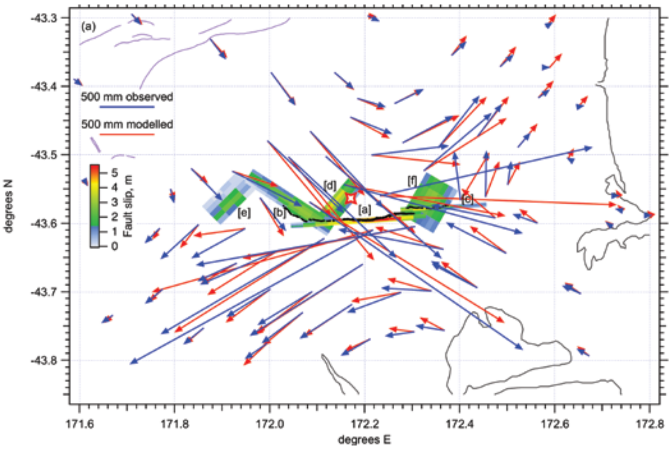

Figure 3a. GPS observed (blue) and modelled (red) horizontal displacements. The black line shows the mapped extent of the Greendale fault surface rupture and the red and white four-pointed star shows the epicentre. The coloured image shows the projection to the Earth's surface of the preliminary fault model. The model consists of slip on the Greendale Fault (labelled a, b and c) plus three thrust segments on NE-orientated planes (labelled d, e and f). [From Beavan et al. 2010]

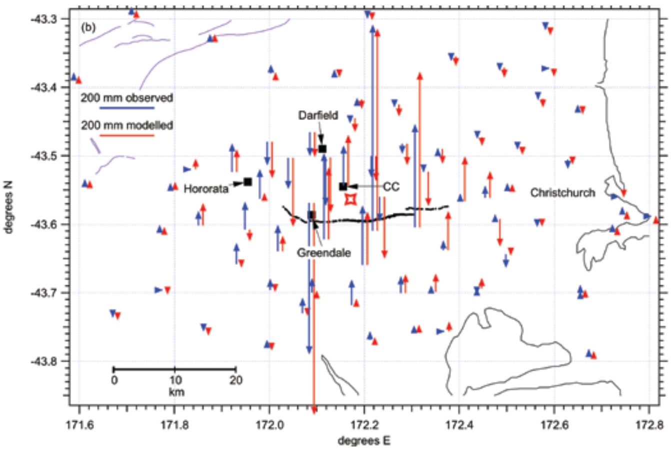

Figure 3b. GPS observed (blue) and modelled (red) vertical displacements. CC is Charing Cross. [From Beavan et al. 2010]

extensive surveys by LINZ to resurvey 190 marks which comprise the LINZ existing 1st to 4th order networks across the affected area. Control for this survey was provided by the marks surveyed during the earlier deformation survey by GNS Science. Displacements derived from this more extensive survey are shown in Figures 4 and 5.

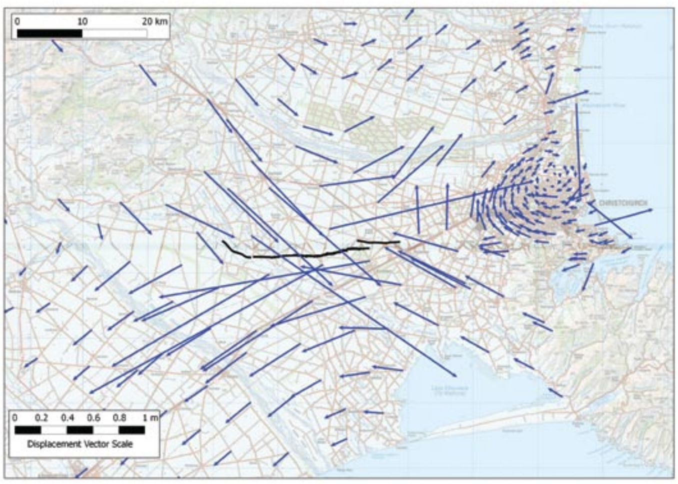

Figure 4: Horizontal displacements in Canterbury resulting from the Darfield earthquake

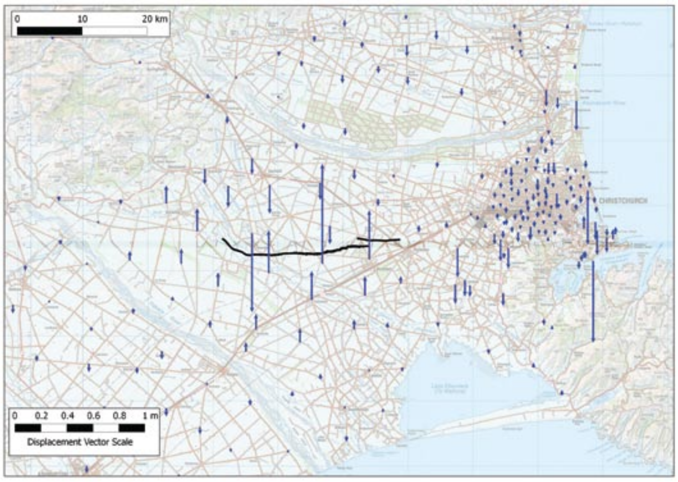

Figure 5: Vertical displacements in Canterbury resulting from the Darfield earthquake

IMPACT ON THE GEODETIC SYSTEM

The survey results indicated horizontal displacements of up to 0.1 m at 50 km from the epicentre. Close to the Greendale fault, horizontal movements of nearly 2 m and vertical movements of nearly a metre were measured. Across Christchurch the movements showed a generally systematic pattern, but some marks showed anomalous movements, both vertically and horizontally. These marks were generally located in areas where localized mark disturbance was suspected to have occurred due to liquefaction.

The numbers of geodetic and cadastral marks affected by ground movements as a function of distance from the earthquake epicentre are summarised in Table 1. Over a million geodetic and cadastral marks were affected within 60 km of the earthquake epicentre where significant ground movements occurred.

Distance from Earthquake epicentre (km)	Geodetic marks (order 5 or better)	Cadastral control (order 6 or better)	Total marks (geodetic and cadastral)
20	223	4816	56835
40	1492	54354	622727
60	4668	82986	1010333
80	5341	86667	1153926
100	5828	88849	1257921

Table 1: Number of geodetic and cadastral marks as a function of distance from the earthquake epicentre

UPGRADING THE GEODETIC AND CADASTRAL NETWORKS

Resurveying the large number of geodetic and cadastral marks affected by the Darfield earthquake is unrealistic and for the most part the effect on mark coordinates can be derived from the updated deformation model

The differences between the observed displacements and those calculated from the early fault model are shown in Figure 6. The model provided a good fit (except close to the Greendale fault and in Christchurch) with residuals of a few centimetres.

It is expected that these could be reduced significantly by further refinement of the model, and by empirically adjusting the calculated deformation in areas where there is a clear systematic error in the modelled deformation. This work is expected to be completed towards the end of 2011. The model could also be enhanced with additional survey data, in particular near the fault.

Using the refined model it should be possible to account for most of the displacement measured at the surveyed marks – it is expected that at least 90% of the geodetic and cadastral marks could be spatially upgraded using the displacement model. This approach offers some significant advantages:

- substantial cost reduction through upgrading the spatial position of marks without resurveying a large number of marks
- quicker to re-establish spatial position of marks
- update geodetic and cadastral coordinates together
- update would all be done at once thus reducing confusion of partially updated datasets

Figure 6: Residual displacements after observed horizontal displacements corrected for displacement model.

Areas close to the fault and areas of non-uniform deformation (liquefaction) where the model did not fit would require additional survey. These plans were well advanced until the Christchurch earthquakes struck the city on 22 February 2011 and 13 June 2011.

EFFECT OF THE CHRISTCHURCH EARTHQUAKE

Following the Christchurch earthquakes in February and June, extensive surveys were again undertaken to quantify the extent and magnitude of ground deformation. It was clear that there were more extensive areas of non-uniform deformation and that to use the displacement model to spatially correct positions of geodetic and cadastral survey marks for this event would be considerably more difficult.

At the time of writing this paper the extent to which these two Christchurch earthquakes can be modelled is still being

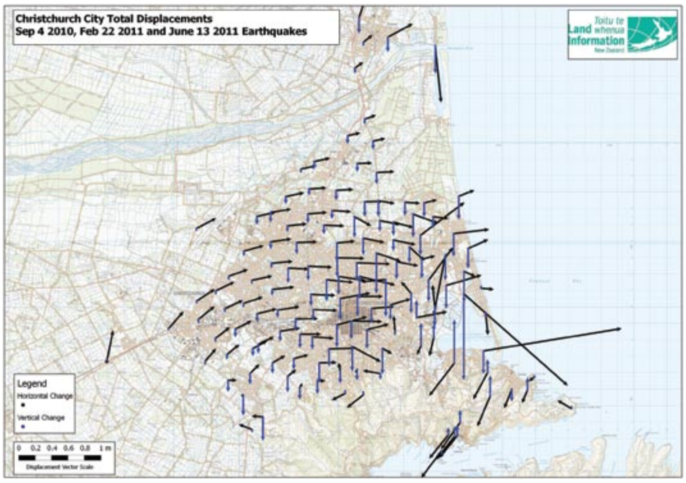

Figure 7: Horizontal (black vectors) and vertical (blue vectors) displacements in Christchurch resulting from the 4 Sep 2010, 22 Feb 2011 and 13 June 2011 earthquakes

analysed. However it is likely that it will not be as successful as for the Darfield earthquake and more actual resurvey of the geodetic and cadastral networks will be required. Detailed geodetic surveys will commence in early 2012, subject to there being no further substantial earthquakes.

CONCLUSIONS

The Darfield earthquake had a major impact on the geodetic and cadastral infrastructure across the Canterbury region. A deformation model has been developed that will be used to correct the spatial position of perhaps 90% of geodetic and cadastral marks affected by the earthquake. Areas close to the Greendale fault and where localised liquefaction occurred will require further surveys to be undertaken to correct for localised damage.

The effects of the more recent Christchurch earthquake may be more difficult to model because of the more extensive localised ground damage across Christchurch. Here, it is likely that more extensive surveys will be required to correct for the effects of this smaller but more damaging earthquake.

REFERENCES

Beavan, J., Samsonov, S., Motagh, M., Wallace, L., Ellis, S., and Palmer, N. 2010, The Darfield (Canterbury) Earthquake: Geodetic Observations and Preliminary Source Model, *New Zealand Society for Earthquake Engineering Bulletin*, Vol 43, No 4, December 2010, pp 228-235.

Blick, G., Crook, C., Grant, D., and Beavan J. 2003, Implementation of a Semi-Dynamic Datum for New Zealand. International Association of Geodesy Symposia, A Window on the Future, Sapporo Japan. Published by Springer, vol 128. 38-43.

Donnelly, N., and Amos M. 2010, *Implementation of a New Survey Control Standard for New Zealand,* in Proceedings of XXIV FIG Congress, April 11-16, Sydney, Australia. Available at: http://www.fig.net/srl/.

Donnelly, N., Ritchie, J., and Amos, M. 2011, *Re-establishment of the New Zealand Survey Control System following the 2010 Darfield (Canterbury) Earthquake*, in Proceedings of FIG Working Week, May 18-22, Marrakech, Morocco. Available at: http://www.fig.net/srl/ .

Jordan, A., Denys, P., and Blick, G. (2007) Implementing localized deformation models into a semi-dynamic datum, *IAG Symposium* Vol 130, Dynamic Planet, Cairns, Australia.

THE TRANS TASMAN RECIPROCAL RELATIONSHIP FOR CADASTRAL SURVEYORS

Abstract There is world-wide interest in the mutual recognition of surveying qualifications. Australia and New Zealand have had an effective system of mutual recognition for cadastral surveyors in place for almost 120 years. The Trans Tasman reciprocal relationship was established in 1892 by the Melbourne Accord. In 2010 it was reaffirmed with a new, much simpler, and currently relevant agreement and formally ratified by the six Australian states, the two Australian Territories and New Zealand surveyors' boards. The agreement is now overseen by the Council of Reciprocating Surveyors' Boards of Australia and New Zealand (CRSBANZ) and allows cadastral surveyors who have been 'accredited' in one jurisdiction to gain the same recognition in all others without further examination. The system was complemented later by general legislation relating to mutual recognition in both countries.

This paper briefly outlines the similarities and differences between the two agreements. It will outline the principles on which the reciprocal relationship was originally based, and the basis of the present agreement. It also briefly outlines the matters that are contained within the 2010 agreement, and the way in which the reciprocal relationship is maintained by the jurisdictions. It then considers the use that is presently being made of the agreement, and concludes by commenting on the relevance and value to cadastral surveyors, the licensing boards, and the jurisdictions generally, in maintaining the reciprocal agreement.

Keywords cadastral surveying, regulation, mutual recognition.

INTRODUCTION

In October 1892, a meeting of officials from five Australian states and New Zealand met at the Custom House in Melbourne 'to deal with the questions of reciprocity in the issue of Certificates to Surveyors – Surveys of Land – and the adoption of the Hour Zone system of time'. The record of that meeting is reproduced in Appendix 1. This meeting had been preceded by correspondence between mostly government officials (i.e. Surveyors-General of the various colonies) and professional bodies. While Tasmania was not represented at that meeting, correspondence was received from the Deputy Surveyor-General, who was supportive of the idea of reciprocity between the colonies (McRae 1989:115).

It took some time following the 1892 accord for all of the statutes around the jurisdictions to come into alignment, and the agreement was not fully effective until after the turn of the century. Thus in a space of less than 20 years, the system of qualifying as a surveyor had moved from the authorisation of suitable candidates by local Chief Surveyors, to a standardised set of examinations and procedures throughout the Australian and New Zealand jurisdictions.

THE MELBOURNE ACCORD

The Melbourne Accord, or Report of the Intercontinental Conference of Surveyors, as can be seen in Appendix 1, set in place a systematic approach to the qualification of cadastral surveyors, most of the principles of which are retained today. Proof of initial competence, certificates of competency, the issuing of licences to practise, the establishment of Registers, and the ability to suspend or cancel either a licence or entry in the Register are all specified, as is the desirability of having Boards appointed with members nominated by the profession as well as the 'head of the Survey Department'. Additionally, it was agreed that the examinations should be identical and held simultaneously, with the papers prepared by a committee consisting of one member from each jurisdiction. The report went on to cover some detailed survey matters (like the adoption of the standard of length, the supremacy of ground marks as evidence, the number of permanent reference marks in a survey) that would become the

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subject of jurisdictional regulations under their respective Survey (or other equivalent name) Acts, and discouraged colonies from allowing tendering for surveying work. The balance of the report dealt with time zones in Australia.

The Melbourne Accord expanded to include the Australian Capital Territory (ACT), New South Wales (NSW), New Zealand (NZ), the Northern Territory (NT), Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic) and Western Australia (WA).

ON-GOING INTEREST IN RECIPROCATION

According to McRae (1989), there continued to be great interest in reciprocation between surveying organisations during the 1930s, 1940s and 1950s, especially between the former British colonies (in particular Australia, Canada, New Zealand, South Africa and Great Britain itself). There was a conference in New Zealand in 1950, with delegates attending from New Zealand, Canada, United States, Ceylon [Sri Lanka], Malaya, Kenya and Sarawak (McRae 1989:126). There is, however, little evidence of outcomes from this conference, although New Zealand and Canada reached an 'understanding', which could not be formally ratified as the Canadian Board was not empowered to enter into such contracts. However they did agree to abide by the spirit of the agreement (McRae 1989:129).

The Royal Institution of Chartered Surveyors (RICS) from the United Kingdom reached separate agreements with Australia and New Zealand in 1955 that allowed a degree of reciprocation. This agreement was limited because the RICS did not have the same degree of control over surveyors and their examinations as did the Survey Boards. This reciprocal agreement lapsed in 1976, but RICS has been active with both the Surveying and Spatial Sciences Institute (SSSI) and the NZIS in pursuing a degree of mutual recognition with these bodies.

The reciprocal agreement between the Australasian jurisdictions has now been in place for almost 120 years. There appears to be no record of problems arising as a result of this Accord, but only mutual benefit to all parties. There is a worldwide interest in the mutual recognition of surveying qualifications, and this long-standing and successfully operated system may provide some lessons for others interested in entering into mutual recognition agreements with other entities. It should be noted, however, that the reciprocation example described here is one that allows cadastral surveyors to undertake work that will provide the basis for a government-guaranteed land titling system, and is therefore dealing with functions that have been delegated by the authorities to legislatively-empowered entities – i.e. Boards. This is a quite different level of mutual recognition than that which may be negotiated between professional societies, either bi-laterally or multi-laterally, and involving recognition of qualifications for reciprocal membership of respective bodies.

RECENT ADMINISTRATIVE CHANGE

The operation of the Melbourne Accord was overseen by the Conference of Reciprocating Surveyors Boards of Australia and New Zealand, which included all members of all Boards. The Reciprocating Boards previously meet as a plenary, with all members of all Boards being invited. In 2001 the Boards adopted a 'slimmer' model by creating the Council of Reciprocating Surveyors Boards of Australia and New Zealand (CRSBANZ), consisting of only the Chairs of each of the 9 jurisdictions. The Council meets once a year in person and once by teleconference. The Council has been serviced for some time by the administration of the Queensland Board. The cost of the administration is shared amongst the Boards according to the number of surveyors on their respective registers, while Boards meet the cost of their respective delegates. Some Boards have made a habit of sending their Secretaries or Registrars as observers to the meetings.

Currently the Council is made up mostly of Surveyors General, with only SA, WA and NZ having independent chairs for their Boards. The Surveyor-General of NSW delegates his attendance to the Chief Surveyor (the Surveyor-General being a statutory office not necessarily held by a surveyor), Queensland's officer is called the Director of Surveys, and the ACT used the term Commissioner of Surveys, although this was recently changed to Surveyor-General.

THE NEED FOR REVIEW

In order to minimise costs, the Council began to meet immediately following, and in the same location as, meetings of the Intergovernmental Committee on Surveying and Mapping (ICSM), a body that comprised the senior managers who head surveying and mapping activities in Australasian government departments (the Australian jurisdictions and New Zealand). ICSM meets to discuss common issues in relation to the regulation of surveying, matters to do with a common interest in spatial data in the region, and to exchange ideas and information for the common benefit. While savings were made on the cost of travel and accommodation for the purpose of having a separate meeting, it became apparent that there were some disadvantages to this schedule of meetings.

First, by the time it came to the CRSBANZ meeting at the end of the week, most of the members (all those with the exception of the independent chairs from SA, WA and NZ) had been discussing technical matters for some days. The result of this was some difficulty in shifting from the mode of the business of ICSM to focus on related but subtly different matters to do with CRSBANZ. As ICSM has a much broader interest, but in matters that are related, discussions on issues in the CRSBANZ meeting often led back to issues more appropriately dealt with in the ICSM forum. Additionally, the establishment of the Council occurred at the same general time that significant changes were being made to the regulation of surveyors in a number of jurisdictions. This was having an impact on the role of the Surveyors General (hence the appearance of independent Chairs at the meetings) as well as the extent to which government regulation was being restricted to cadastral matters.

So in the first instance, the regulation of surveyors was being separated from the regulation of surveying, both of which in the past had been within the function of the Surveyors General. In some cases, such as New Zealand, this had led to the creation of Board Chairs who were not Surveyors General. Secondly, the range of activities that came within the jurisdiction of Boards was being narrowed to matters of cadastral competence only in some jurisdictions. This was complicated by the fact that it was not happening simultaneously, nor was it happening in any uniform or coordinated way.

It is not clear how or when, but the professional qualification of surveyors, which was begun to ensure the competence of general surveyors for the colonies, expanded to cover areas related to surveying, such as municipal engineering and town planning. More recent legislation (mostly since the year 2000) has tended towards restricting the jurisdiction of the Surveyor's Boards to cadastral surveying only. These changes have not been uniform throughout the region as each state of Australia has adopted its own approach. In particular, the Queensland Board retains the authority to examine and discipline surveyors in aspects other than cadastral surveying. These related areas, which were removed from the control of other Boards in a desire to operate in a minimally regulated environment with respect to professional services, were introduced through the 1980s and 1990s, in a variable manner throughout the region. It is useful to note at this point that the issue of variability between jurisdictions is compounded by the fact that Australia has no federal legislation for the regulation of the surveying profession or for the setting of standards for surveys, and that all governing legislation is state-based.

Furthermore, since the 1950s, the testing of the theoretical knowledge of intending surveyors, generally referred to as 'cadets', had progressively moved from direct examination by the Boards, to reliance on university departments of surveying. While the Boards, in 1892, had agreed to have not only the same examinations, but to have them sat simultaneously, the universities were under no such obligation. The universities did not (and do not) gather to discuss curriculum issues in the reciprocating region, but developed their own curricula over time, presumably with some consultation with the Board of the jurisdiction within which they were located. As the Melbourne Accord was principally to give mutual recognition to fully qualified surveyors, the question of mutual recognition of university qualifications did not need to be addressed. While individual Boards have taken steps to recognise the education provided by universities in other jurisdictions, the CRSBANZ has not given formal recognition to this.

THE NEW AGREEMENT

The new agreement is much shorter, simpler, is agreed to by all of the 9 jurisdictions, focuses specifically on cadastral surveying, and the recognition of qualified surveyors between those jurisdictions. In particular the 'Trans Tasman Reciprocal Agreement on Cadastral Surveyors 2010' focuses specifically on: educational standards; post graduation experience; examination procedures, standards and competencies for entry onto a Register; requirements for continuing competence; processing of complaints; the exchange of information with respect to disciplinary actions; and the penalties imposed. The agreement requires that the signatories monitor these matters and collaborate to maintain consistency so that reciprocity may be maintained. While ensuring that the respective Boards work together, it preserves the autonomy of each Board to deal with any or all of these issues in its own particular way, as constrained (or empowered) by its own legislation.

Effectively what it has done is to bring the focus of Trans Tasman reciprocation onto matters related to cadastral surveyors. It has clarified that the standards for surveys are outside the ambit of this reciprocal agreement (although it does not exclude any other agreement being reached on other uniform standards – such as by ICSM) and has excluded consideration of those 'fringe' disciplines such as 'Town Planning' that had found their way into the surveyor's regulatory framework. It also does not preclude the development of bilateral (or multi-lateral) reciprocal agreements between any of the jurisdictions outside the framework of this particular agreement, say in the areas of mining, or hydrography, for example.

HOW MUCH IS IT USED?

According to Coutts (2011a), there are approximately 3,500 'live' licences throughout the region in any one year. This number has not changed significantly since 2005. The term 'live' is used to indicate the number of licences that have been issued by Boards. The term 'active' was deliberately avoided, as it is known that there are surveyors who have 'live' licences but do not use them (Coutts 2010). Numbers supplied by the Boards for the last 5 years of data available at the time of the preparation of Coutts (2010) (late 2010) have been used to generate Table 1.

Table 1: Number of licences by jurisdiction (after Coutts, 2011)

	2005	2006	2007	2008	2009	Average
ACT	57	65	66	71	72	66
NSW	1044	1066	1061	1061	1076	1062
NT	80	80	77	75	76	78
NZ	714	707	727	731	727	721
Qld	530	626	613	617	605	598
SA	145	141	145	144	146	144
Tas	57	65	66	71	72	66
Vic	579	535	514	514	504	529
WA	244	237	245	248	251	245
TOTAL	3450	3522	3514	3532	3529	**3509**

The gross figures for the number of 'live' licences shown above can be used for comparison in the following discussion, but it is also of interest to see how well supplied each of the jurisdictions were in terms of the relationship between the number of cadastral surveyors and the total population of the jurisdiction. Jurisdictional populations were accessed from Wikipedia on 24 August 2011. More accurate populations were not considered necessary as the comparisons are only needed to ascertain gross figures. The results are shown in Table 2.

Table 2: Density of surveyors by population.

Jurisdiction	Population	Licences	Licenses/100,000
NT	229,675	78	**34**
ACT	358,894	66	**18**
NZ	4,393,500	721	**16**
NSW	7,238,819	1062	**15**
Qld	4,516,361	598	**13**
Tas	507,626	66	**13**
Vic	4,932,422	529	**11**
WA	2,296,411	245	**11**
SA	1,644,642	144	**9**

These figures indicate that the range, generally, is not large. However there are an exceptionally high number of surveyors per head of population in the NT. There is no obvious reason for this, other than that as the population is relatively small, a minor variation in the number of surveyors would have a noticeable effect on the result.

Table 3 gives a break-down of the number of surveyors who have requested a licence in another jurisdiction under the terms of the reciprocal agreement from data supplied by the respective Boards. There were 189 requests in the 10 year period for which data was sought. Table 3 also shows the jurisdiction of the original licences, thus indicating how many surveyors have been 'exported' from each jurisdiction. No account is taken in either Table 3 or 4 of the number of surveyors who hold a licence in more than one jurisdiction, i.e. applying for a licence in another jurisdiction under the reciprocating provisions does not necessarily imply that the licence in the original jurisdiction is relinquished. It would be possible to hold a licence in each of the jurisdictions. Particularly within Australia, surveyors may be holding second or multiple licences because they work for employers who have offices in more than one jurisdiction and who, to facilitate the mobility of their staff, require them to be licensed in each of the relevant areas. Table 3, therefore, may indicate the number of surveyors 'exported' by each jurisdiction.

Table 4 indicates how many times each jurisdiction has been required to issue a licence on the request of a surveyor from elsewhere. The numbers are generated from the same data as Table 3, but have been collated differently. That is, Table 4 shows how many surveyors have been 'imported' into each jurisdiction. It might be noted that while QLD ranks second highest in the export of cadastral surveyors, it also ranks highest in the import of them, such that they are almost in balance.

Table 4. Number of licences issued by reciprocation per jurisdiction (after Coutts, 2011).

ACT	NSW	NT	NZ	Qld	SA	Tas	Vic	WA	TOTAL
34	28	24	1	35	16	9	32	10	**189**

As Coutts (2011a) points out, there are some similarities between Table 3 and Table 4: the larger and more populous jurisdictions receive the most requests, with one significant difference. While the number of New Zealand surveyors seeking reciprocal licences in Australia correlates with the population of surveyors in New Zealand, the number of requests received by New Zealand to recognise Australian surveyors from any of the eight jurisdictions is minimal. In fact, there has been only one request in the 10 years covered by the data. That is, New Zealand has exported its 'share' of surveyors, but has not imported a proportional number of surveyors. While global economic factors might impact on the figures since 2008, this does not explain the earlier imbalance. As might be expected, the smaller Australian jurisdictions (ACT, NT and Tas) are among the proportionately larger importers of professional surveyors, and as ACT and NT do not have surveying education courses provided within their territory, this must always be.

Based on these figures, the use being made of the reciprocal agreement is quite limited, on average 19 times per year out of approximately 3500 surveyors, which equates to about

Table 3: Number and origin of requests for reciprocation (after Coutts, 2011)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
ACT					1					1	**2**
NSW	4	4	1	5	2	1	9	16	17	10	**69**
NT			1		1		1				**3**
NZ		1		3	3		1	3	3	7	**21**
Qld	10	2	1	6	7	1	2	4	3	3	**39**
SA	4	1			1	1	1		3		**11**
Tas					1		1	2		1	**5**
Vic	3	1		2	3	2	4	5	3	6	**29**
WA	2	2	1	2	1				2		**10**
TOTAL	**23**	**11**	**4**	**18**	**20**	**5**	**19**	**30**	**31**	**28**	**189**

0.6% of the total number. It is also apparent that while there is mobility within Australia, it is predominantly one way traffic from New Zealand. In saying this, it does still represent a very small percentage of the total number of surveyors. This may not be surprising in the few years since the global economic downturn as work is more abundant in Australia, but it is a little more surprising over the longer term. Lifestyle choices and higher salaries also play a part in the decisions of some New Zealanders to emigrate. Within Australia the figures will be distorted by those who hold multiple licences, and may reflect the nature of the work individual surveyors choose to be involved in, as the Australian jurisdictions have their own predominating industries, for example mining in Western Australia.

CONCLUSIONS

While the reciprocal agreement appears to be reasonably well known and understood, little use is made of it. Some 20 applications per year only are processed, and the cost of maintaining the agreement could be questioned. The costs are the meetings of the Council (accommodation and travel of the delegates, and any teleconferences) and the fee to the Queensland Board for administration. These costs are borne by all of the surveyors in the region who purchase licences, as there are no government subsides. There may be economies when Council meetings are held in conjunction with other events (ICSM or national conferences) but predominantly the cost falls on those most likely to benefit – the licensed or registered cadastral surveyors. (For identification of those jurisdictions that use the term 'licensed' and those that use 'registered' see Coutts 2011a).

The reciprocal agreement appears to work principally in favour of the Australian jurisdictions and Australian cadastral surveyors within Australia. In particular, it facilitates the movement of qualified surveyors between the Australian jurisdictions without imposing the disincentive of re-testing or re-validation of licensing requirements when crossing jurisdictional borders. While the agreement works in favour of movement within Australia and between the jurisdictions, it also enables New Zealand cadastral surveyors to move to Australia, especially when there are times of shortages of employment opportunities locally, or when there are skill shortages in Australia and attractive employment conditions may be offered as inducements to relocate. The potential for serious skill shortages in Australia with respect to cadastral surveyors was raised at the CRSBANZ meeting in Canberra in 2005 (Blanchfield 2005) and is discussed by Coutts (2010).

Use of the agreement tends to be made in proportion to the number of surveyors within any jurisdiction, and cadastral surveyors move at random between jurisdiction, with several notable exceptions. Tas and the NT are generally 'importers' of cadastral surveyors, in all likelihood due to their small size, and in the case of NT, due to the absence of a tertiary education programme in surveying. In contrast, and on its own, NZ is an 'exporter' of cadastral surveyors to Australia. Should Blanchfield's fears come to fruition, then the well-supplied jurisdiction of New Zealand may find itself contributing more cadastral surveyors to Australia than it has in the past.

The old and the new agreements are based on quite different foundations. The original Melbourne Accord set in place a system whereby all candidates within Australasia wishing to become qualified cadastral surveyors sat the same examinations, and in any one year, sat them at the same time. While final qualification came from the individual jurisdictional boards, the theoretical knowledge of all candidates was assessed on the same basis. Differences would appear only in the practical training, and the assessment of that training through board interviews. There was, therefore, a high degree of consistency throughout the region.

The present system operates under quite different circumstances. Since the 1950s, the role of supplying the theoretical part of a cadastral surveyor's education has been progressively taken over by universities. Each board accredits one or more universities with the ability to provide a qualification that will be recognised as equivalent to the previous board-run examinations, or suitable to be regarded as the up-to-date equivalent. The universities providing these courses do not have a mechanism in place to check whether they are each producing graduates with similar education in cadastral surveying, and the reciprocating boards put their trust in all of the other individual boards in each jurisdiction to maintain sufficient over-sight of the cadastral education to be able to confirm that they are satisfied with its quantity, quality and continued relevance. Appendix 3 lists the accredited degrees within the region.

Furthermore, each board relies on a consistency in the quality of post-graduation training, as well as consistency in the process of ascertaining when a candidate meets the required standard for entry in the register of fully qualified cadastral surveyors. Such trust may be based on the fact that the land registration systems are largely the same, and that each board has the protection of the integrity of its cadastre as a prime purpose. There may be, therefore, a self-interest in ensuring there is such consistency that surveyors moving between jurisdictions would also be motivated by self-interest to ensure that they understood any differences between the legislative or regulatory systems operating in any unfamiliar jurisdiction before entering into practice.

Although the reciprocation is only invoked about 20 times a year, and could be covered by each country's Mutual Recognition statutes, it is well worth preserving as a way of providing a simple means of facilitating the mobility of qualified cadastral surveyors throughout the region, of maintaining strong links between the surveyors and the survey systems of each country, and of acknowledging the common origins and future directions of our systems. It has the added advantage of only requiring a light hand.

REFERENCES

Blanchfield, F. 2005. Registered Surveyors in the ACT and NSW. Will there be enough in 2025. Unpublished paper. Council of Reciprocating Surveyors Boards of Australia and New Zealand.

Coutts, B. J. 2010. Some demographics for New Zealand cadastral surveyors. *In*: C. Ackerley, M. Buckenham, A. Finigan, J. Hannah, & J. Hill (Eds.), *A salute to the Captain: Celebrating the 100th birthday of Emeritus Professor J. B. Mackie.* (pp. 56-71). Dunedin, New Zealand: Development & Alumni Relations Office, University of Otago.

Coutts, B.J. 2011a. Disciplinary Principles for Cadastral Surveyors: A Case Study in Australia and New Zealand. *Journal of Spatial Science*, 56 (1): 3-13.

Coutts, B.J. 2011b. Reciprocation and Discipline in Australasia. *Journal of Spatial Science*, 56 (2): 155-168.

McRae, J.A. 1989. *New Zealand Institute of Surveyors 1888-1988*. New Zealand Institute of Surveyors. Wellington, New Zealand.

APPENDIX 1

Report of the Intercolonial Conference of Surveyors

To deal with questions of reciprocity in the issue of Certificates to Surveyors – Surveys of Land – and the adoption of the Hour Zone system of time. The Conference met at the Custom House, Melbourne, on the 31st October 1892 when there were present the following representatives of the Australasian Colonies:

NEW SOUTH WALES	
Government	E. Twynam, Chief Surveyor R. McDonald, District Surveyor
Institution	G. H. Knibbs, President Institution of Surveyors, NSW, and Lecturer on Surveying, Sydney University T. F. Furber, Secretary Institution of Surveyors, NSW
NEW ZEALAND	
Government and Institute	A. O'N. O'Donahoo, Wellington
QUEENSLAND	
Government	Hon A. C. Gregory, CMG, MLC, &c A. McDowall, Surveyor General
SOUTH AUSTRALIA	
Government	G. W. Goyder, CMG, &c, Surveyor General C. Todd, CMG, MA, FRS, Government Astronomer and Postmaster-General
Institute	William Cumming, Vice-President South Australian Institute Of Surveyors John H. Packard, Secretary South Australian Institute of Surveyors
VICTORIA	
Government	R. L. J. Ellery, CMG, FRS &c Government Astronomer and Chairman Board of Examiners for Land Surveyors J. M. Coane, CE, Member of Board of Examiners for Land Surveyors
Institute	Thomas Walker Fowler, MCE, President of Victoria Institute of Surveyors and Lecturer on Surveying, Melbourne University Stuart Murray, CE, Chief Engineer, Victorian Water Supply Department
WESTERN AUSTRALIA	
Government and Institute	J. S. Brooking, Deputy Surveyor-General, President Board of Examiners, and Vice President West Australian Institute of Surveyors
Mr R.L. Ellery, CMG, was unanimously elected President.	

The Conference after full and careful consideration of the subjects placed before them unanimously recommended as follows:

1. That reciprocal recognition by each colony of certificates of competency to survey issued by the other colonies is desirable.
2. That the Board of Examiners for each colony should be corporate body constituted by Act of Parliament, and empowered:
   (a) To conduct examinations and otherwise enquire into the competency of gentlemen seeking the right to practise as Surveyors, and to certify as to the results of such examinations and enquiries.
   (b) To issue licences authorising the holders thereof to practise as Surveyors, in the colony for which the Board is authorised to act, to gentlemen holding any of the following qualifications:
      i) A certificate of competency issued under Sub-section A by any of the Australasian Boards of Examiners.
      ii) Any qualification which in the opinion of the Board of Examiners is equivalent to a certificate of competency issued by the Board.
   (c) To enter the names of all gentlemen to whom licenses under Sub-section B have been issued in a book, to be called the 'Surveyors' Register'.
   (d) To suspend or cancel any Surveyor's licence, and to remove the Surveyor's name from the 'Surveyors' 'Register' during the suspension of his licence (or permanently in case such licence has been cancelled) where, after due enquiry, it is shown that
      i) The Surveyor has wilfully and improperly certified to the accuracy of any survey or plan knowing the same to be incorrect or without taking reasonable precautions to verify its accuracy, or

ii) Surveys effected by or under the direction of the Surveyor are inaccurate and untrustworthy, or

iii) The Surveyor has been registered and obtained his licence by fraud or has been convicted of felony, or

iv) His name has been removed from the 'Surveyors' Register' of any of the Australasian Colonies and his licence suspended or cancelled.

3. That the Board for each colony (consisting of not less than five qualified persons) should be appointed by the Governor-in-Council. Of these not less than one-half should be nominated by the Council of the Institution of Surveyors, or other recognised body representing the practising Surveyors of the colony, and the remainder should be nominated by the professional head of the Survey Department.

4. That the regulations for examination for Surveyors, the subjects for examination, and the standard of efficiency required throughout the Australasian Colonies, should be identical. The draft regulations attached to this report are recommended for adoption.

5. That no alterations should be made in the regulations or subjects for examination, without the consent of a majority of the Boards of Examiners.

6. That simultaneous general examinations for Land Surveyors should be held in the various colonies, the papers for such examinations being prepared by a committee, consisting of one representative from the Board of Examiners of each colony.

7. That the examinations should begin on the first Tuesday in the month of September of each year, and in case additional examinations be found necessary, that such additional examinations should begin on the first Tuesday in the month of March following. Provided, however, that should either of the days named be a public holiday in any one colony, the examination should begin on the first day thereafter which is not a public holiday.

8. That the Board of Examiners for each colony may, at its discretion, issue a certificate of competency, under the regulations adopted by the Australasian Boards, to any applicant now holding a certificate as a qualified Surveyor in such colony either with or without examination or upon passing such portions of the examination prescribed in the regulations as the Board may in his case require. Provided that the certificate shall be conferred without examination, only when there is no reason to doubt that the qualifications required by the regulations are possessed by the applicant.

9. That any Surveyor, holding a certificate prior to the reconstitution of the Boards, who does not obtain a certificate under the provisions of the preceding recommendation, should be entitled to continue to practise in, and to have his name enrolled on, the Surveyor Register of the colony only for which his certificate was issued.

10. That only Surveyors licensed and registered by the Board of Examiners for any colony should be permitted to practise under the Real Property and transfer of Land acts in such colony.

11. That the licence to practise as a Surveyor in any colony should include the right to practise both as a Surveyor of Crown Lands, and as a Surveyor under the Real Property and transfer of land acts.

12. That no future Surveys by unlicensed persons affecting titles to land should be recognised.

13. That Crown Survey boundaries as marked on the ground (except in cases of fraud) should be unalterable and accepted, and that, where necessary, deeds should be corrected to agree with such boundaries.

14. That before plans of any Township are received into the Lands Titles Office or General Registry Offices of deposit, at least four permanent marks should be laid down in the Township, and referred to on the plans; and where found necessary Acts of Parliament should be amended so as to allow this recommendation to be carried out.

15. That the Surveyors-General for the various colonies be requested to have at least four permanent marks, wherever possible, consisting of hard stone or cement or other suitable material, laid down in every newly surveyed Government Town at the time of survey, and referred to upon the original plan; and that when Crown lands are being cut up for suburban or country sections occasional permanent marks be laid down and also referred to upon the original survey plans.

16. That, where original survey marks now exist upon alienated lands, the public bodies under whose control the said lands are placed should take immediate steps to either preserve such marks or have their positions fixed by means of permanent marks.

17. That the legal measure of length used in all Australasian surveys being the English measure of length, as provided by English Statute law, standards 66 ft and 100 ft in length, in terms of such legal standard, should be established in the principal Australasian cities and adopted as the standards of surveys in all the colonies.

The Conference would urge on the Governments of the various Australasian colonies the necessity of completing, as far as possible, the Topographical and Geological surveys of their respective territories, seeing that the information obtained from such surveys would frequently enable Engineers to save large sums of money in carrying out important National works and in addition, would provide valuable information in connection with the development of the mining resources of the country.

The Conference would further urge the desirableness of extending and connecting the Trigonometrical surveys of the colonies, as by this means the measured bases could be utilised as bases of verification, and the results applied to statutory surveys when such may be decided upon, as well as the elucidation of many points in connection with the figure of the earth.

The Conference views with disapproval the system in vogue in many of the colonies, by which Government surveys are tendered for competitively, and recommends that this practice be abolished.

The Conference is of opinion that a standard of time should be established throughout the Australasian colonies on the basis of the hour zone system of time computed from the meridian of Greenwich. The adoption of such a standard would not only facilitate the internal business of each province, but would be a great convenience in connection with railway and telegraphic communication between the colonies.

That for this purpose the true mean time on the 150th meridian east of Greenwich should be adopted as the standard time for all railway, telegraphic and other purposes, and that it should be made the legal standard of time within the colonies of New South Wales, Tasmania, Victoria and Queensland. Also that South Australia should adopt the same time, or the mean time of the 135th meridian, which is exactly one hour later, and that West Australia should adopt the mean time of the 120th meridian, which is two hours later.

The Conference considers it desirable to submit with other papers accompanying this report, a draft memorandum for a bill including recommendations with reference to the issue of survey licenses, and which it would recommend should be given effect to by the various colonies at the earliest convenient date.

The members of this Conference wish to urge on their respective Governments the importance of uniformity in the issue of certificates to Surveyors, of uniformity in the Trigonometrical, Topographical and Geological surveys of Australasia, and of the adoption of the hour zone system of time, on the basis of the foregoing recommendations, and submit that it is important that there be early legislation, where requisite, for securing these objects.

Geo. Roberts, Secretary
Melbourne, November 7th, 1892.

APPENDIX 2

Trans Tasman Reciprocal Agreement on Cadastral Surveyors 2010

Preamble

The parties to this agreement are the respective registering or accrediting authorities of Australia and New Zealand for cadastral surveyors. These parties or their predecessors have, since 1892, operated a reciprocal agreement that recognises the qualifications of a surveyor with respect to their ability to carry out cadastral surveys in each others' jurisdictions without further examination or testing.

Definition

'Surveyor' in this document means a person authorised by relevant legislation to carry out and certify cadastral surveys.

Parties to the Agreement

Cadastral Surveyors Licensing Board of New Zealand;
ACT Survey Practice Advisory Committee;
Land Surveyors Licensing Board of Western Australia;
New South Wales Board of Surveying and Spatial Information;
Surveyors Board of the Northern Territory of Australia;
Surveyors Board of Queensland;
Surveyors Board of South Australia;
Office of Surveyor-General Tasmania
Tasmanian Land Surveyors Accreditation Board; and
Surveyors Registration Board of Victoria.

Scope

The scope of this agreement is to update the agreement of 1892 and facilitate the implementation of the Trans Tasman Mutual Recognition legislation of both countries with respect to surveyors such that a surveyor in one jurisdiction will be recognised by each other jurisdiction, and that on an application accompanied by a Letter of Accreditation, a surveyor will be licensed by any other jurisdiction.

Agreement

The parties agree to collaborate to maintain reciprocity of surveyors by monitoring and ensuring consistency between the parties in the following matters:

- content and standards of educational requirements;
- content and nature of post graduation experience requirements;
- examination process, standards, and competencies for entry to a Register;
- requirements for demonstrating continuing competence;
- processes for receiving, hearing and deciding complaints;
- the exchange of information between jurisdictions

regarding actual or possible disciplinary proceedings; and

- penalties for cadastral surveyors found guilty of professional misconduct.

Mutual concerns will include:

- the assessment of overseas (non Australian or New Zealand) qualifications;
- that surveyors with multiple licenses observe the laws, rules and guidelines of every jurisdiction in which they are listed on the Register and
- an understanding of the survey standards required by each jurisdiction.

The parties agree that:

The governance of this agreement shall be by a Council of Reciprocating Surveyors Boards of Australia and New Zealand consisting of the Chairs, or their nominees, of the parties, who will meet face-to-face at least once in every year at a time and place mutually agreed; and

The Council shall arrange for its administration through an agreement with one of the parties.

Signed:

Dated: 2010

	Cadastral Surveyors Licensing Board of New Zealand
	ACT Survey Practice Advisory Committee
	Licensed Surveyors Board of Western Australia
	New South Wales Board of Surveying and Spatial Information
	Surveyors Board of the Northern Territory of Australia
	Surveyors Board of Queensland
	Survey Board of South Australia
	Office of Surveyor-General Tasmania
	Tasmanian Land Surveyors Accreditation Board
	Surveyors Registration Board of Victoria

APPENDIX 3

Courses accredited by Boards within the region

ACT adopts New South Wales accreditations;

NSW University of New South Wales
Bachelor of Engineering (Survey and Spatial Information Systems)
Bachelor of Engineering (Geomatic Engineering);
University of Newcastle
Bachelor of Surveying;

NT no degrees within the jurisdiction;

NZ University of Otago
Bachelor of Surveying (that includes all core courses and the Advanced Cadastral Surveying paper);

Qld Queensland University of Technology
Bachelor of Urban Development;

University of South Queensland
Bachelor of Spatial Science – Surveying Major (available extramurally);

SA University of South Australia
Master of Surveying and Bachelor of Sustainable Environments (Geospatial Information Systems);

Tas University of Tasmania
Bachelor of Surveying and Spatial Sciences;

Vic Royal Melbourne Institute of Technology (RMIT)
Bachelor of Applied Science (Surveying);

University of Melbourne
Master of Geomatic Engineering;

WA Curtin University of Technology
Bachelor of Surveying.

EVALUATION OF AUTOMATED FLOW DIRECTION ALGORITHMS FOR DEFINING URBAN STORMWATER CATCHMENT BOUNDARIES

Abstract High spatial precision is critically important when delineating catchment boundaries for the purpose of building hydrological models of the built environment. Catchment delineation from digital elevation data frequently utilises one of a number of flow direction algorithms. This study applies a horizontal difference metric to assess the goodness of fit between manually determined catchments and those derived from stochastic (Rho8) and deterministic (D8) flow direction algorithms. An important finding is that multiple applications of a stochastic model can provide important information on the uncertainty of catchment boundary locations caused by modelling errors. Furthermore, a stochastic model can reveal hydrologically significant aspects of the topography that are not apparent from the application of a deterministic model.

Keywords Urban drainage, automated catchment delineation, stochastic flow routing, Geographical Information System (GIS), Digital Elevation Model (DEM)

INTRODUCTION

Stormwater catchment boundaries delimit the spatial extent of those parts of an interconnected drainage network that discharge to a specific outlet, such as a road sump (sometimes referred to as a mudtank or catchpit) or the entrance to a culvert. The spatial extent of a catchment directly influences the expected volumetric flow rate at the catchment outlet due to a specific storm event. Consequently, catchment area has relevance when modelling hydrologically significant features of the built environment such as roads, buildings and fences for the purpose of designing drainage infrastructure. The size of a catchment is the dominant spatial element in determining expected volumetric flow rates in regions containing isotropic land cover, terrain characteristics and underlying soil types and conditions. However, where surface characteristics vary rapidly with location, such as in the urban environment, the accurate determination of catchment boundaries can become critically important.

Surfaces in the built environment can have highly variable and spatially discontinuous levels of permeability due to relatively impermeable surfaces such as concrete and asphalt being interspersed with more permeable, natural surfaces. There is also variability in the short-term storage capacity of the built environment due to the presence or absence of small surface depressions that require filling before incident rainfall can generate surface runoff. In addition, engineered drainage channels and storm water reservoirs can have large, but highly localised, effects on a catchment's surface water hydrology.

The determination of catchment boundaries was traditionally done manually by interpreting surface contours on an appropriately scaled topographic plan. Modern techniques involve automated processing of a Digital Elevation Model (DEM), usually represented as a raster (a regular, two-dimensional array of surface elevation levels referenced to some vertical datum). A flow direction algorithm is then applied to the DEM to determine the expected direction of surface flow for each element (also referred to as a 'pixel' or 'cell') in the DEM. This output is further processed to estimate a particular catchment's surface water 'accumulation' and boundary. Deterministic flow direction algorithms provide precise, repeatable catchment boundary definitions for a given DEM. However, despite this level of precision, various data and modelling uncertainties can affect the accuracy of the result. A catchment map produced by a deterministic algorithm represents a single instance of a range of plausible solutions given a particular set of input data. Stochastic methods, on the other hand, produce a range of solutions within which the expected catchment boundary location lies, as well as providing an indication of the level of uncertainty.

This study evaluates the ability of a stochastic flow direction algorithm called Rho8, developed by Fairfield & Leymarie (1991), to correctly determine the spatial extents of urban stormwater catchments. This will be accomplished by comparing Rho8 outputs to an industry standard deterministic flow direction algorithm called D8 (O'Callaghan & Mark 1984), as well as catchment boundaries determined using the traditional method of manually interpreting surface contours. Additionally, the sensitivity of catchment boundary positioning to catchment topography will be assessed by analysing the variability of Rho8 determined boundaries for individual catchments. The study considers surface water flows

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only, as these are the dominant hydrological drivers when designing urban features such as road networks, stormwater networks and surface drainage systems. Subsurface flows, although important for ecological systems, slope stability and soil strength, do not generally play a large role in the design of stormwater infrastructure.

Sections 2 and 3 provide background information on urban surface water hydrology, an overview of the presented hydrological modelling processes, and a theoretical analysis of the strengths and weaknesses of the Rho8 flow direction algorithm compared to D8. The remaining sections present an experiment that was conducted to compare catchment boundaries produced from Rho8, D8 and the manual method. The chosen study area for the experiment is the steeply-sloped suburb of Ravensbourne, Dunedin.

The work presented herein was largely undertaken by the principal author while studying for his BSurv Honours degree in the National School of Surveying, University of Otago.

BACKGROUND

The hydrological cycle describes the movement of water between the Earth's atmosphere, land surfaces and water bodies. Powered by the sun, water evaporates from the Earth's water bodies and rises into the atmosphere, where it is transported by wind currents and eventually falls back to the Earth's surface as precipitation in the form of rain or snow. When precipitation occurs over landmasses, the rain, or melt water in the spring if the precipitation fell as snow, generally flows down slope on its return trip to the ocean, where it is ready to start the cycle all over again.

Rainfall occurring over land may infiltrate the soil where plants may take it up and eventually return it to the atmosphere via evapotranspiration. Alternatively, it may percolate down to the ground water table and flow into underground aquifers or re-emerge as surface water. Water that does not infiltrate the soil, or water that has re-emerged, may be stored in surface depressions and subject to evaporation, or may run off the surface of the land in the form of surface flow. The portion of precipitation contributing to surface flow increases with increasing duration of the precipitation event as storage mechanisms become saturated (Chow et al. 1988).

The effects of urbanization on the hydrological cycle must first be understood before efforts can be made to minimise the impact of development on the quantity and quality of the generated surface runoff. Urbanisation is generally defined as the development of land into higher density communities, and is driven by new migration into populated areas. As we adapt the environment to our needs, we alter natural systems, including the network of streams, ponds, lakes and rivers that drains precipitation from the land. For instance, we build structures with impermeable roofs to keep dry, and roads of asphalt and concrete to facilitate travel. Due to the increase in impermeable surfaces, less precipitation is able to soak into the ground and a greater proportion of it is realised as 'surface runoff'. Smooth, impermeable surfaces also allow runoff to flow more quickly. Therefore, during a given rainfall event, greater areas of land can simultaneously contribute flow to a single discharge point, or in other words, larger catchments can become fully 'developed' during a particular storm event.

Communities construct networks of channels and pipes to augment the parts of the natural system that have been disturbed, but as the process of urbanisation continues, these constructed drainage networks may become increasingly strained. Planning authorities encourage mitigation of urbanisation's effects on drainage systems, and the need is growing for a clearer understanding of how urban catchments work. Also needed are engineering tools for producing effective, appropriate and resilient solutions to urban drainage problems.

OVERVIEW OF HYDROLOGICAL COMPUTER MODELS

Computer models are often used to enhance understanding of hydrological systems, make predictions and run 'what if' scenarios. Hydrological models investigate a number of processes occurring in both natural and built environments, including the generation of surface runoff. Geographical Information System (GIS) databases often include spatial information about the components of the urban environment, such as stream and road centrelines, pipe networks and surface level information in the form of contours or DEMs. These GIS data can be used as inputs to automated urban drainage models, but models are often limited by the simplifications, assumptions and accuracy of both the input data and the model itself.

Raster DEM hydrological analysis

The term DEM denotes the full range of methods used to store elevation data, referenced to the 'z' axis, distributed over a two-dimensional planar coordinate system referenced to the 'x' and 'y' axes, and includes such methods as rasters and Triangulated Irregular Networks (TINs). Raster datasets represent spatial phenomena as values assigned to two-dimensional grids of contiguous cells. The smallest unit of resolution is the spacing of the grid and all points within the cell are assumed to have equal values. The elevation data for DEMs are sourced from terrestrial, photogrammetric and LiDAR techniques.

A raster based, automated catchment process can be divided into three main steps; first, the production of a flow direction raster, second, the production of a flow accumulation raster and third, the partition of the DEM into subcatchments. For some algorithms the second and third steps are undertaken simultaneously. The three-step process is usually accompanied by a hydrological conditioning that ensures realistic results by resolving 'sinks' (those pixels where water can flow into, but not out of) and incorporating ancillary data. The computed flow direction, flow accumulation and catchment rasters provide the spatial location and extent of a given catchment, and identify those pixels to which the majority of other pixels 'flow into'. These pixels represent where saturation and channel formation are most likely to occur.

Flow direction is defined as the direction a drop of water falling on a given pixel would take as it leaves the pixel and flows towards the catchment's outlet. It is equivalent to the direction of the steepest downhill path. The value of pixels (or cells) in a flow direction raster represents the adjacent cell to which water from the cell in question would flow. Each of the adjacent cells is assigned a number, and a cell's flow direction value is set to the number of the cell it flows into (see Figure 1). It is usually determined using a 'local operation', which means that only immediately adjacent cells influence the determination of a given cell's flow direction. Many flow direction algorithms are available for modelling surface flow. As discussed further in Section 3.3, D8 and Rho8 are examples of single flow direction algorithms that permit flow only to a single cell, and restrict flow direction to one of eight possible directions (i.e. only into one of the eight neighbouring cells).

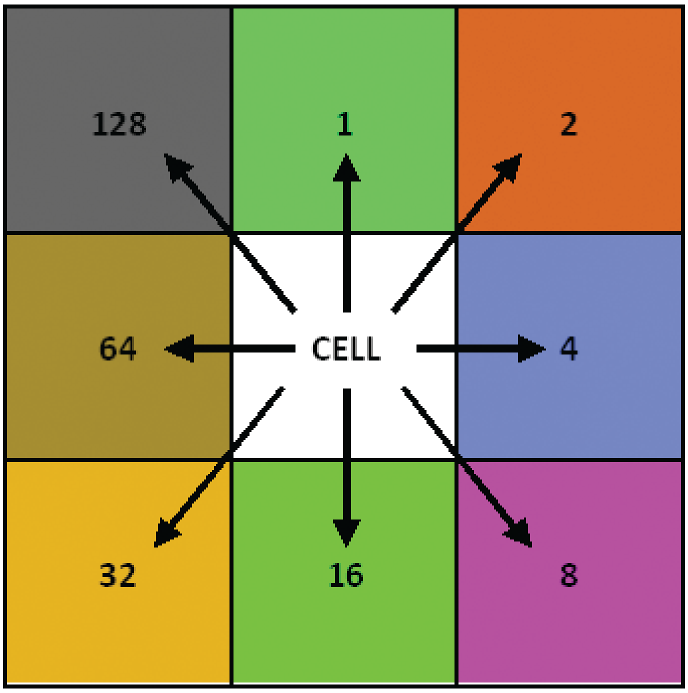

Figure 1. D8 flow directions. The centre cell is assigned a number representing the direction of the steepest down slope neighbour. GIS software symbolizes the flow direction values using nominal colours to aid visual interpretation. The above colour scheme is used in Figure 2.

Flow accumulation is analogous to 'Total Contributing Area', which is the upslope area contributing flow to a specific location in a catchment. A flow accumulation raster is an array of cells where the value of the cell is equal to the number of upslope cells that drain into it. There are a number of ways of determining flow accumulation from a flow direction raster, including recursively climbing the upslope 'links' of the flow direction raster as used in this study. Flow accumulation rasters are often equalised for display purposes, as a small number of cells often end up having a much greater flow accumulation than the bulk of the cells.

In a catchment raster, each cell is assigned a nominal value that represents the sink or outlet of the catchment, so cells that have the same value belong to the same sub-catchment, and each sub-catchment is assigned a unique value. Catchment rasters are generally determined from flow direction and flow accumulation rasters. However, there are also inundation algorithms that form catchments without first forming flow direction rasters, as discussed in Couprie et al. (2005).

Data errors in raster DEMs can be propagated using Monte-Carlo realisations of the original surface (Raaflaub & Collins 2006). These realisations are variations of the surface where the elevation data has been altered using a stochastically generated error matrix representing the probable ranges of known uncertainties in the source data. Running the model on a large number of realisations gives an indication of the effect of data uncertainty on the model outcomes. The Monte-Carlo method is particularly useful when data errors are difficult to model analytically.

In addition to data uncertainty, catchment determination algorithms can also contribute to overall output uncertainty. Although both are important, this study investigates uncertainties due to flow direction algorithms only, and does not address uncertainty due to elevation data errors.

Hydrological enforcement

DEMs for hydrological modelling are usually preconditioned to accurately model water movement in a process called hydrological enforcement. Hydrological enforcement techniques can either be applied during the process of resampling from point or contour data to DEM, or immediately thereafter. Alternatively, hydrological enforcing can be accomplished by manipulating the flow direction or other derived raster datasets to achieve a connected network without altering the DEM.

Sinks Accurate catchment boundaries cannot generally be determined from un-conditioned DEMs because of discontinuities in drainage networks called sinks. Sinks in grid DEMs are raster cells with no 'lower' neighbouring cells. Resolving sinks involves raising or lowering cells, so water can drain out of them. Raising cells and subsequently routing flows through any flat areas created by this process is called 'filling'. Flat areas can be resolved, for example, by routing to the nearest neighbour with a resolved direction (O'Callaghan & Mark 1984). Lowering cells to clear blockages is called 'breaching' or 'draining'. Breaching generally alters less of the DEM than draining (Kenny et al. 2008). Combinations of filling and breaching are also commonly applied. Sinks can similarly be resolved in the catchment raster by amalgamating sub-catchments within a specified distance. This approach is comparable to flooding small sinks and allowing adjacent catchments to combine, and is the method used in this study. Hydrological enforcement of flow direction or catchment rasters avoids potential loss of data due to filling and breaching, but can create inconsistencies between the DEM and the derived datasets. For instance, altering a flow direction raster to resolve a sink will create a flow path that, referenced to the DEM, is uphill.

Sinks are removed from DEMs on the assumption that they are rare in nature (Hutchinson 1989; Goodchild & Mark 1987) and therefore an artefact of data collection or interpolation. This is not necessarily true in the built environment. The development of land creates sinks, which are then typically drained into underground pipe networks. For obvious reasons, these sinks should not be filled for the purposes of modelling urban hydrology.

Ancillary data Hydrological modelling can incorporate data ancillary to the elevation model. A common example is 'stream burning', which is a method for incorporating known watercourses into a DEM. Stream burning is a function available in ArcHydro (Maidment 2002), which is a hydrology module that has been developed for the ESRI ArcGIS software package. Stream burning at its simplest involves creating a channel in the DEM so that water will flow along it. A more computationally expensive procedure involves minimising the effect of stream burning on the DEM by creating an exponential curve along the flow path (Saunders 2000). Another adaption involves creating a riparian zone of linear falls into the stream, in order to channel passing flows into the watercourse (Hellweger 1997).Known water courses can also be used to drain sinks and flats (Kenny et al. 2008).

Other elements of the built environment with known position and hydrological characteristics can be burnt into the raster DEM in processes similar to stream burning. Surface features such as roads, drainage ditches and kerb and channel that are included this way can capture and divert large volumes of surface water, despite often being smaller than the resolution of the raster DEM. In such cases, the features being modelled need to be exaggerated sufficiently to be represented in the output before 'burning' into the elevation data.

Strengths and weaknesses of D8 and Rho8 flow directions

This sub-section describes the D8 and Rho8 algorithms in detail and analyses differences between them using three mathematical surfaces with predictable drainage characteristics, to illustrate how each algorithm departs from the expected result. The mathematical surfaces; a helix, cone and plane are illustrated in Figure 2.

D8 Originally proposed by O'Callaghan & Mark (1984), D8 is a deterministic flow direction algorithm that directs flow from each grid cell to the adjacent cell that is the steepest down slope neighbour. D8 first determines the elevation difference

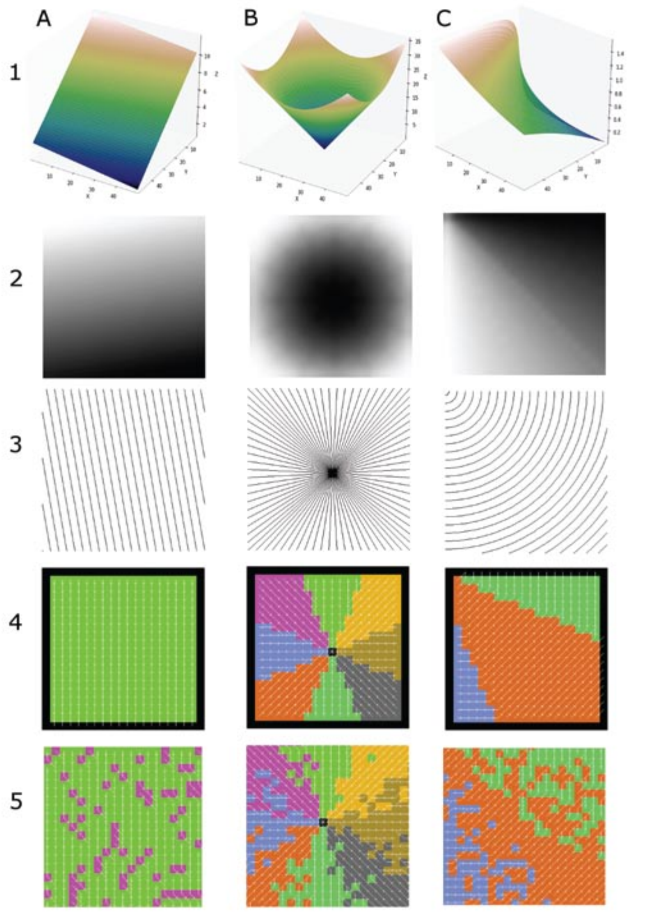

Figure 2. Mathematical surfaces and results from hydrological analysis. Each column presents results from a different surface. Column A is a plane that slopes downhill at a direction of 170° from the top of the diagram, Column B is a cone shaped pit, Column C is a helical curve descending anti-clockwise. Row 1 shows three-dimensional representations of the surfaces. Row 2 shows raster DEMs of the surfaces where lower elevations are darker. Row 3 shows theoretical flow paths originating at evenly spaced points at the top of the surfaces. Row 4 shows D8 flow direct results. Row 5 shows Rho8 flow direction results. Rows 4 and 5 use the colour scheme in Figure 1 with white arrows overlaid to illustrate direction.

between the centre of the cell in question and the centre of each of its eight neighbours (including diagonal cells).The greater distance to the diagonal neighbours is accounted for by multiplying the elevation difference by $\frac{1}{\sqrt{2}}$. The direction to the neighbouring cell with the greatest downhill elevation difference is then assigned as the flow direction. The flow direction is usually stored as a single integer, 1, 2, 4, 8, 16, 32, 64 or 128 representing N, NE, E, SE, S, SW, W or NW respectively (see Figure 1), although other numbering systems are also common. D8 is the most widely used flow direction algorithm; it is used by several commercial packages including ArcGIS, InfoSWMM, PCI Geomatica and IDRISI.

There are distinct and predictable errors in D8 generated flow directions. The D8 algorithm has a direction bias because it can only select from eight possible directions, so any terrain features that naturally drain between these directions are modelled poorly (Tarboton 1997). On some surfaces, these inaccuracies cancel out along the flow path, preventing the flow from departing too far from the true location. However, the plane surface (see Figure 3) demonstrates how this is not always so. As flow descends along the plane's surface, the flow lines diverge farther and farther from the theoretical lines. D8 also tends to create parallel streams that do not converge. For example, the cone surface (see Figure 3) contains areas of parallel lines and only localised convergence. D8 direction bias can affect catchment boundary location, particularly when the boundary is formed by an indistinct ridge.

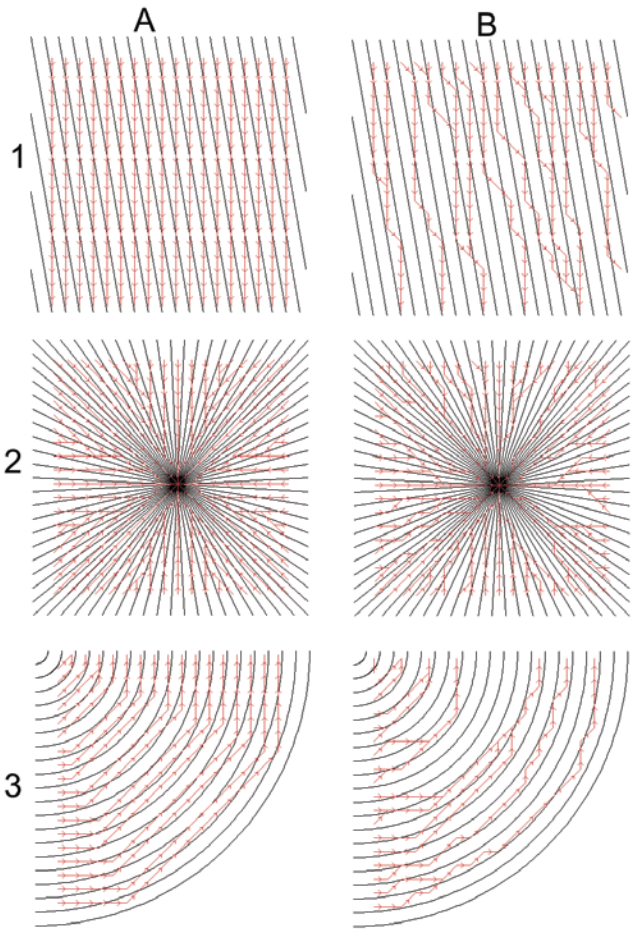

Figure 3. Flow paths of D8 and Rho8 (shown in red). Theoretical results are shown in grey. Column A represents D8 results. Column B represents Rho8 results. Row 1 shows results for the plane surface, Row 2 the cone surface and Row3 the helical surface.

Several methods have been proposed to overcome D8 direction biases. For instance, 'Functional' (Quinn et al. 1991) and Tarboton (1997)'s 'D∞' (pronounced 'D infinity') are methods that avoid directional bias by permitting flow to two or more cells. However, multiple-cell flow methods are not favoured for catchment boundary determination, as they do not form connected flow networks. Catchment outlets in multiple-cell flow methods can receive flow from cells that also contribute to other catchment outlets. Flow from the contributing cells can be proportioned between the outlets to determine relative flow accumulation values, but the spatial extent of the contributing area is undefined. Therefore, discharge rates cannot be accurately determined in areas of inconsistent surface runoff, such as the built environment. Other methods for modelling flow include Lea (1992)'s rolling ball method and Costa-Cabral & Burges (1994)'s two-dimensional flow tube (called DEMON). Some flow direction algorithms define aspect by using least squares to fit a plane to the local neighbourhood. However, least squares flow direction methods are shown to generate loops on some terrains (Tarboton 1997).

Rho8 Fairfield & Leymarie (1991) attempted to mitigate the directional bias of D8 by introducing a random variable into the slope calculation, thereby creating Rho8. Due to this randomness, the flow from a particular cell within a DEM processed by Rho8 may potentially be directed to different cells in subsequent Rho8 applications. Therefore, although cell aspect is restricted to the original D8 directions, the expected value of the flow direction can now be any direction. Rho8 introduces randomness into the process by multiplying the elevation difference between the cell and its diagonal neighbours by a random factor, ρ_8, given as:

$$\rho_8 = \frac{1}{2 - \sigma}$$

where σ is a uniform random variable between zero and one. The expected value of $\rho_8 \approx {}^{1}/_{\sqrt{2}}$. Compared to D8, if $\rho_8 < {}^{1}/_{\sqrt{2}}$, the cardinal neighbour (non-diagonal) is favoured, if $\rho_8 > {}^{1}/_{\sqrt{2}}$ the diagonal neighbour is favoured, if $\rho_8 = {}^{1}/_{\sqrt{2}}$ the D8 solution is invariably applied.

Figure 2 shows examples of Rho8 produced flow direction arrays for the three test surfaces. Unlike the D8 results (see Figure 2, Row 4), the Rho8 flow lines do not consistently flow in one direction. Some cells randomly select alternative directions, with this occurring at a frequency proportional to the gradient difference between the two options, thus creating a mottled appearance. Different runs of Rho8 produce flow direction rasters with approximately the same relative proportions of selected flow directions, but due to the random factor, the calculated flow direction for an individual cell may change from run to run.

Rho8 essentially adds noise to the flow direction, which allows the computed flow path to follow the 'true' surface aspect more closely by occasionally choosing a less steep slope for its flow direction, but never an uphill slope (Fairfield & Leymarie 1991). Adding noise to the DEM could achieve a similar outcome, but this may make water flow uphill, and the amount of noise required would vary depending on whether a cell's aspect was a multiple of 45° (the minimum resolvable angle in D8). As a result of the random factor, Rho8 flow lines in Figure 3 generally follow the theoretical paths more closely than the D8 flow paths. However, using stochastic behaviour to improve the flow path also introduces non-repeatability and spurious convergence into the result.

The random variable in Rho8's flow direction calculations produces non-deterministic behaviour. The randomness is non-repeatable, so results will differ between model runs. A related issue with Rho8 is that flows on parallel paths merge and cannot separate, so downstream errors will accumulate, with more and more flow erroneously concentrated onto some cells (Costa-Cabral & Burges 1994). Figure 3 confirms that the degree of flow convergence in Rho8 differs from the expected behaviour for a theoretical surface. In the plane example shown in Figure 3, Row 1, Column B, the original 18 flows converge to only five flows at the bottom of the plane. Convergence is a common occurrence in natural flows, but on plane and helical surfaces, convergence in Rho8 flow directions is caused by randomness, not underlying topography. Random convergence causes some downstream cells to receive inflated flow accumulation values.

Flow accumulation rasters for D8 and Rho8 are shown in Figure 4. The cone surfaces demonstrate the response of the flow algorithms to the full range of possible directions. D8 flow accumulation displays bias to boundaries between D8 directions (See Figure 4, Row 1, Column B). Conversely, Rho8 accumulations display bias toward regions where there is less random convergence, corresponding to the D8 directions. Qualitatively, the Rho8 flow accumulations look more like water flowing over a surface than the D8 flow accumulation because the Rho8 texture is more organic, and individual flow paths are visible. The meandering paths of the Rho8 flow accumulations suggest the meandering paths of water navigating through undulations, whereas the D8 flow accumulations ignore undulations and present a surface with sharp edges and an ordered structure that looks crystalline rather than organic. It is easier to detect and identify the underlying surfaces in the Rho8 flow accumulation. The angle of the plane and the curving shape of the helical surface are visible in the Rho8 surfaces, but these features are not apparent in the D8 images. However, D8 is more consistent in its treatment of cells, and in the case of the plane, is closer to the theoretical result.

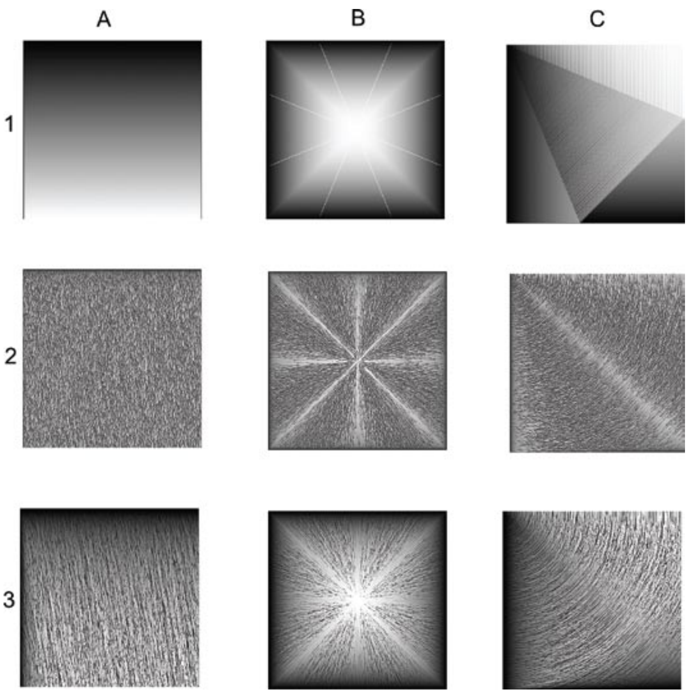

Figure 4. D8, Rho8 and Multiple Rho8 flow accumulations. Column 1 shows flow accumulations for the plane surface, Column 2 the cone surface and Column 3 the helical surface. Row 1 shows D8 flow accumulations, Row 2 shows Rho8 flow accumulations and Row 3 shows multiple Rho8 flow accumulations.

Figure 4 also illustrates the outcome of averaging multiple Rho8 flow accumulation rasters. Averaging a sufficiently large number of Rho8 runs mitigates both the primary weaknesses of Rho8 by producing a result that is both repeatable (given a sufficient number of runs) and does not contain areas of high concentration due to random convergence. The visual impact of averaging multiple Rho8 runs can be seen by comparing Figure 4, Row 3 to Figure 4, Row 2. Averaging multiple Rho8 runs evens out the mottled appearance and highlights broader regions of cells that are bright or dark due to topography, not random convergence. Similar flow accumulation results can be achieved using D∞, but as discussed previously, D∞ does not easily yield catchments, since D∞ does not form connected drainage networks.

A representative Rho8 catchment boundary can be produced from multiple Rho8 runs by averaging the catchment boundaries of individual runs in a process similar to the weighted catchment boundaries generated from the Monte-Carlo realisations by Endreny & Wood (2001), as will be illustrated in the next section.

EXPERIMENT METHODOLOGY

An experiment was undertaken to evaluate how well the Rho8 algorithm identified catchments when applied to a real (i.e. non-theoretical) surface. This was accomplished by comparing Rho8 output to catchments generated from the D8 algorithm and the manual method. Additionally, the sensitivity of catchment boundary location with respect to catchment topography was assessed by analysing the variability in Rho8 determined boundaries for individual catchments. Comparisons were made using a Horizontal Displacement (HD) metric that measures the areal difference between polygons per unit length of polygon perimeter. The experiment was implemented using the Python scripting language and ESRI ArcGIS.

The chosen study area was a steep section of suburban catchment in Ravensbourne, Dunedin, featuring several roads and intersections. The study area is shown in Figure 5. The input data was 2-metre contours and road centre lines sourced from the Dunedin City Council GIS database. No kerb data was available so kerbs were taken to be located 4 metres from the centreline.

The manual catchment boundaries were derived directly from the 2-metre contours. Flow lines, representing flow directions, were drawn as curving lines that intersected contour lines at right angles. Catchments were then determined by tracing flow lines back from the sinks to the ridgelines. Road centre lines and the estimated locations of kerb and channel were taken to be catchment boundaries. Flows that were not captured by sinks within the data area where not included within a catchment. The sinks identified in the hand drawn catchment map were numbered from 1 to 13, with this numbering scheme also being applied to the automated processing. The manual process is necessarily subjective as the flow path between contours is not always clear.

Hydrologically enforced DEM creation

In order to create a hydrologically enforced DEM, the 2-metre contours were first converted into a 1-metre resolution grid DEM using the ArcGIS 'Topo to Raster' tool, which is an implementation of the Hutchinson (1989) ANUDEM interpolation. Roads were introduced into the DEM using an idealised road burning technique since the spatial resolution of the 2-metre contours was insufficient to represent them. This process involved creating a dense TIN layer from the DEM, followed by the creation of 4 and 6-metre 'buffers' from the road centrelines. The 4-metre buffer represents kerb and channel, and the 6-metre buffer represents the footpath edge. TIN elevation values were applied to the centre line and buffers using ArcGIS 'Interpolate Shape' tool. Then the centre line was raised 2 metres and the kerb and channel dropped 2 metres to create a highly exaggerated road profile, which was introduced to the TIN as hard breaklines. The TIN was then converted back to a grid DEM that now featured ridges at the road centre lines, and valleys where the kerb and channels were assumed to occur.

No filling was applied to the DEM as part of the hydrologic enforcement process. Instead, sinks were resolved in subsequent catchment rasters by identifying the elevation difference between the sink and the 'pour point' of the catchment, which is the lowest elevation cell on the catchment boundary, i.e. the location where flow would escape if the catchment flooded. If the pour point was less than 1 metre higher than the sink, the catchment was amalgamated with its neighbour. The result is equivalent to breaching barriers up to one metre high, except only the catchment raster is altered, not the underlying DEM. Due to the comparatively high sink resolution, only sinks created by the exaggerated road intersections are likely to remain in the output.

Another potential source of surface topography data for this experiment was LiDAR data. Despite generally being at a higher spatial resolution, DEMs produced from LiDAR data still require hydrological conditioning. LiDAR data is often captured at a spatial resolution that makes it possible to resolve road drainage features, but this is not always the case. This can have an adverse effect on road burning processes as inaccurately positioned ancillary data such as road centrelines could potentially create undesirable artefacts when combined with LiDAR elevation data containing information on drainage features (Goepfert & Rottensteiner 2009).

ANUDEM interpolations (such as the one used in this study) are mathematical surfaces that have been fitted to the input data. Therefore, in terms of abstraction, the surfaces derived from contours using ANUDEM interpolation generally fall between mathematically defined surfaces and LiDAR data. The relatively smooth ANUDEM produced DEM permits the application of comparatively simple road burning techniques.

A total of 201 catchment rasters were produced for this study; one using the D8 algorithm and 200 using the Rho8 algorithm. The catchment rasters were converted to polygons using the ArcGIS 'Raster to Polygon' tool, with the 'simplify shapes' option selected. After creating the polygons, any disjointed catchments were dissolved into multipart polygons. Sink numbers were spatially joined to the catchment polygons. Any computer-generated catchments that did not contain sinks from the manually defined catchments were discarded. The multiple Rho8 flow accumulation and the spatial locations of the D8, manually defined and multiple Rho8 catchments are shown in Figure 5.

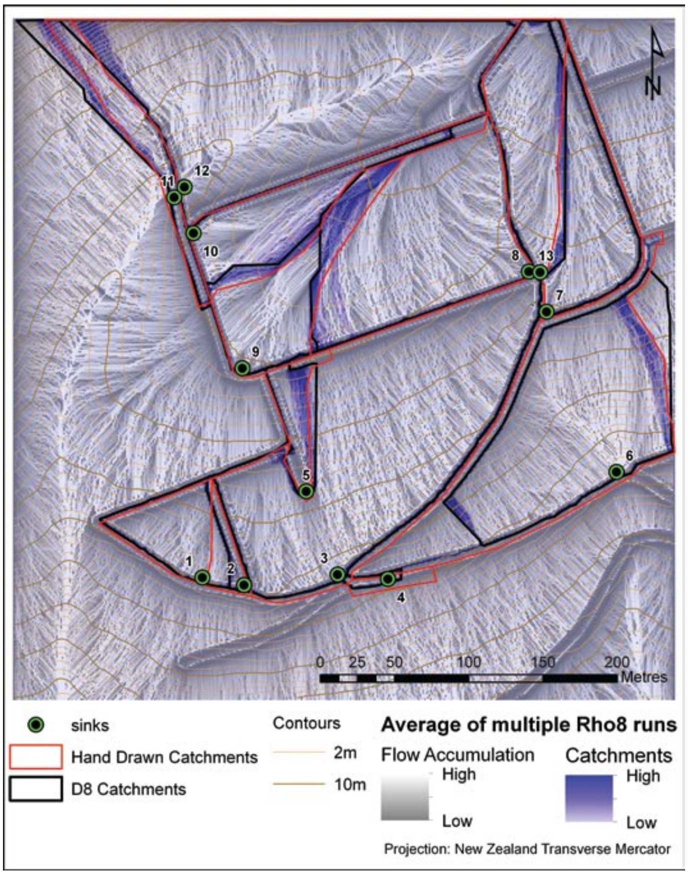

Figure 5. Map of the study area showing the catchment boundaries. Also shown are the flow accumulation raster (indicated by the grey shading) and catchment boundaries (indicated by the blue shading) generated from averaging multiple Rho8 runs. Note the numbers refer to the catchments and are placed next to the catchment outlets (sinks).

Metric for catchment comparison

Comparing catchments can be misleading if only flow accumulation or catchment size is considered, as two similar sized catchments in very different locations may appear to be the same. A quantitative measure for determining actual differences in the positions of two polygons is the Horizontal Difference (HD), as described by Reinoso (2010). HD is determined from the symmetrical difference between two polygons. If a polygon is considered a set of points in $\mathbb{R}^2$, the symmetrical difference of polygons A and B (SD_{AB}) is the set of points that is contained by one, but not both, of the polygons, and is given as:

$$SD_{AB} = (\alpha \cup b) - (\alpha \cap b)$$

where α is the set of points contained within polygon A and b is the set of points contained within polygon B. A definitive measure of the horizontal displacement between polygons A and B (HD_{AB}) can be found by normalising the area of SD_{AB} by the mean length of the perimeters of A and B (MP_{AB}), given as:

$$MP_{AB} = \frac{1}{2(Perimeter_A + Perimeter_B)}$$

$$HD_{AB} = \frac{Area(SD_{AB})}{MP_{AB}}$$

The result is in linear units (m) and represents the average distance one polygon's boundary would have to move, across the interior of the polygons, in order to align with the second polygon. In this case, the raster resolution was 1 metre, so a HD of 1 metre represents an average movement of the catchment boundary of 1 pixel. If comparing two vector data sets containing n polygon pairs, a weighted mean horizontal difference (M_{HD}) can be calculated; this value represents the mean HD for all polygons in the map, weighted by the size of each polygon's boundary and is given by:

$$M_{HD} = \sum_{i=1}^{n} \frac{HD_i \times MP_i}{\Sigma_{j=1}^{n} MP_j}$$

In this study, horizontal displacement values for the 13 catchments were calculated comparing the single D8 and the 200 Rho8 outputs to the manual method. If a sink was not associated with a catchment in both datasets, that sink was not given a HD value. The Rho8 HDs contained some clear outliers, so the 5% most extreme values were discarded, creating a 5% trimmed mean and standard deviation. M_{HD} was calculated for each of the 200 Rho8 comparisons and the single D8 comparison.

RESULTS AND ANALYSIS

Figure 6 presents a histogram of M_{HD} for Rho8 generated catchments. The distribution is centred around 3m, with a noticeable tail extending up to approximately 9m. The M_{HD} of D8 is 3.4m which is just to the right of the Rho8 histogram's peak, indicating that the majority of Rho8 M_{HD} values are lower than the D8 value. This can be interpreted as the Rho8 generated catchments generally being more similar to the hand drawn catchments. However, a portion of the Rho8 M_{HD} values is significantly higher than the mean.

Figure 7 plots catchment perimeter versus HD for both Rho8 and D8 generated catchments. Also shown is the standard deviation of the multiple Rho8 runs, indicated by the error bars. It can be seen from this figure that there is no discernible correlation between HD and catchment size, and most catchments show 'tight' Rho8 distributions, with D8

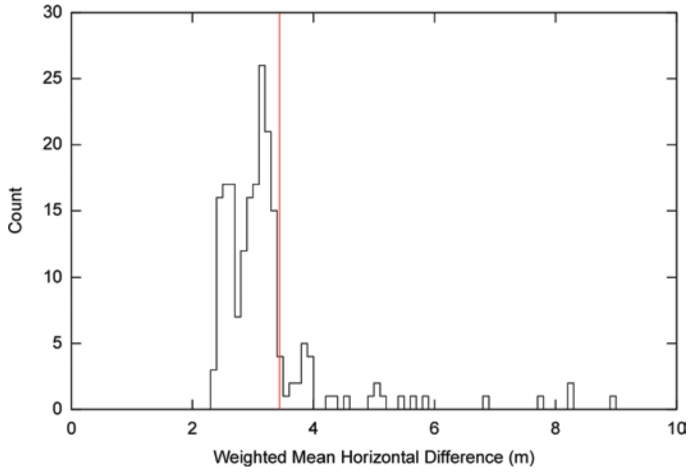

Figure 6. Histogram of Rho8 weighted mean horizontal differences for a 0.1-metre bin size. The red line represents the weighted mean horizontal difference for D8.

values generally located within, or very near to, one standard deviation of the corresponding Rho8 value. However, the Rho8 generated catchment 6 polygons have much larger standard deviations than the other catchments. In addition, the D8 HD values for catchments 8 and 9 are outside the corresponding Rho8 intervals. Catchments 3 and 5 also have large standard deviation intervals for both HD and mean perimeter.

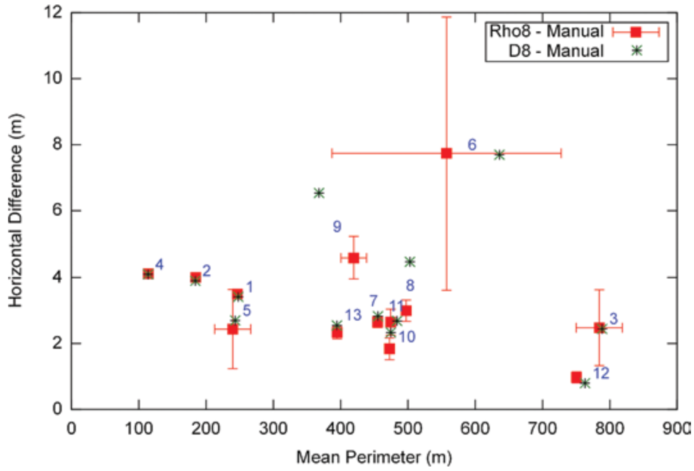

Figure 7. Catchment (indicated by number) *HD* means and standard deviations calculated from Rho8 and D8 outputs. Note that Rho8 *HD* standard deviations (shown as vertical error bars) should not be compared directly to perimeter standard deviations (shown as horizontal error bars) as they have not been normalised, i.e. a horizontal bar of an equivalent length to a vertical bar in reality indicates a much larger perimeter error than the corresponding *HD* error.

Figure 8 presents HD histograms for selected catchments representing different classes of results illustrated in Figure 7. The catchment 2 histogram is tightly grouped in the centre of the distribution, and there is a strong agreement between D8 and Rho8. Catchment 5 has a wider distribution indicating a broader range in Rho8 results, and moderate agreement with D8. Catchment 6 has a bimodal histogram and poor agreement between the automated techniques and the manual method. Catchment 9 has a very broad, flat Rho8 distribution and poor agreement between all three methods.

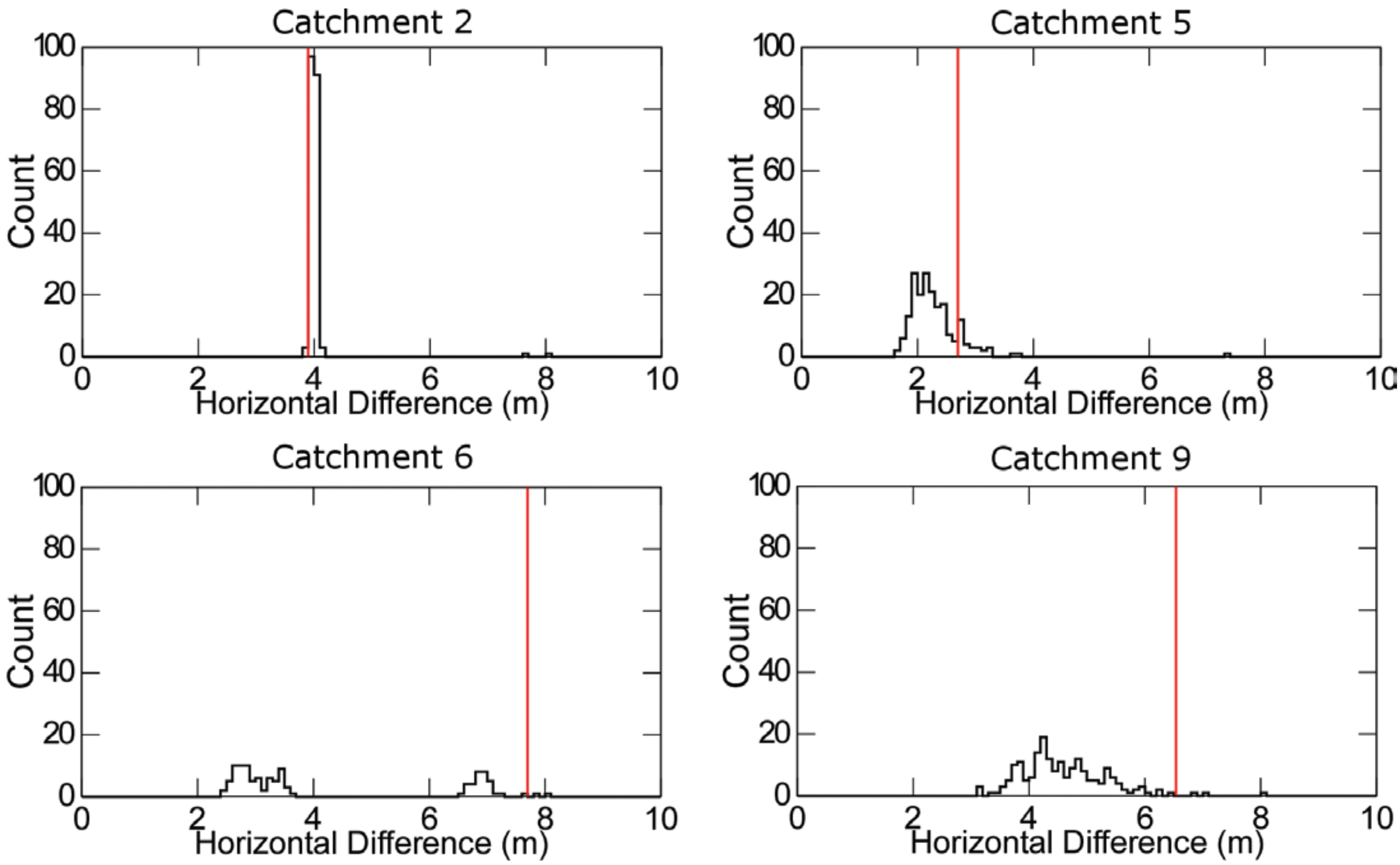

Figure 8. Histograms of *HD* for multiple Rho8 runs for four individual catchments. The red line in each graph represents the corresponding D8 *HD*.

DISCUSSION

Overall, both Figure 5 and Figure 6 indicate that D8 is not equivalent to the most probable Rho8 solution and that Rho8 is generally better than D8 in matching the manually determined catchment boundaries. However, Rho8 and D8 generally produce catchments that are more similar to each other than to manually generated catchments. D8 direction bias is probably the cause of the difference between D8 and most Rho8 catchments. Despite Rho8 being generally closer to the manual method, it is not advisable to rely solely on output from a single run of Rho8 to define catchments, due to the significant number of outliers produced by this study. Instances, such as for catchment 2 (see Figure 8), where there is a strong agreement between Rho8 and D8 and a tight Rho8 *HD* distribution, but poor agreement with the hand drawn catchment, suggest potential errors in the manually generated catchments.

Catchments 1, 2, 4, 7, 12 and 13 show very little Rho8 *HD* variability. These catchments are defined mainly by burnt-in road features, which restrain flow to specific areas. Catchments 3, 8, 9, 10 and 11 show some Rho8 *HD* variability and reasonable agreement between D8 and Rho8. These catchments have one or two boundaries that are not restrained by a burnt-in feature or clearly defined ridgeline, which introduces uncertainty into the result. As the variability of Rho8 *HD* increases, the D8 result tends to move away from the centre of the distribution (compare catchments 2, 5 and 9 in Figure 8), indicating that the D8 model may be a poor fit in loosely defined catchments where direction bias can significantly affect the catchment boundary.

Catchments 8 and 9 show the greatest disagreement between D8 and Rho8, and they have some of the highest *HD* values. Catchments 8 and 9 are adjacent, so the problem is likely to be the highly variable catchment boundary between them. The D8 solution for the boundary between catchments 8 and 9 is clearly in disagreement with the Rho8 boundaries (see Figure 6). The poor agreement between the three methods in the location of this boundary indicates the topography here is particularly sensitive to the flow direction algorithm.

In catchment 6, a large number of outliers and a non-normal histogram distribution raises the mean and increases the variability of the Rho8 output. Catchment 6 is easily the most variable (see Figure 7) and exhibits bimodal behaviour in its Rho8 histogram (see Figure 8). Looking at Figure 5, there is a point about a third of the way (moving from west to east) on the southern boundary where flow either escapes the burned-in channel and leaves the study area, or continues along the channel to be trapped by sink 6. This behaviour causes catchment 6 to take one of two possible shapes, one of which includes the 'triangle' in the south-west corner of the catchment. The bimodal behaviour is due to the steep terrain represented by the tightly spaced contour lines in that area. The steep gradient has caused the slope of the road burning to be roughly equal but opposite to the slope of the terrain, so water can potentially escape the catchment when modelling the flow with Rho8 and, in fact, does escape using D8. Using D8 alone would not have detected this point of divergent behaviour. The bimodal behaviour could also indicate that during heavy rainfall the subcatchment may divert into an alternative flow path.

The Rho8 random factor should self-adjust to work well in both flat and steep catchments because it is introduced by multiplication, therefore the magnitude of the stochastic effect is proportional to slope. However, this study indicates that Rho8 generated catchment boundaries are more variable in catchments that are not formed by sharp ridges. Such areas may occur more frequently in flatter catchments resulting in greater uncertainty in the boundary definition. Gently sloping catchments also provide different requirements for road burning. If the terrain is level, simulated flows will not easily escape burned in channels so less exaggerated road burning is required. Using more accurate DEMs from LiDAR or ground survey where the elevation of the road is accurately captured will also reduce the extent of hydrological enforcement required.

This study calculated catchments for sinks formed where roads intersect one another or cut across valley floors, which represents the minimum requirement for positioning road sumps in order to prevent surface flooding. Typically, road sumps occur at more frequent intervals along the road to allow for optimising flows in both kerb and channel and road sumps. Such 'intermediate' sumps will often have poorly defined catchment boundaries on at least one side of the catchment and generally not be located on a sink in the DEM. Automated generation of catchments for intermediate sumps may therefore require hydrological conditioning in order to represent correctly these sumps and their corresponding catchments.

CONCLUSIONS AND FUTURE WORK

The horizontal difference metric was found to be the preferred method for comparing D8 and Rho8 results. This method was chosen over other metrics, such as a comparison of catchment area differences, because of its ability to describe the goodness of fit between two catchments in terms of both catchment area and location in a single metric. The accurate determination of both of these parameters is important when constructing urban stormwater catchments, as they have a significant impact on the volume of surface water runoff generated and the location where this runoff is injected into a stormwater network.

This study has shown that D8 and Rho8 provide similar catchment results. Although both produced catchments that differed from manually defined catchments, in this study, Rho8 catchments were more similar on average. Some Rho8 runs were shown to produce significant outliers, indicating that multiple Rho8 runs should be utilised to define catchments where precise determination of boundaries is required.

Running the Rho8 algorithm multiple times provides more information than D8, particularly when boundaries are not clearly defined, or ancillary data has been introduced to the DEM. Comparing multiple Rho8 runs to a given result also provides insight into the accuracy of that result, and the effectiveness of any hydrological conditioning applied to the DEM. For instance, bimodal behaviour is easily identified in the distribution of Rho8 HDs and identifies catchments that contain areas where flow can potentially go one of two ways, due to ineffective hydrological conditioning or localised divergent topography. Multiple Rho8 runs also give an indication of the level of uncertainty in the result, which is not possible to get from the D8 algorithm. The issues relating to poorly defined catchments and areas of divergence are noticeable when manually defining catchments, however, the automated Rho8 process is able to quantify these characteristics using the HD metric, and although computationally expensive relative to D8, running multiple Rho8 is generally faster than the manually defining and analysing catchments.

Running an automated process to determine catchments for a stormwater system using multiple Rho8 runs will highlight catchments that are less certain, by producing a large distribution of Rho8 solutions. The variability of solutions can either be quantified using the HD metric or visualised in a catchment map. Catchments where the D8 solution is outside the Rho8 produced distribution may indicate where D8 is affected by direction bias. A systematic comparison between Rho8 and D8 could identify areas where D8 is likely to be inaccurate. An automated system using stochastic flow direction algorithms could be developed as an add-on to programs such as ArcGIS or 12d that provides not just locations and areas of catchments, but also an estimate of the associated error. This process could be enhanced by weighting the errors according to the characteristics of the area, such as surface slope and permeability.

The techniques discussed here warrant further exploration using more detailed LiDAR data and hydrological conditioning techniques that, ideally, would introduce a greater range of urban features. HD and M_{HD} are useful metrics for assessing the wide range of automated catchment algorithms available, and allow a way to incorporate stochastic algorithms into these comparisons. Another potential line of research is comparing Rho8 stochastic analysis of modelling error to Monte-Carlo analysis of DEM data errors. Rho8 is computationally expensive so algorithms that could produce similar results with fewer runs would be beneficial. Finally, the Rho8 function itself could be further optimised, or stochastic characteristics could be applied to other existing flow direction algorithms.

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REFERENCES

Chow, V. T., Maidment, D. R., & Mays, L. W. 1988. *Applied Hydrology*. McGraw-Hill, New York. (Surface Water, pp. 127-200).

Costa-Cabral, M. C., & Burges, S. J. 1994. Digital elevation model networks (DEMON): A model of flow over hillslopes for computation of contributing and dispersal areas. *Water Resources Research, 30*(6): 1681-1692.

Couprie, M., Najman, L., & Bertrand, G. 2005. Quasi-linear Algorithms for the Topological Watershed. *Journal of Mathematical Imaging and Vision, 22*(2-3): 231-249.

Endreny, T. A., & Wood, E. F. 2001. Representing elevation uncertainty in runoff modelling and flowpath mapping. *Hydrological Processes, 15*(12): 2223-2236.

Fairfield, J., & Leymarie, P. 1991. Drainage Networks from Grid Digital Elevation Models. *Water Resources Research, 27*(5): 709-717.

Goepfert, J., & Rottensteiner, F. 2009. Adaptation of roads to ALS data by means of network snakes. *International Archive of Photogrammetry and Remote Sensing, 38*(3/W8): 24-29.

Goodchild, M. F., & Mark, D. M. 1987. The Fractal Nature of Geographic Phenomena. *Annals of the Association of American Geographers, 77*(2): 265-278.

Hellweger, F. 1997. AGREE–DEM surface reconditioning system. *Dr Maidment's Home Page* Retrieved October, 2009, from http:www.ce.utexas.edu/prof/maidment/gishydro/ferdi/research/agree/

Hutchinson, M. F. 1989. A New Procedure for Gridding Elevation and Stream Line Data with Automatic Removal of Spurious Pits. *Journal of Hydrology, 106*(3-4): 211-232.

Kenny, F., Matthews, B., & Todd, K. 2008. Routing overland flow through sinks and flats in interpolated raster terrain surfaces. *Computers & Geosciences, 34*(11): 1417-1430.

Lea, N. L. 1992. An aspect driven kinematic routing algorithm. *In* A. J. Parsons & A. D. Abrahams (Ed.), *Overland Flow: Hydraulics and Erosion Mechanics*: Chapman & Hall, New York.

Maidment, D. 2002. *ArcHydro: GIS for Water Resources*. Redlands, CA: ESRI.

O'Callaghan, J. F., & Mark, D. M. 1984. The Extraction of Drainage Networks from Digital Elevation Data. *Computer Vision Graphics and Image Processing, 28*(3): 323-344.

Quinn, P., Beven, K., Chevallier, P., & Planchon, O. 1991. The Prediction of Hillslope Flow Paths for Distributed Hydrological Modeling Using Digital Terrain Models. *Hydrological Processes, 5*(1): 59-79.

Raaflaub, L. D., & Collins, M. J. 2006. The effect of error in gridded digital elevation models on the estimation of topographic parameters. *Environmental Modelling & Software, 21*(5): 710-732.

Reinoso, J. F. 2010. A priori horizontal displacement (HD) estimation of hydrological features when versioned DEMs are used. *Journal of Hydrology, 384*(1-2): 130-141.

Saunders, W. K. 2000. Preparation of DEMs for Use in Environmental Modeling Analysis. *In* D. Maidment & D. Djokic, (Ed.), *Hydrologic and Hydraulic Modeling Support with Geographic Information Systems*. Redlands: CA: ESRI Press.

Tarboton, D. G. 1997. A new method for the determination of flow directions and upslope areas in grid digital elevation models. *Water Resources Research, 33*(2): 309-319.

Book Review

MAKING OUR PLACE: EXPLORING LAND-USE TENSIONS IN AOTEAROA NEW ZEALAND

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'100% Pure? Yeah, right.' could have been the alternative title of *Making Our Place*, which provides a thorough, informed and engaging look at the many ways our presence has shaped and scarred the Aotearoa New Zealand (ANZ) landscape. It reveals several sources of land-use tensions in ANZ – between Māori and Pākehā, development and protection, dairying and tourism – but its key contribution is in how these tensions are managed and resolved. As one author states, the book aims to 'develop a range of tools to ensure that economic development and landscape protection are allies, rather than enemies.' (pp 170-171). One of the recurring strategies for negotiating land-use tensions is simply by ensuring that communication lines between policy and decision-makers, business and investors, and community are clear and open. This needs to be done despite a news media more interested in pitting these interests against each other. In words borrowed from Shonagh Kenderdine's foreword the book 'peels back layers of misinformation around many of our most difficult land-use tensions.' (p10). The book thus provides a refreshingly balanced and informative perspective and is a must-read for anyone who values their place in ANZ.

A total of 12 individual contributions, all but one from academics, are divided into three sections to address three key themes. The first section, Challenges, lays out some big issues related to the use and ownership of land, and is spearheaded by a chapter on the contested marine and coastal area (or foreshore and seabed). The second section, Transformations, draws attention to the radical human impacts on landscape in places such as Taranaki, Auckland and the Taieri Plains. The final section, Negotiations, illustrates how tensions in these arenas have been and can be negotiated. It highlights case studies, such as the world-leading Waikato River co-management scheme and the greater recognition of wāhi tapu, as signs that common ground is being sought in many instances where land is under dispute.

Jacinta Ruru launches the book by discussing the contested Foreshore and Seabed Act 2004, and the subsequent Marine and Coastal Area (Takutai Moana) Act 2011, which says that no one 'owns' the foreshore and seabed. She provides an illuminating comparison of the two Acts in tabular form. The chapter provides a very good background to the issues and must be read by anyone who has ever felt they were not getting the whole story from the media. Two recent letters to the *Dominion Post* editor reveal how misinformation has bred malcontent amongst the general public. They asked why – given that 'New Zealanders no longer own the foreshore and seabed' (Cronin 2011) – Māori were not taking responsibility for cleaning up beaches in Tauranga in the wake of the Rena oil leak (Campbell 2011). The newspaper exacerbated the misunderstanding by headlining their letters with 'Pakeha don't own this any more'. Ewan Lincoln's measured and informed response, published three days later, reminded us that the Act has not given Māori ownership of the foreshore and seabed. 'Fourth, even if Maori did own the area in question, that wouldn't make them solely responsible for its cleanup. If a truck crashed into your house, creating a fire and dispersing toxic chemicals, would you expect to put out the fire and clean up the chemicals yourself?' (Lincoln 2011)

Maria Bargh's suggestion that the 2004 Act was motivated by financial gain is pertinent here. Despite the then Labour government's claims to protect public access to the beach through the Foreshore and Seabed Act 2004, vigorous economic activity – an increase in iron sand mining licences, sea floor surveys, valuation of the foreshore and seabed, and even gold prospecting – occurred within one year of passing the legislation, so 'the exploitation of the foreshore and seabed in this way is not a random and unexpected development but rather part of a broader agenda of privatisation, commercialisation, and extension of the market mechanism' (Bargh 2006:16). The then government's rhetoric around "protection" apparently did not extend to ecological and environmental protection.

In Chapter 3, Raewyn Peart, Senior Policy Analyst for the Environmental Defence Society, discusses poorly regulated urban development as a challenge to the aesthetic in the coastal region of Tūtūkākā – an issue that challenges other coasts around the country. Reflecting on her own experience, this author suggests that identifying areas of common interest will make a surer step forward than previous approaches to coastal conflict in Tūtūkākā. Her innovative suggestion of a nationwide 'heritage coasts' brand could invest the whole country in the preservation of local coastal landscapes.

In Chapter 4, Lyn Carter brilliantly summarises the debate over the reintroduction of the 'h' into "Wanganui" – reminding us of the question of identity at the heart of the issue. 'Māori and Pākehā bestowed, adopted or adapted place names to substantiate their occupation of particular places and landscapes.' (p58). Mic(h)ael Laws' dogged determination – going so far as to publicly rubbish the opinion of an 11-year old – to hang on to a misspelt place name is not surprising given the implicit question that Whanganui poses to his own identity and connection to the place of Wanganui. The public perception of the NZ Geographic Board is also discussed here, alongside sobering evidence of some of the racism that NZ Geographic Board decisions can ignite.

Mick Abbott's chapter describes our kinaesthetic experience of landscape in recreational walking and tramping: the less intrusive the track through a wilderness the more we can 'be' the landscape. He presents ways in which nations in North and South America have encouraged a more local and experiential interaction with wilderness, and suggests that we can learn much from doing the same.

New Zealand's dairy industry has relatively recently shifted from smaller family-run operations to corporate and externally managed dairying. In Chapter 6, Tom Brooking argues that this is symptomatic of feudal farming evident in the settler nations of England, Ireland and Scotland. By suggesting a whakapapa/ genealogical connection to hegemonic practices of the 19th century Great Britain, he notes ways in which echoes of traditions in the motherland are seen here.

In Chapter 7, Mick Strack examines the Taieri Plain as a case study of the damage that has been done to Māori conceptions, use and occupation of land by the 19th century surveyor's work of dividing up and parcelling land. He points out how Māori land was alienated and swamps drained by the redesignation of land blocks to settlers. His observation that that 'the cadastral map was prepared with almost no regard for either indigenous landforms, land cover, or customary occupation and land use...' (p108) recalls Lyn Carter's earlier discussion on the names and stories that are lost in the renaming (or rebounding, in this case) of landscape. Strack illuminates the contrast between traditional Māori and Pākehā conceptions of land, stating that 'Māori mapped their landscapes verbally' (p110) and that geographies and histories were remembered through stories and landforms. He reproduces the iconic Ngai Tahu elder's map of the South Island to illustrate how a local privileged a perspective that spatially foregrounds their own sites of significance. He poetically illustrates the tensions between a surveyor's 2D line and a local's 'lived landscape' by reproducing a passage from Maurice Shadbolt's *Monday's Warriors*.

Bruce Clarkson's chapter 'traces the ecological transformation of Taranaki's original landscape' (p116) from a time prior to human occupation, through Māori, then Pākehā, arrival, to government and community interventions into Taranaki's ecological preservation in the present day. The chapter provides a vivid description of the flora and fauna endemic to Taranaki, and the devastating impacts that the introduction of carnivores such as dogs, kiore, rats, cats, and human predators had on this ecosystem. Clarkson agrees with Tom Brooking that 'Today, dairying continues to be the dominant shaper of the landscape and ecosystems' (p127). But he paints an optimistic picture, based upon the local community investment and involvement in the ongoing preservation of Taranaki's ecology.

In Chapter 9, Murray Rae chooses key architectural features on the landscape that occupy prominent hilltop positions in Auckland, and consider what these represent about markers of our cultural and social history, as well as how their design reveals a (Pākehā) negotiation of connection to both the motherland of Great Britain, and this land. Contending that we tell stories about ourselves through the markers we place on land, Rae argues that the Sky Tower reveals our current focus on business and economy. By contrast, markers built earlier – such as the Holy Trinity cathedral, with its 'Pacific gothic' design evident in the hybridity between Toy's local nave and Towles' continent-inspired design – remind us of the significance we once placed upon religion, or a pioneering social welfare system (the Savage memorial) or protest in bringing about justice for Māori (Bastion Point). For the latter, Rae perhaps overestimates how well known is the story of the Bastion Point occupation by Ngāti Whātua and supporters. While for Māori, this story is inscribed and remembered in the landscape, Rae does not engage with the prevailing cultural differences between Pākehā and Māori landscape markers.

In Linda te Aho's chapter, the connection of the tangata whenua to their awa is foreground, through several narratives related to the river. These remind us of the emotional, social and spiritual connection of locals to the physical resource, whose water quality has been severely degraded. The emergent force of the Waikato River Authority (WRA), a co-management agreement brought about through the Waikato-Tainui Treaty settlement, could be an exemplar of issue resolution, with everyone mucking in to achieve a common goal: in this case the cleanup of the Waikato. This chapter highlights that Treaty settlements are often not about ownership, but responsibility and governance. The WRA allows tangata whenua to be involved in decision-making (as the Treaty guarantees) and to maintain customary relationships with the places to which they are lyrically tied.

In Chapter 11, Anna Thompson writes 'the Mackenzie Country… can be regarded as a cultural landscape, and is valued by many New Zealanders as part of our national heritage.' (p161) However, the environment that has become the poster board behind the 100% Pure NZ campaign is under pressure from increased dairying. 'The touristic image is of wilderness and apparently untouched nature...' (p162) is not formally recognised or protected, and dairying stands to pose a shift in the landscape's iconic palette 'from tawny gold to green.' (p162) Thompson's chapter draws from research that probed what tourists valued about the Mackenzie basin and she ultimately suggests that the way forward is to preserve what is unique about the landscape, and to maintain and promote merino sheep farming.

On this matter, I note that a way out of the dairy trap is suggested by Professor Sir Paul Callaghan (2009). ANZ needs to shift its focus from unsustainable agricultural increases to reaping proportionately greater dollar value from high value and high tech niche products.

Robert Joseph's chapter explains how the concept of wāhi tapu has been accounted for in land use and management – from pre-Treaty European settler recognition of 'wahhe taboo', to the influence of the Resource Management Act 1991 in regulating activity on land related to wāhi tapu. He examines several case studies heard by the Environment Court. One interesting case of a nonMāori family objecting to a single residential development in Whaingaroa (p181-182) on the grounds of wāhi tapu, anticipates the extent to which wāhi tapu and taniwha may become a part of our national consciousness. It seems Māori and Pākehā can use the concepts, not just in a supernatural or metaphysical sense, but in a physical, phenomenological and practical way. Joseph also highlights the importance of communication to negotiate the application of wāhi tapu. 'While the principles and values are deeply embedded and enduring, they are always in practice interpreted, weighted and applied by iwi and hapü according to the context. …It is not about preserving wahi tapu for the sake of preservation, but pragmatically deciding on the most appropriate course of action.' (p182-183)

In the final chapter of the section on Negotiations, Janet Stephenson and Seth Gorrie tackle wind farms, revealing them to be the most nationally approved but locally contested form of energy generation. No wind farm proposal has ever been approved without being appealed through the Environment Court. One of the most common public concerns about wind turbines is their 'visual intrusion' of the landscape. This chapter compares how residents – both in favour and opposed to wind farm development – talk about the meaning of landscape to them. We gain insight into peoples' embedded cultural, historical and social relationship with the land and the potential of wind farms to disrupt that relationship. 'Conflict is inevitable if developers select a site on the basis of its wind characteristics, while the public respond on the basis of its social/cultural meanings.' (p196) The authors suggest that if developers sought submissions in ways that reveal the social and cultural meanings of landscape, we may have a means to resolving and even avoiding these conflicts.

In the book's concluding chapter, the editors remind us that 'Conflicts are most heightened where issues become two-sided.' (p206). The media is largely culpable for the presentation of debates as two-sided, revelling in the drama and conflict that results when Māori and Pākehā are pitted against each other (Abel 2007), and this stymies the resolution of land issues. What this book argues is that in spite of the diverse ways that we talk about, represent, understand and make 'our place' – land, property, environment, place, landscape, resource and whenua – we are a nation with a pedigree of understanding, compromise and negotiation. The examples presented in the book are testament to this. But there is work yet to be done. 'When place is seen purely as property, the world is reduced to boundary lines and ownership rights, and this perspective is a strong legacy of our colonial past.' (p204) It behoves us all to approach, understand, and embrace different perspectives, because we cannot all endure on the same whenua without that understanding.

The timing of the book has precluded any mention of the debilitating earthquakes in Christchurch. How do a people renegotiate their place when 'the landscape reinvents itself' (p203) and continues to do so? When key markers on that landscape have been shifted or lost, how do people reinstate their identity upon the landscape through public, local and national governmental action, in an impoverished economic climate? As 'making our place' follows 'beyond the scene', 'shifting ground' could be the subject of a third book. Such a volume would be welcomed, and would be in safe hands with this team of authors.

With only a couple of exceptions, authors in the book directly acknowledge and confront tension between Māori and Pākehā land use and occupation. By not avoiding these issues, what is revealed is the overall tension between our own short, selective, human memories, and the capacity of the landscape to retain the scars, and memories, of our impact upon it. This book, thus, ultimately re-confronts us with our social and cultural pasts and reminds us of how those markers on the landscape have arisen, reminding us of our enduring but fragile connection to the landscape of Aotearoa New Zealand.

References

Abel, Sue, 2007. Tūhoe and 'Terrorism' on Television News. In Danny Keenan (ed.) *Terror in Our Midst?* Wellington: Huia Publishers. pp113-128.

Bargh, Maria, 2006. Changing the game plan: The Foreshore and Seabed Act and constitutional change. *Kōtuitui: New Zealand Journal of Social Sciences Online.* **1**(1):13-24.

Callaghan, Paul, 2009. *Wool to Weta: Transforming New Zealand's Culture and Economy.* Auckland: Auckland University Press.

Campbell, Mollie, 2011. Letter to the Editor. 12 October: B4. Wellington: the Dominion Post.

Cronin, Barry, 2011. Letter to the Editor. 12 October: B4. Wellington: the Dominion Post.

Lincoln, Ewan, 2011. Letter to the Editor. 15 October: A26. Wellington: the Dominion Post.

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