It is implicit in Public Choice Theory, and its various manifestations, that there is no trust between the funder and provider – why else is a contract required? Contracts of this nature are important in commercial activity, accepting that the inputs and outputs can be defined and measured. But these conditions (measurable input and outputs) do not apply to science and hence such contracts are largely offensive and demeaning to science and scientist. They feel untrustworthy. Related to this is the view among modern science bureaucracy that scientists, if left to their own devices, will simply squander resources on their own personal interests and pursuits. For this reason they argue a system must be devised to 'force' scientists to work for the good of the economy. Scientists are intelligent – that is one reason they are scientists – and most, sensing the charade they see, feel undervalued in the current system.

Ironically, the history of science is full of examples of people who devoted their lives to science with little, and often no, financial reward. Most modern scientists know that a career in science is not a path to financial wealth and most are more than happy with that compromise, given the non-tangible, but very deep and personal, satisfaction that comes from the pursuit of truth through knowledge. This is the tradition of science and it is this tradition which is demeaned and dishonored by the current commercial science model and environment. I suggest that this is the primary reason why 75% of the current CRI scientists would not recommend a science career to the next generation, and why 20% of current science graduates choose to take their skills overseas.

Conclusions

In the scientific tradition, what conclusions are allowable from the evidence?

There is evidence both empirical and theoretical showing that the science system is malfunctioning. It is predictable that the current problems will not be resolved by further tinkering with the current system. A new science management model is required, built on evidence-based and objective analysis of the needs of science and the needs and goals of New Zealand. Some solutions have been suggested (see for example Edmeades 2004) but further development of these ideas waits further evidence-based policy development.

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conference report

International symposium on volcanic-ash soils and field workshop in Mt Fuji area, Japan

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Introduction

An international symposium on Andisols and related soils, comprising one day of invited lectures at the Ikuta campus of Meiji University (17 March, 2006) and a two-day field trip in the Mt Fuji-Hakone area (18–19 March), was convened by soil scientist **Professor Hiroshi Takesako**, School of Agriculture, Meiji University (Ikuta campus), Kawasaki city, Kanagawa prefecture (near Tokyo). The symposium and field trip were followed by the 50th anniversary meeting of the Japanese Society of Pedology (JSP), which consisted of one day of presentations (20 March) in the College of Bioresource Sciences, Nihon University (Shonann campus), Fujisawa city, Kanagawa prefecture. The symposium was sponsored by the Institute of Science and Technology of Meiji University, and by JSP.

Prof. Hiroshi Takesako, who twice has visited the Department of Earth Sciences at University of Waikato (in September, 2001 – see Lowe, 2001 – and in August-September, 2004), organized the symposium partly to expose his students to an international panel of English-speaking soil scientists with some expertise in Andisols or related volcanic-ash derived soils. Hiroshi was also keen to sponsor and support scientists from developing Asian countries (and New Zealand). Consequently, six invited speakers each presented ~40-minute lectures on the first day of the symposium. All wrote up their lectures as papers for publication in the Proceedings (edited by Hiroshi Takesako). Copies of powerpoint presentations were made available as handouts (most in colour) for the participants to help enable them to follow the talks. Around 50 geoscientists and students attended the symposium lectures.

Symposium lectures

Professor Masami Nanzyo (Tohoku University, Japan) spoke on 'Changes in elemental composition in the genetic processes and conspicuous functions of Andisols'. His excellent and comprehensive presentation initially described the genesis of Andisols, both allophanic and non-allophanic types, and how their elemental composition (involving 56 elements) changed over time. Silicon and some alkaline and alkaline-earth elements are removed and many heavy metals are retained in Andisols during their formation, with Al- and Fe-rich materials (allophane, imogolite, ferrihydrite, Al-, Fe-humus complexes) with variable charge dominating many properties. Nanzyo pointed out that Andisols have many functions beneficial for crop production and environmental protection (see also Dahlgren et al., 2004; Nanzyo, 2002, 2005), but also noted that some are effectively a 'double-edged sword'. For example, high phosphate retention is effective for P removal from waste water but P deficiency is a problem for crop production. High humus accumulation in A horizons contributes to carbon sequestration whereas nitrogen mineralization is relatively slow due to the high stability of Al-humus complexes. Andisols show resistance to acid deposition because of a high surface area with functional groups Al-OH, $Si\text{-}O^-$, and COO^- that neutralize acids. A high preference of heavy metal cations for humus and short-range ordered material results in the natural accumulation of these metals in Andisols (in comparison with other soils). Sections on anion sorption, heavy metal sorption, water retention, and relationships with biological activities formed the basis of the second part of the talk. Two interesting conclusions were that strongly acid non-allophanic Andisols were effective at suppressing potato scab and bean-root rot, and that allophone absorbs the tobacco mosaic virus (the soil has an anti-virus effect). Another was that P fertilizer use is made more effective by root growth from P-foraging plants including *Brassica pekinensis* and *Fagoppyrum esculentum*.

Associate Professor David Lowe (University of Waikato, New Zealand) spoke on 'Andisols downunder: an introduction to the genesis and character of Andisols in New Zealand and South Australia and their utilization'. He began by defining Andisols and by outlining the processes of andisolization (for an excellent recent review of the formation of allophane, see Hiradate and Wada, 2005), and the classification of Andisols in Soil Taxonomy (Soil Survey Staff, 1999). Lowe then described the origin and distribution of Udands (Allophanic Soils) in North Island in terms of their multisequal profile character (rate of upbuilding vs. topdown pedogenesis), tephra composition (rhyolitic, andesitic, mixed rhyolitic and andesitic, basaltic), udic moisture regime (strong leaching), and age. He emphasized their versatility for a wide range of productive uses including pastoral farming (with NPK input), horticulture, and effluent disposal. Some problems ('bush sickness') and triumphs (pine plantations) of Vitrands (Pumice Soils) were also touched upon, including their role in helping to establish Soil Bureau and in catalyzing tephra studies. Lowe then turned to the small but perfectly formed occurrences of Xerands of southeast South Australia around the Mt Gambier and Mt Schank mid-Holocene basaltic volcanic complexes. Comprising barely 85 km^2, the Xerands are rare both in terms of Australian soils (~0.001%) and on a global basis (Xerands comprise only 3.5% of Andisols) because andisolization processes are favoured by strong leaching in udic (or, to a lesser degree, ustic) moisture regimes. The Xerand properties were influenced both by parent mineralogies (especially glass content, much greater in Mt Schank eruptives than those from Mt Gambier) and by the xeric moisture regime, as well as a relatively young age (c. 5000 years). The Xerands of the Mt

Gambier-Schank area provide valuable, versatile soils, and have been used for agriculture (dairying, grazing) and market gardening (chiefly potatoes, onions, cut flowers) since the 1850s (see Lowe and Palmer, 2005).

Mr Rodelio Carating (Bureau of Soils and Water Management, Philippines) spoke enthusiastically on the 'Occurrence and characteristics of Taal-influenced volcanic ash soils in Batangas province, Philippines'. He opened by commenting that volcanic-ash derived soils are widely distributed over ~1 million ha and used extensively for agriculture. His study then focussed on the composition and especially mineralogy of ash-derived soils in Taal-volcano-influenced regions of Batangas and Cavite that lie to the south of Manila. A refreshing and commendable aspect of Carating's presentation was his candour in admitting to making errors in his earlier mapping in the area because of inexperience (join the club!). Although some of the findings regarding weathering sequences seemed (to me) to be perhaps open to question, the general conclusions relating to the interplay between intermittent ash-fall and pedogenesis were reasonable.

Professor Zueng-Sang Chen (National Taiwan University, Taiwan) was a veritable tour-de-force with his presentation entitled 'The characteristics and genesis of volcanic soils in Taiwan'. He described a range of the soils associated with activity from ~20 Pleistocene volcanoes that lie in Yangmingshan Volcanic National Park. Around 86 pedons, which included Andisols (Hapludands and Fulvudands), Inceptisols, Ultisols, and Vertisols, were studied on a series of transects. Soil mapping was undertaken using sampling transects, terrain analysis based on digital elevation models, and GIS. Transitions between between Andisols and Ultisols were examined closely on two transects, with four kinds of soils distinguished on the toposequences: Acrudoxic Hapludands (elevation >700 m), Andic Dystrudepts (~440 to 700 m), Typic Dystrudepts (~100 to 400 m), and Typic Paleudults (<100 m). These soils showed increasing bulk densities, decreasing amounts of short-range-order clays and lower phosphate retentions, and increased silicate clay contents. The relationships between soil properties such as these and environmental factors were discussed, as were the potential benefits of using terrain attributes to predict the distribution of soils. However, Chen acknowledged the difficulty in establishing reliable soil-landscape models for such a large area with only limited sampling (40 pedons). One point I picked up was that Taiwan has used Soil Taxonomy, rather than a national soil classification, almost exclusively since inception, apart from some use of the Japanese 'Classification of Forest Soils' (see below). All the terminology was routine. A second point was that small areas of non-allophanic Andisols, the properties of which are dominated by Al-humus complexes rather than allophane or ferrihydrite, are known in northern Taiwan, and that these additionally contained small amounts of 2:1 clays, gibbsite, and kaolinite. Chen spoke later at the JSP conference about some of the impressive successes and challenges for soil science in Taiwan (see below).

Dr Toshiaki Ohkura (National Institute for Agro-Environmental Sciences, Japan) gave a fluent presentation on the 'Characteristics and classification of Andosols derived from [eruptives from] Fuji volcano', a talk serving partly as an introduction to the field trip. He opened by commenting on the origins of the name 'andosols'. American soil surveyor W.S. Ligon in post-war Japan suggested that a great group 'ando podzolic soil' or preferably 'anshoku podzolic soil', derived from volcanic ash, be adopted by USDA. The 'podzolic' component was dropped as inappropriate but 'ando' (*an*, dark; *do*, soil, i.e. darkish/blackish soil) remained rather than the more commonly-used 'anshoku' (*an*, dark; *shoku*, colour or tint, i.e. dark complexion or blackish), probably for reasons of simplicity for English speakers (see also Simonson, 1979). The Japanese term kuroboku (*kuro*, black; *boku*, soft and friable) is widely used in Japan and is the name used for an order (Kuroboku soils) in the most recent classification system, the JSP's 'Unified Soils Classification System of Japan' (2002). The terms Andosols and Black Soils were used in earlier, separate classifications: Andosols in 'Classification of Cultivated Soils' (CCS, 1996), and Black Soils in 'Classification of Forest Soils' (1976). Ohkura then described four soils formed on mainly Holocene, Al-rich basaltic tephras from Mt Fuji, which were classified as Eutric Melanudands (Humic Cumulic Andosol in CCS), Pachic Melanudands (High-humic Cumulic Andosols), and Typic Fulvudands (Humic Haplic Cumulic Andosols). He noted some issues with the order of keying in *Soil Taxonomy*. (Later on the field tour, Dr Ohkura commented on the ongoing development of the 'Unified Soils Classification System', and I was invited to make some comments based on New Zealand and Australian experience in developing national classification systems.) Finally, he commented on the positive relationship between Ti and Fe in the basaltic-ash derived soils and suggested that Ti (from weathering) had been substituted for Fe in ferrihydrite and goethite. Furthermore, humus-rich surface horizons had high oxalate-extractable Ti and Fe (i.e. mainly ferrihydrite) whereas subsurface horizons had high dithionite-extractable Ti and Fe (i.e. mainly goethite). Ohkura suggested from these depth relationships that the high amounts of humic material had prevented crystallisation of secondary Ti and Fe in the surface horizons.

Professor Hiroshi Takesako (Meiji University, Japan) completed the lectures with a talk (his first-ever conference presentation in English) on 'Palaeoenvironmental change in south Kanto district: a 150-ky record based on physico-chemical analysis of a multilayered sequence of tephra deposits and andic paleosols'. He began by outlining the stratigraphy of tephra deposits and associated paleosols that occur in the Kanto district (greater Tokyo region) and introduced the concept of 'loam formation' (LF) that was used to divide the sequence (the Kanto Loam Group) into four parts (youngest to oldest): Tachikawa LF (*c*. 11,500–33,000 cal. yr BP), Musashino LF (*c*. 33,000–60,000 yr BP, Shimosueyoshi LF (*c*. 60,000–130,000 yr BP), and Tama LF (*c*. 130,000–400,000 yr BP). (The LF is approximately equivalent to the time-transgressive formations of accumulating 'packages' of andesitic tephras and andic soil material as used in New Zealand.) A series of four terraces has been mapped in the region, the oldest (Tama Terrace) being underlain by all four LFs and the youngest (Tachikawa Terrace) by just the Tachikawa LF. Takesako then described the results of a range of analyses undertaken on the sequence including humus, carbon, and phosphate contents, three-phase and particle size analysis, CEC, EC, base saturation, pH, total analysis of various elements (Si, Al, Ca, K, Fe, Ti, Mn), selective dissolution analyses of Si, Al, Fe, and clay mineralogy via XRD analysis. His findings included the observation that the humus and phosphate contents could be related to vegetation cover and hence climatic change, with vegetation cover sparse from c. 33,000 to c. 11,500 cal. yr BP during marine oxygen isotope stage (MIS) 2, but more luxuriant in the warm, temperate early Holocene than now. The concentration of humus (>15%) in the early Holocene was coincident with the start of the Jomon cultural era (and hence landscape change) and has resulted in the formation of the very distinctive, ~1-m thick 'Fujikuro' or 'Fuji Black' buried soil (Fig. 1). Less frequent tephra-fall from

Fig. 1. *The distinctive, 1-m thick, early Holocene 'Fuji Black' zone (mid-photo) sandwiched by orange scoria layers and andic horizons, Hirano section, Yamanakako village, ~20 km northeast of Mt Fuji. Organic carbon content in FB horizons is 5.2–8.6%.*

Mt Fuji at this time also allowed for rapid accumulation of humus. Phosphate content, being more sensitive, was a better indicator for palaeovegetation cover than carbon content. Points of relatively high humus/phosphate content coincident with buried A horizons may relate to interstadials including MIS 3. Allophane was the dominant clay mineral with small amounts of poorly-ordered halloysite occurring at depth as a result of receiving soluble Si from upper horizons. Small amounts of 2:1 Al-interlayered vermiculite in the upper soil horizons (mainly Holocene) were attributed to the deposition of aeolian dust during windy and dry conditions.

Field trip

The tour party of around 30 (Fig. 2) was treated to a mountain-and-plains landscape and remarkable

Fig. 2. *Participants on the field trip by Lake Yamanaka, with Fuji-san (3776 m) behind at left. The latest eruption of Mt Fuji was in 1707 AD.*

soils over the two-day trip primarily in Kanagawa prefecture to the west and southwest of Tokyo. Of central interest were Mts. Fuji and Hakone (within the Fuji-Hakone-Izu National Park) that have supplied tephras making up the mainly basaltic parent materials of the Andisols (Kurobokudo) in the region. The field guide (edited by **Dr Yudzuru Inoue**, Tokyo Institute of Technology, who attended the 50th anniversary meeting of NZSSS in Wellington, 2002) contained brief notes about the geomorphology, climate, vegetation, and general soil pattern. More detailed soil data, some obtained from masterate thesis work supervised by Prof. Hiroshi Takesako (Fig. 3) or from his own research, were given for the soil and tephra-paleosol sequences examined at each of three or four stops each day (including lunch breaks). One stop had to be abandoned on day 1 because heavy weekend-tourist traffic slowed traffic to a standstill at times. Overnight accommodation was in comfortable dormitory-style bunkrooms at the Tsukaba University field station on the shores of Lake Yamanaka adjacent to the Mt Fuji massif. Student helpers were ubiquitous both in the field and in preparing and serving the evening meal. Temperatures dropped to near freezing at night.

Fig. 3. *Prof. Hiroshi Takesako explaining the stratigraphy and pedogenesis of Ohkura soil, Hadona city, ~40 km east of Mt Fuji. Topmost label by extended hand marks Hoei (Ho) Scoria of 1707 Fuji eruption; base of sequence shown is c. 3000 cal. yr BP.*

The soils were impressively thick (e.g. Fig. 4), the 'Fuji Black' horizon soon became a 'friend' (diagnostic stratigraphic marker), and the discussions, both in the field and during periods of travel, were wide ranging and stimulating. A contrast with many New Zealand tephra-paleosol sequences was the dark colour of most of the buried humus-rich horizons (black A rather than brownish or yellowish brown AB or Bw horizons) (see section below on the origins of the humus). Also, the tephrostratigraphy and hence chronology was based mainly around differences in scoriaceous layers that provided ^{14}C-dated marker beds. Occasionally, distal, siliceous marker beds were present in sequences, including the 'Kawakawa of Japan', namely the *c*. 26,000 cal. yr BP 'AT tephra' from Aira caldera of southern Kyushu.

Fig. 4. *The impressive Fujisawa soil on Nihon University's Shonann campus in Fujisawa city. The upper A horizons (to ~1 m depth) represent humus accumulation (organic C content 6–11 %) in weathered scoriaceous eruptives from Mt Fuji dating to c. 6000 cal. yr BP; the lower (buried) A horizons (to ~ 2 m depth) represent humus accumulation in the Fuji Black zone dating from c. 6000 to c. 11,500 cal. yr BP. The soil is a Pachic Melanudand, a classic Kuroboku soil in the 'Unified Soils Classification System of Japan' or Thick High-humic Cumulic Andosol in the 'Classification of Cultivated Soils of Japan'. Brownish 20-cm-thick horizon at ~2 m depth (just below FB and overlying yellowish-brown ash) might represent loessic material associated with the Younger Dryas chron (my interpretation).*

Highlights on the trip, apart from the dramatic, black soil profiles and associated landscapes, friendly discussions, and tasty meals, included great views of the impressively bulky and high Mt Fuji on day 2 (3776 m high, *cf*. Mt Cook 3753 m), the susuki grasslands (Japanese pampas grass; Fig. 5), the intensive use of almost all arable flat land for both upland ('dry') cropping or gardening or orchards, and paddy fields for rice (awaiting planting in May), and the mixed forest cover of almost all mountains apart from the Japanese Alps (of which we caught a glimpse).

Fig. 5. *Extensive grasslands of Miscanthis sinensis in foreground, some cut over, at Sengokuhara in Hakone caldera.*

We were accompanied on the trip by several executives from the Fujiwara Scientific Company, and the amiable company president, **Mototsugu Fujiwara**, kindly donated a beautifully-made and functional stainless steel sampling tool for use by the Soils Group at Waikato University. We were also shown the capabilities of Fujiwara mechanized augers on day 1, and we visited the high-tech Shimadzu Corporation factory which was laden with gleaming analytical equipment including advanced electron microprobes, bench-top XRF systems, lazer sizers, and chromatographs.

Origins of humus in Kuroboku soils

A major part of soil organic carbon in Andisols and associated soils comprises humic acids, which are characterized by their stability and aromatic (humified) structure (Shoji et al., 1993; Hiradate et al., 2004). These features arise from the presence of labile and active metals, chiefly Al and Fe, supplied by the weathering of glass and other tephric materials, which are able to bind humic substances through strong coordination bonding to form macromolecules of Al- and Fe-humic acid complexes very resistant to degradation or leaching (Hiradate et al., 2004). The resultant very dark A horizons, typically melanic epipedons in *Soil Taxonomy*, can contain up to 15% organic carbon (Hiradate et al., 2004). Japanese pampas grass, M. *sinensis*, a C4 plant, has been maintained artificially for millennia in ancient Japan to provide roofing material, straw bags, and fodder, and burning the grass in early spring before germination was common practice (buds of the pampas grass are several centimetres underground and so are not damaged). During burning, large amounts of very dark-coloured and charred microparticles were produced and these provided a second source of humic acids, and the pampas grass had been regarded as a classic 'andisolizer' (Shoji et al., 1990, 1993; Hiradate et al., 2004) (see also Sase and Hosono, 1996, for a New Zealand perspective).

The relative importance of these two mechanisms (stabilization of humic acids by complexing reactions with Al and Fe, or cultivation of *M. sinensis* and its charred derivatives as a major source of carbon in humic acids) was evaluated by Hiradate et al. (2004) using $\delta^{13}C$ analyses of humic substances in a range of soils. They were able to compare the contributions from C3- or C4-plant-derived carbon because *M. sinensis* was effectively the only C4 plant species in (traditional) Japan. Hiradate et al. (2004) found that the contribution to humic and fulvic acids of carbon derived from *M. sinensis* ranged from 18% to 52%. Their conclusions were that although highly-humified, i.e. dark-coloured, humic acids tended to be derived from C4-plant-derived carbon (ultimately *M. sinensis*), the dominant source of carbon for humic and fulvic acids in many cases was from C3 plants (mainly forest vegetation). Consequently, the overriding importance of active Al and Fe especially on the formation and accumulation of the dark-coloured humic acids in Kuroboku soils (Andisols) was reinforced (Hiradate et al., 2004).

Mekong Delta highlights (not related to Andisols)

Another highlight was a pair of talks presented by invited Vietnamese soil scientist, **Dr Vo Quang Minh** (Cantho University, Vietnam), on the major problems facing rice farmers and soil scientists in the Mekong Delta region of southern Vietnam. Vo outlined very clearly seven problems in the region: extensive areas of acid-sulfate soils (mainly Sulfaquepts) and potential acid-sulfate soils, high P fixation (high Fe oxides), organic soils (Histosols) underlain by potential acid-sulfate materials, Vertisols, very sandy soils, high salinity, flooding, and soil degradation (mainly from excessive use of N and P fertilizers). All these required careful land management. Examples include growing pineapples in acid-sulfate soils (apparently tolerant of low pHs, <3.5, and very sweet when harvested), raising honey bees on the Histosols in melaleuca forests (*Melaleuca quinquenervia*, originally from Australia, known also as ‘paper bark trees’), and growing both rice and shrimps on a seasonal basis on potential acid-sulfate soils. In the last case, rice is cultivated in raised beds (to encourage leaching of toxins) during the wet season (May–December) and shrimps are farmed in flooded ‘ponds’ in the dry season (January–May), the key being to keep the soils permanently wet to prevent sulfuric or sulfidic horizons forming.

Shrimps were also being cultivated in mangrove forests, and the very sandy soils were used for upland crops (beans and other vegetables, citrus) using ‘fresh’ well-water for irrigation (water from areas of acid-sulfate soils was too toxic). Along the main rivers, farmers became fishermen when the soils were inundated with 1–3 m of floodwater each year. In the areas of Histosols, large fish (2 kg) were caught in drains alongside the melaleuca forests (the latter occasionally caught fire accidentally during honey harvesting by farmers using smoke). The application of fertilizers, especially N and P (with Cd contaminants), was recognized as unsustainable in the long term because of groundwater pollution. Substantial lime applications were also unsustainable because changes in pH were only temporary. A feature of Vo’s work was the practical use of the tropics-oriented Fertility Capability Classification (FCC) system and how the Mekong Delta work had led to its improvement for the intense cultivation of rice (see Sanchez et al., 2003).

JSP 50th anniversary conference

This conference with around 75 participants was held in plush, 5-star-hotel-like surroundings of the private (non-state) Nihon University at Fujisawa city. The JSP has ~600 members and usually holds one meeting each year for all members. In contrast, the Japanese Society of Soil Science and Plant Nutrition, with ~3000 members, holds one full-scale national conference, and one local conference at each of six branches, each year.

Oral papers, including an opening review covering the last 50 years of JSP, were followed by 21 poster papers and then Professor Zueng-Sang Chen gave an invited talk (the only one in English) about the achievements and problems of pedology in Taiwan over 50 years. I was interested and impressed with his messages: many large-scale soil maps had been produced, familiar USDA-based systems and terminology had been used since 1938 (e.g. use of soil series, type, and phase; there are about 1000 soil series in Taiwan *cf.* ~1800 in New Zealand), the use of GIS and terrain analysis for predictive soil mapping was well advanced, and substantial amounts of soil information were readily available on the internet (somewhat similar to the ‘soils portal launch’ planned for New Zealand, as described by Gibb and Hewitt, 2006). Truly impressive was the commitment shown by central government to the value and importance of soils and soil functioning in the form of a US$3-billion, four-storey building housing a permanent national soil museum with >200 soil monoliths and associated material on display. Smaller, mobile soil education displays have also been constructed to illustrate soil functions at a more local level. In looking ahead, Chen recognized, like many others (a panel discussion on this topic concluded the JSP conference), the need for new ‘angles’ to help stop the decline of pedologists (currently there are about 10–15 pedologists active in Taiwan) and to re-awaken the central role of soil science in society. He emphasised the need to encourage students into the disciplines of pedology and soil science by showing them how they could make practical contributions in (at least) three areas: soil pollution prevention, soil remediation, and soil environmental analysis.

This message is now very clear and those of us involved in soils education must move our courses (and research projects) in these directions, even if it means re-naming our discipline 'environmental soil science' or perhaps amalgamating with hydrology to become 'environmental soil and water science'. The theme for this year's NZSSS conference in Rotorua, 'Soils and Society', is most apt. Our attempts at developing a modest soil science exhibit for Te Papa offer a marked contrast to the success in Taiwan, and I dearly wish that our leading politicians could be given a guided tour of the soil museum in Taiwan by Prof. Chen. In earlier discussions, Chen additionally commented that his university in Taipei is essentially paper-free: with only rare exceptions, no one is able to print off any documents, a conservation-driven, cost-saving policy.

Conclusion and acknowledgments
The Meiji University symposium and field trip, organized and run very ably by Prof. Hiroshi Takesako and his colleagues and hard-working students, was very stimulating, friendly, and worthwhile. I am deeply appreciative of the generous support I and the other guest speakers received from the sponsors and from Prof. Takesako personally in attending and participating in the symposium. It was also an honour to participate in the JSP 50th anniversary meeting, at which I encouraged Japanese (and other Asian) soil scientists to come to New Zealand for the next joint Australia-New Zealand soils conference at Massey University in 2008. There are strong historical links between Japanese and New Zealand soil scientists – founded chiefly in Andisols and associated soils – and long may they continue.

I also thank Dr Syuntaro Hiradate (National Institute for Agro-Environmental Sciences, Tsukuba) for providing information about Japanese pampas grass and for giving me a series of excellent papers on new research undertaken in his laboratory. It was wonderful to meet up with colleagues and students whom I had met previously in Japan, and especially those who have visited New Zealand recently including Drs Toshiro Nagasako, Yudzuru Inoue, and Hiroaki Sumida, Prof. Renzo Kondo, Yoshi and Yohko Tsuda, and Kosuke Moriwaki.

Note: I have copies of the references below including the Meiji Proceedings – please email me if you would like copies.

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thesis abstract

Abstract of thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Earth Sciences, the University of Waikato.

Effects of severe cattle treading on soil physical properties and pasture productivity

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Severe cattle treading can result in compaction and pugging, of which the latter was the focus of this thesis. Pugging is one of the severest forms of treading damage to soil, and occurs when soil is grazed while near saturation, resulting in plastic and liquid soil deformation. The research objectives were to quantify effects from one-off treading events, at different severities, on soil physical properties and sward characteristics, to monitor recovery from the one-off treading event, and to develop methods of estimating potential effects of treading on pasture productivity.

Three field experiments were carried out on a Te Kowhai silt loam soil (NZ soil classification, *Typic Orthic Gley*; USDA soil taxonomic classification, *Typic Endoaqualf*) supporting a mixed sward of ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.). A one-off treading event of either 0 (control), 3, 9, or 24 hours was carried out using lactating Holstein-Friesian cattle (300 cows ha^{-1}) at three soil moisture contents (65%, 71%, and 81% gravimetric soil moisture content). Soil physical properties, soil surface features, and sward characteristics were monitored for up to 34 weeks after the treading event.

Longer treading durations at wetter soil conditions had increasingly detrimental effects on soil macroporosity, saturated hydraulic conductivity (K_{sat}), unsaturated hydraulic conductivity (K_{-40}), surface roughness, depths of pug prints, bare ground area, ryegrass tiller density, and herbage accumulation. Soil dry bulk density and total porosity did not change, even under the severest of treading damage, because decreases in macroporosity were offset by increases in microporosity ($r^2 = 0.63$; $P < 0.001$).

The area of bare ground increased to up to 87% of the soil surface and correlated with decreased in herbage accumulation ($r^2 = 0.73$; $P < 0.001$). Sward botanical composition did not change after treading damage, except when large patches of bare ground persisted into spring, resulting in the establishment of broad-leaved plantain (*Plantago major* L.).

Soil and sward recovered (i.e. no significant difference compared to simultaneous controls) following treading damage and when the pasture continued to be rotationally grazed. The recovery of macroporosity, K_{sat}, and K_{-40} indicated that the soil had an increased susceptibility to further treading