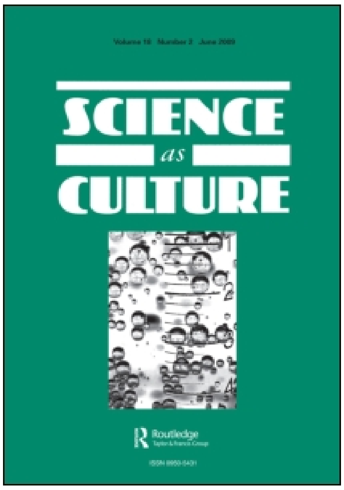

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Banking Seed: Use and Value in the Conservation of Agricultural Diversity

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ABSTRACT *Since the 1930s it has been widely acknowledged that agricultural crop diversity is being lost at an alarming rate. The international response to this genetic erosion has principally taken the form of ex situ genebanks. In these facilities and in the international regulatory frameworks that now surround them, it is genetic diversity that is the focus of conservation efforts. This focus, however, passes over the many other important diversities—both biological and social (or 'biosocial')—that exist in, and depend on, agricultural environments. These diversities cannot be conserved in genebanks. In addition to failing to actually conserve agricultural diversity (in any full sense of the term), ex situ banking projects also produce important potential inequalities—in terms of which material is banked and who has access to it. If, however, we refuse to accept an exclusive focus on the genetic components of plants, and instead insist on a brand of conservation that includes whole biosocial, more-than-human communities, then the role of banked resources must be radically rethought. Genebanks might instead take the place of central nodes in networks of diversity sharing, helping to keep plant varieties growing and circulating. This focus, in turn, requires that we also pay more critical attention to the various economic, legal and other mechanisms that prevent or stifle the flow and development of plant genetic resources in/to agricultural communities—especially those of peasant and indigenous farmers that play such a crucial role in conserving the world's (agro)biodiversity.*

KEY WORDS: Conservation, agriculture, nature, genebanks, plant genetic resources (PGR)

Introduction

At this point in the history of our planet we are losing species diversity far more quickly than it is evolving (Quammen, 1997). We are in the midst of what some scholars are calling the Earth's sixth great extinction event—the first one caused by a single species, our own. The diversity of life on this planet is quite literally slipping away, perhaps ushering in the 'age of loneliness' that E.O. Wilson (2003) has referred to. In agricultural domains this loss of diversity has been going on for quite some time, and has a number of complex causes—central to them, however, is the ongoing and widespread replacement of traditional varieties with 'improved' ones (FAO, 1996b, p. 13). As the human

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population grows, placing more and more pressure on a diverse range of ecosystems, the push to increase food production—largely through the 'modernisation' of agriculture and the adoption of a more limited range of 'high yielding' crop varieties—is only increasing. Efforts to conserve agricultural diversity have always taken place at this complex intersection between loss and modernisation—a space that is becoming increasingly difficult to navigate, while it is also becoming ever more important: in terms, for example, of responding to the growing incidence of malnourishment and hunger around the world (FAO, 2002). Historically, and up to the present day, these agricultural conservation efforts have been dominated by *ex situ* genebanks. But what kinds of diversity matter in these banking practices? How are nature and diversity imagined and produced here, and with what consequences for whom? Finally, what alternative possibilities might be opened up by a rethinking of diversity and its conservation?

In an effort to address these questions, I begin by charting some of the important events of the past decades that have contributed to the production of the specific brand of international agricultural conservation with which we find ourselves today. Ultimately, I argue that at both a regulatory and a practical level, international 'conservation work' aims only to ensure access to valuable genetic resources as opposed to really *conserving* plants or agricultural environments. This focus on genetic resources is highly consequential. In this case it has important outcomes both in terms of who has access to banked resources, and perhaps also in terms of which resources are conserved at all. The final half of this paper draws out these consequences with specific reference to interviews conducted at a genebank and two seed saving NGOs (in Australia and the US). This discussion centres on the way in which nature and human/crop relationships are imagined in these facilities, and the way in which these understandings influence the work of banking seed. Ultimately, the paper argues that it might be possible to 'bank well', but that these practices must be premised on conserving 'biosocial' natures, on understandings and systems of banking in which resources are not stockpiled, but are rather shared and kept moving in more-than-human agricultural communities.

Rethinking Nature

Drawing on interviews and field visits, together with a close reading of international agreements on conservation and literature from a variety of different disciplines, I explore the ways in which nature and diversity are conceptualised and ultimately conserved in gene banking projects. This discussion is rooted in the simple idea that how we conserve nature depends on how we understand that nature that must be conserved. In her work on bioprospecting, Cori Hayden has explored the way in which conservation practices are entangled with nature/s, both in terms of the ways that they imagine nature, and in terms of the natures that they help to produce. In doing so, Hayden has highlighted a transition over the past few decades in which biodiversity has come to be increasingly revalued as an 'informational' input into the drug, biotechnology and agrochemical industries. This situation has in turn contributed to the widespread adoption of a particular brand of conservation-as-cataloguing in which it is the genetic informational components of biodiversity that are often most highly valued (Hayden, 1998, 2003, pp. 53–59).

The origins of the conservation projects discussed in this paper predate by several decades the bioprospecting that Hayden has discussed. Specifically *agricultural* conservation projects began in the 1960s and 1970s after it was internationally acknowledged that crop diversity was being lost at an alarming rate. These projects primarily took form around the collection and storage of seed in genebanks (called '*ex situ* conservation'). Decades later, this banking-work is still the central part of international agricultural conservation efforts. It is clear, both in the context of the work carried out in these *ex situ* facilities and in the regulation of agricultural conservation in the United Nations, that—in line with Hayden's observations—a particular kind of nature is being imagined and produced here. More specifically, my position is that these projects do not aim to conserve agricultural biodiversity at all, but rather aim to protect *and make readily available for use* a unique kind of instrumentalised genetic life. This life is captured in these international agreements under the rubric of 'Plant Genetic Resources for Food and Agriculture' (PGRFA). This focus on PGRFA has, however, meant that the conservation of the genetic information contained in organisms now often takes centre stage at the expense of conserving the 'messy, thick organisms' themselves (Haraway, 1997, p. 246), let alone the environments and co-evolutionary interactions within which these organisms are themselves produced and nourished.[1]

A central focus of my analysis, however, is the broader agricultural context beyond the genetic materials of plants. As will be discussed in greater detail below, this broader context includes both biological organisms of various kinds *and* their diverse socialities—their ways of knowing and interacting with one another. In an agricultural context these socialities must be understood to include all of the cultures of agriculture; the diverse systems of understanding, farming and generally getting on in agroecosystems that have developed between humans and non-humans over countless generations. In this paper I have employed the term 'biosocial' to refer to these broader natures and diversities which exceed (*but also take in*) the merely genetic components of plants that have become so central to conservation efforts. The term 'biosocial', therefore, marks the way in which humans are inextricably entangled with various non-humans in both the cultivation of crops and the making of agricultural socialities, knowledges and practices. With this in mind, my usage of the term has more in common with the 'mixing' work that Haraway's (1997) concepts of material-semiotics and naturecultures are doing, than it does with Rabinow's 'biosociality' (1992).

This paper also employs the concept of the 'more-than-human' world to describe environments and interactions in which humans come together with non-humans. The term is not equivalent to 'non-human', but rather describes, as Patrick Curry has noted, the 'more-than-(but including)-human' (Curry, 2008). While all environments—especially agricultural environments—are to an important extent 'more-than-human', this term is important in the context of discussions of agricultural conservation work because it describes communities and places in which human projects and desires are not completely dominant. These are multi-species communities in which a space is held open for other organisms to live and possibly even flourish. In this context I have sometimes contrasted genebanks as human dominated environments to the more-than-human communities of life that can be conserved in farmers' fields—especially those of low input (semi-) subsistence farmers, whose 'cultures' and ways of life are often intimately entangled with agricultural practices. This is clearly not a black and white distinction, and is intended simply to mark a general difference in conservation priorities between *in situ* and *ex situ* methods.

Ultimately, this analysis—which focuses on the ways in which 'nature' and 'diversity' are understood and conserved—highlights the deep roots *at both a practical and a* *regulatory level* of the exclusive focus on the genetic components of plants that has come to dominate agricultural conservation, as well as the highly consequential nature of this focus. Additionally, by focusing on understandings of nature and diversity, this approach opens up a space to rethink these concepts. Doing so reveals that conservation cannot be separated off from the broader legal, social and economic context within which crop development and farming today take place. This analysis ultimately shows that it is only through an acknowledgement of these connectivities and a willingness to do the difficult work of navigating and renegotiating them, that we might hope to conserve agricultural diversity into the future.

Conserving Agricultural (Bio)diversity

The realisation that potentially valuable agricultural diversity (at both a varietal and a species level) was being lost, first gained public awareness in the 1930s—far earlier than the more widespread 'environmentalist' concern about the loss of biological diversity that took hold in the 1980s and 1990s (Pistorius, 1997, p. 69). H. V. Harlan and M. L. Martini are usually credited with having first recognised this 'genetic erosion' of crop plants (Brush, 1999; FAO, 1996b, p. 20). In making this observation in the 1930s, Harlan and Martini also pointed out that a significant cause of this erosion was the replacement of traditional cultivars with 'improved' varieties, a situation that still remains one of, if not *the* greatest, cause of agricultural biodiversity loss (Brush, 1994, p. 4; FAO, 1996b, p. 13; Hawkes *et al.*, 2000, p. 6).

In addition to noting the relationship between the introduction of improved varieties and agrobiodiversity loss, Harlan and Martini also pointed out (in 1936) that in this context collections of germplasm would be immensely valuable in the future:

> When new barleys replace those grown by farmers of Ethiopia or Tibet, the world will have lost something irreplaceable. When that day comes our collections, constituting as they do but a small fraction of the world's barley, will assume an importance hard to visualize (quoted in Kloppenburg, 2004, p. 162).

This awareness of agricultural biodiversity loss, which was definitively formulated in the late 1960s and early 1970s, led to a global conservation effort (Brush, 1999). In a climate of crisis, this effort primarily took form around the *ex situ* storage of germplasm (primarily in the form of seeds) in genebanks, as opposed to attempting to conserve plants in the environments in which they originated, or were currently found—called *in situ* conservation (FAO, 1996b, p. 20).

The two central forces in the initial years of this conservation effort were the Food and Agriculture Organization (FAO) of the United Nations (UN) and the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is a 'strategic alliance of countries, international and regional organizations, and private foundations' (CGIAR, 2006) which together support 15 International Agricultural Research Centres (IARCs). These centres have been founded over the last several decades (starting with CIMMYT in 1959), with mandates to develop new higher yielding varieties of specific crops in particular regions.[2] In 1974 the FAO joined forces with the CGIAR to found the International Board for Plant Genetic Resources (IBPGR, subsequently IPGRI, and now Bioversity International) which was to oversee the *ex situ* banking of Plant Genetic Resources

(PGRs) (Kloppenburg, 2004, pp. 163–165). By this time several of the IARCs of the CGIAR had been established for over a decade and had developed large germplasm collections for use in their breeding programmes (Kloppenburg, 2004, p. 161). These facilities had ready access to this germplasm because they were largely based in the (Vavilov) centres of diversity for the crops on which they worked.[3]

In addition to the CGIAR facilities, many national and regional genebanks have also been established, and it is these facilities that now store by far the majority of the estimated 6.1 million agricultural plant accessions that are held in approximately 1,300 facilities worldwide. As the FAO's (1996b) report on the state of the world's PGRFA has documented, however, there are numerous problems with these facilities around the world. In particular, many of them do not have long-term storage capabilities, and a large percentage of the accessions (perhaps as many as a million) held by many other facilities are in desperate need of regeneration—the process whereby seeds are planted, cultivated and recollected to keep them viable (FAO, 1996a, Art. 10a).

In addition to these physical facilities, efforts to conserve agricultural genetic resources have been worked out in important ways in various international fora. The first broad reaching international agreement on the conservation and equitable use of plant genetic resources (PGR) was the FAO's 1983 *International Undertaking on Plant Genetic Resources*. This agreement was, however, quickly supplemented by three annexes and eventually largely superseded by the two agreements that today form the basis of the international consensus on PGR conservation, namely, the UN Environment Programme's 1992 *Convention on Biological Diversity* (CBD) and more specifically in the case of agricultural plants, the UN FAO's 2001 *International Treaty on Plant Genetic Resources for Food and Agriculture* ('Treaty'). In a joint paper with Carolina Roa-Rodríguez, we have outlined the specific dimensions of each of these international agreements and the significance—for conservation, property rights and shared use—of the transitions between them (Roa-Rodríguez & van Dooren, 2008).

Seed as 'PGRFA'

But what type of conservation do these international gene banking projects and agreements like the Treaty aim to achieve? Which 'natures' and what kinds of human/plant relationships are imagined and produced here, and with what consequences for whom? My position is that in *ex situ* banking projects seed is used as a kind of 'proxy' for agricultural plant varieties that are being lost. By definition, however, a proxy is not equivalent to that which it 'stands in' for. Rather, as Bronwyn Parry has argued, proxies are representations or parts of objects or organisms that are more readily useable for a specific purpose (i.e. storable, tradable, transmissible) and reproduce some aspect/s of that thing in a reliable, or at least acceptable form (Parry, 2004, pp. 22–23). In other words, the proxy is a 'good enough' embodiment or representation of something for some given purpose. As previously noted, in the climate of crisis that surrounded the discovery of the genetic erosion of crop varieties, *ex situ* seed banks were adopted as a conservation strategy. Here, seed became a proxy for these plant varieties. As a 'good enough' representation, however, the question remains: *what for* and *for whom* are seeds 'good enough'?

The first thing to note in this regard is that what the Treaty explicitly aims to conserve are not real embodied organisms involved in processes of growth and evolution [called 'biological diversity' in the CBD (Art. 2)]. Instead, the focus of the Treaty is on conserving and providing access to the *genetic components* of organisms (PGRFA). In both the CBD and the Treaty, these genetic components are clearly distinguished from the 'biological resources' within which they are found. Both agreements define 'genetic materials' as any material containing 'functional units of heredity' (Treaty, Art. 2; CBD, Art. 2).[4] It is these materials that the Treaty aims to conserve and equitably share (Art. 1.1). In contrast, 'biological diversity' is not even defined in the Treaty. The term is only used twice, and then only in the context of its relevance to the sustainable use and conservation of *genetic* resources (Art. 6).

Understandably, this focus on the genetic over and above the biological components of organisms is also present in the way in which agricultural conservation efforts have been, and still are, carried out. As previously noted, these efforts centrally revolve around the *ex situ* conservation of germplasm. While the important role that *in situ* conservation might play has been increasingly acknowledged in recent years—for example in the CBD (Art. 8) and the Treaty [Art. 5.1(d)]—current international conservation efforts are very clearly weighted in favour of *ex situ* projects. In contrast to *in situ* conservation projects in which genetic resources are conserved within the 'biological diversity' that they represent, the dominant *ex situ* strategy is particularly interesting because it reduces what must be saved down to its most essential features. Partly for reasons of cost, partly for ease of access, and partly because we cannot hope to conserve all of the world's vanishing agricultural diversity, the way in which *ex situ* genebanks 'do seed' highlights a series of priorities.

In particular this approach to biodiversity separates off what must be conserved from the expensive and unnecessary biological components within which it is normally found. Seed, pollen, vegetative propagation materials and DNA are all utilised as vessels for genetic resources in these *ex situ* projects.[5] These tangible vectors are used to embody or 'capture' the genetic information of the plants that they come from or will grow into, in various forms that are reasonably easy and economical to store and access. Bert Vissier *et al.* clarify an important part of this situation when they point out that the CBD:

> distinguishes three integration levels of biodiversity, including agrobiodiversity, i.e. 'the diversity within species, between species and of ecosystems' . . . Only genetic resources, i.e. the biodiversity at the lowest integration level, can be conserved *ex situ*, at a site distant from the original occurrence of the conserved material. Diversity between species and of ecosystems, as well as the indigenous knowledge relating to agrobiodiversity can only be effectively maintained *in situ*, in the agricultural production context in which these are functional (2002, p. 13).

In the banking of seeds, therefore, it is neither 'cultural', nor even biological diversity (in any full sense of the term), that is to be conserved. Rather, it is simply genetic diversity that is being banked. The meaning of the term 'diversity' changes here in a subtle but important way. Within the context of *in situ* conservation, diversity is a relational concept that captures co-evolutionary interactions within a field of *biosocial* complexity—that is, within a space in which religious, nutritional, economic, and a host of other broadly cultural *and* biological factors are (or at least can be) inextricably entangled (van Dooren, 2007). In the case of genetic conservation *ex situ*, however, diversity has become purely a numbers game. More types equals more diversity. Thus, even while genes are conserved *ex situ*, both biological organisms (human and not) and the relationships which comprise the biosocial natures that *are* agriculture, cannot be.

In the world of biodiversity conservation, the distinction between biological/cultural diversity on the one hand, and genetic diversity on the other, needs to be understood alongside another distinction: namely, that between genetic *materials* and genetic *resources* (which is made in both the Treaty and the CBD). In both agreements 'genetic material' is understood to be any material 'containing functional units of heredity'. Similarly, both fundamentally define 'genetic resources' as 'genetic material of actual or potential value' (CBD, Art. 2; Treaty, Art. 2). Genetic resources, therefore, are a subset (albeit an undetermined and changing one) of genetic materials, separated off by the promise of 'value'. This is a distinction that might be missed on a surface reading of either document. The Treaty, for example, defines its objectives as:

> the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security (Art. 1.1).

Thus, it is not plant-based agricultural genetic diversity *per se* that the Treaty seeks to conserve and equitably share, but only the subset of (potentially or actually) *valuable* resources within it. Nigel Maxted and Shelagh Kell confirm this position when they remind us that:

> The goal of plant genetic conservation is primarily direct use through exploitation for crop improvement. We expend resources on the maintenance of genetic, species and ecosystem diversity because of their immediate or potential utilization value to humankind (Maxted & Kell, 2007, p. 450).

Within this context, conservation is solely about preserving access to a plant's genetic information for future human use. The category of life that must be conserved in these agreements and banking projects—PGRFA—emerges here as a particular type of *instrumentalised genetic* life, divorced from broader webs of relationality and viewed solely as an input into human endeavours. In these seed banking practices the biological components of organisms and their environments (the other two types of diversity noted by the CBD) are completely unimportant, and it is only genetic diversity that must be conserved. As a conservation-proxy, therefore, seed is only being used (and to an important extent only able) to 'stand in' for agricultural plant varieties and ecosystems in a very limited way. In other words, it isn't really 'good enough' for conservation. What then is it good enough for?

In large part the answer to this question is provided by the Treaty itself which, as noted above, clearly points to both conservation and the sustainable *use* of PGRFA as its key objectives. Alongside developments in molecular biology and genetic engineering, and a burgeoning trade in the disaggregated genetic, biochemical and informational components of organisms, genetic materials have themselves become both very useful and very valuable resources (Parry, 2004). In the case of specifically *agricultural* conservation, however, seed banking projects predate the well documented legal, economic and scientific developments in the 1970s and 1980s that aligned to produce the current situation in which life has been rematerialised as potentially very valuable pieces of genetic informational property.[6]

Even in this earlier period, however, seed was understood as a useful and valuable conservation-proxy for disappearing agricultural varieties and ecosystems. From at least the 1960s to the present day, seeds have been valued and utilised in international conservation projects as a means of conserving and making readily available genetic resources that might otherwise be lost. Unlike much of the current genetic conservation and property environment, which is in large part driven by profits secured through the isolation and/or modification of genetic material and subsequent patent claims, these earlier agricultural conservation efforts were initially motivated by the sustainability of agricultural systems, and later also the profitability of agricultural inputs [protected by both patents and Plant Variety Protection (PVP) systems]. Although the scientific, legal and economic contexts have changed markedly over this period of time, seed has remained a 'good enough' proxy because these efforts have only ever aimed to conserve *PGRFA* (under different rubrics and guises). Their objective has simply been to make genetic resources available for human use, not to conserve agricultural environments and diversity in any fuller sense of these terms. It is this reality that, decades later, was captured in the priorities of the International Treaty on PGRFA that I have outlined above.

In order to use seed as a conservation-proxy in this way, the nature that has to be imagined is one in which non-humans, or at least agricultural plants, exist solely for use in human projects. There is an important instrumentalisation of non-humans going on here (Plumwood, 1993, pp. 52–53), one that attaches no real or essential value to their living for their own sake, or to the broader relationships that comprise agricultural environments. It is only through this reductionist and economically convenient understanding of 'nature' that the conservation carried out in *ex situ* banking projects and mandated in agreements like the Treaty can look like *conservation* at all. What, though, are the consequences of this approach to nature and its conservation? Is there really a significant difference between having plants growing out in the world, in more-than-human communities, and having genes or seeds in a bank?

Other Diversities in PGRFA Worlds

In raising this question I have not intended to imply that resources held in genebanks are not 'in the world', but rather simply that they are in the world in a specific (and limited) way, namely, as genetic informational resources for human use. The important differences between 'living' in a genebank and in a farmer's field introduce crucial questions about the ways in which, and the people for whom, seed is a good enough proxy. The following quote from Daniel Querol's fieldwork in Jala, Nayarit (Mexico) raises for me precisely these questions.

> The maize of Jala, known for its big size (ears of up to 60 cm in length) ... had apparently disappeared. According to the peasants, Jala maize could not 'compete' with the hybrid, as it was getting contaminated with pollen from the hybrid which was widely planted in the area. Fortunately, there is maize of this kind in the germplasm bank of the Ministry of Agriculture in Mexico (Querol, 1993, pp. 46–47).

With this situation in mind, my question is: how does it help a peasant farmer that genetic material from a variety of maize that they once grew is stored in a genebank in Mexico? Does the disappearance of this variety of maize from their community still mean something even if its genes are banked? Is diversity still 'lost' in an important sense? In raising these questions I am not denying the importance of conserving crop germplasm *ex situ*. As we move deeper and deeper into the Earth's sixth great extinction event any effort to prevent diversity loss should be taken very seriously. This does not mean, however, that we should not attempt to analyse the many important differences between various conservation projects—in this case, *inequivalences* between *ex situ* PGRFA and actually existing *in situ* 'biological diversity'. In drawing out these inequivalences, I aim to show that PGRFA-inflected conservation both imagines *and produces* particular kinds of natures which have important consequences for all life on this planet. These consequences emerge from the reality of both what gets banked and also how (and for whom) it is made available for use. As a result, only certain kinds of natures, only certain human/plant relationships and possibilities, are supported and nourished in these conservation projects.

Seeds as Genetic Resources

Within the context of the focus on genetic resources that I have outlined above, the seeds held in national and international genebanks are primarily utilised as a convenient form of 'gene storage'. Consequently, it is the genetic information that a seed contains, as opposed to the plant that it might grow into, that is valued. This database focus, however, ultimately contributes to the shaping of the way in which these facilities are both designed and operated. An instructive contrast can be drawn here between genebanks and community seed banks/fairs. While the latter are focused on providing seed directly to farmers (either after large 'disasters', local crop failures, or as a day-to-day means of sharing and trading diversity) (Lewis & Mulvany, 1997), genebanks primarily provide genetic resources to plant breeders and other gene storage facilities. They are simply not designed to be of *direct* benefit to farmers. This is the case for a variety of reasons, ranging from the fact that these facilities only provide small amounts of seed (that would need to be multiplied through labour, time, and land intensive processes to be of use to most farmers), to the fact that most of the world's farmers live 'in areas with poor and/or inaccessible road and electronic services', and so could not make use of these banks even if they did know that they existed (Musa, 1998). These are problems that are, of course, exacerbated by holding accessions in DNA, pollen or *in vitro* forms that require particular infrastructures and expertise to be utilised at all.

While it is possible, therefore, that genebank accessions might be used directly by farmers—in fact this has happened with CGIAR seed after severe disruptions to agricultural systems in Nicaragua, Honduras and Rwanda (CGIAR—Future Harvest, 1999; Mezzalama, personal correspondence, 25 March 2006)—this is not primarily how seed gets 'done' in these facilities. Although there are very definite holes in available data about who uses these genebanks and why (Rubenstein & Smale, 2004, p. 2), it is clear that—with the exception of some possible future use through their long-term conservation—these collections are almost exclusively used as inputs into crop breeding or other research programmes. This is a point that Kelly Day-Rubenstein and Melinda Smale make well in their analysis of the US National Plant Germplasm System

(NPGS). Drawing on user surveys, Day-Rubenstein and Smale argue that '[t]he type of germplasm distributed suggests a user community that is actively involved in plant breeding' (2004, p. 13); they find that motivations for requesting germplasm from the US NPGS are exhausted by breeding, research and conservation agendas (2004, p. 15). I have also confirmed this point in conversations with staff at both CIMMYT (Mezzalama, personal correspondence, 25 March 2006) and the Australian Winter Cereals Collection (AWCC scientist, 18 April 2006).[7]

In addition to these facilitates being primarily designed for the use of specific groups, their day-to-day operations also generate the possibility of another set of important inequivalences in terms of which genetic materials are actually banked within them. As noted above, the distinction between 'genetic materials' and 'genetic resources'—made in both the Treaty and the CBD—is premised on the 'actual or potential value' that the latter are thought to possess. This situation clearly prompts the questions: what constitutes *value* in this context, and who decides what does and does not possess it? While recent in-depth overviews of international germplasm collections are limited, some older studies show a strong correlation between the banking of crops and their international market relevance (Querol, 1993, pp. 70–74; Salick & Merrick, 1990; Lyman, 1984, pp. 4–5). If this correlation holds true, many crops that are very significant to developing nations—such as cassava (FAO, 1996b, p. 9)—may not be receiving adequate conservation attention.

A Tale of Two Seed Banks

The importance of the contrast between direct use by farmers and gardeners on the one hand, and use as an input into breeding programmes on the other, was clarified for me when I visited and interviewed staff at two different seed banks. The first of these was the afore-mentioned Australian Winter Cereals Collection (AWCC) and the second was an NGO called The Seed Savers' Network.

The AWCC is run by the New South Wales (NSW) state government's Department of Primary Industries and is based in the rural town of Tamworth, NSW. The facility was established in 1967 and holds approximately 50,000 accessions, primarily of wheat, barley, oats, rye and triticale. Its primary purpose, as explained to me by an AWCC scientist, is to provide accessions to 'bona fide researchers'. 'In the long run', he explained 'all that it [the collection] is for is cultivar enhancement' (AWCC scientist, 18 April 2006). In order to make this genetic material as useful as possible, however, the staff at the AWCC try to attach as much information to each accession as possible. To this end, it has become standard practice for collecting missions to use global positioning systems (GPS) to record the precise location of collection. This information is now often used as part of the Focused Identification of Germplasm Strategy (FIGS) to provide precise environmental data about the sample.

FIGS is the result of a collaboration between the AWCC, the International Center for Agricultural Research in the Dry Areas (one of the IARCs of the CGIAR) and the N.I. Vavilov Research Institute of Plant Industry in Russia. The project aims to attach agro-climatic parameters to specific collection sites to 'build up detailed environmental profiles of the habitats in which a given genotype evolved' (FIGS, 2005). Based on these profiles, the scientists hope to be able to identify samples that are more likely to exhibit specific resistances or tolerances to conditions like drought, salinity, specific pests, etc. In so doing, FIGS aims to increase the ability of breeders to find the specific traits that they are looking for. At present the project is working exclusively on bread wheat, but the system being developed is in principle applicable to any genetic material.

A few days after visiting this facility I visited a seed bank of a very different kind in the coastal town of Byron Bay in northern NSW, Australia. Michel and Jude Fanton (see Figure 1) started the Seed Savers' Network in 1986 with the goal of both informing people about the impacts of restrictive laws on seed saving, and producing a network through which people might save and share crop diversity (Michel Fanton, 21 April 2006). In contrast to the government run AWCC and its refrigerated, humidity protected, seed storage, the Seed Savers' Network is run from the Fanton's house, and its 'main collection' is stored in what looked like old card file catalogues, as well as in the gardens around the house.

While speaking with Michel Fanton, however, I discovered that the seed that was held locally was not really the Network's main collection at all. As Fanton described it, there are four different kinds of seed banks/collections. Most large *ex situ* banks have three of these different types of collections: long term, short term, and working collections. According to Fanton, however, the Seed Savers' Network is part of a fourth seed bank, the diffuse seed bank which is 'in culture' and is the backbone of these others (Michel

Figure 1. Michel and Jude Fanton, founders of the Seed Savers' Network, Byron Bay, Australia. *Credit*: Michel and Jude Fanton.

Fanton, 21 April 2006). The 'main collection' of the Seed Savers' Network, therefore, is in the gardens and fields of the people that have received the approximately 500,000 packets of seed that they have sent out over the past 20 years.

> We understood straight away that the human factor was very important, and that we were not going to become a frozen seed bank. So straight away we kept hardly any seeds here, we kept on moving them straight away, knowing that other people will do it if you give them the tools and the methods—we got these methods from farmers and gardeners around Australia . . . So we started redistributing knowledge and seeds . . . asking people to save seed and to keep as much genetic diversity as possible. People end up with an embarrassing amount of seed, what do they do with it? They share it (Michel Fanton, 21 April 2006).

In contrast to a more conventional genebank, therefore, the Seed Savers' Network teaches people to save and share diversity by continually keeping seeds growing and moving. To this end they have established Local Seed Networks around Australia and similar projects in East Timor and the Solomon Islands (Seed Savers' Network, 2004). They also run workshops and training courses on seed saving and have written a handbook on the topic. With a map of the Australian Local Seed Networks on the wall (see Figure 2), the office of the Seed Savers' Network looks (and operates) more like mission control than a central

Figure 2. Map of Australian Local Seed Networks at the Seed Savers' Network, Byron Bay, Australia. *Credit*: Thom van Dooren.

repository of seed. Its main goal seems to be introducing and co-ordinating a vast network of people, plants and their seeds.

Despite these differences, the Fantons see their work as being complementary to, not at odds with, that of the international genebanks. They are, however, more than a little annoyed by the unwillingness or inability of many of these larger banks to share their accessions with farmers and gardeners in useful and meaningful ways. On this topic Michel Fanton said:

> We would like for them [*ex situ* banks] to show good will and do some repatriation, and not just media gestures . . . systematic repatriation of seeds to organisations [and people] that are capable of maintaining the seeds—and they would be because you're talking about indigenous farmers that are fluent in the skills of the earth (Michel Fanton, 21 April 2006).

In this context Fanton relayed the experiences of some colleagues in Cuba who were attempting to set up a seed network for local farmers in Havana. When they applied to genebanks for capsicum seeds, however, they either received no response or where told that the sample was too small and they should go elsewhere. In this context he commented that:

> Perhaps these people are getting the run around, perhaps the system is just too clogged up, or perhaps well meaning people are part of a system that's just not designed to give back seeds (Michel Fanton, 21 April 2006).

At least in part, I think that Fanton's final suggestion is correct. These genebanks are simply not designed to share seed with farmers. I am arguing, however, that a large part of the reason for this is that they have been designed around, and operate with, a specific imagination of nature.

Imagining Natures in a Seed Bank

In developing this contrast between a facility that is actively sharing seed with farmers and gardeners, and another that is focused exclusively on banking seed and sharing it with researchers (primarily for crop breeding), my intention has not been to praise one facility at the expense of the other. As Michel Fanton pointed out several times in our discussions, there is a powerful potential for these groups to work together. At the AWCC, I encountered a group of people who are passionate about saving genetic diversity and producing useful varieties of plants for Australian farmers—by all accounts they have been very successful in both areas. These scientists also clearly appreciate the work that the Seed Savers' Network is doing, even using me as a courier to deliver a packet of seed storage bags to the Network and pass on their regards.

The important difference that I see between the two, however, is in the way in which they understand human/crop interactions, how they imagine natures, and consequently in what they are each trying to achieve. The AWCC is operating within the PGRFA inflected framework that was the subject of the above discussion; it is conserving *genetic* diversity, and is doing so solely as a *resource* for human projects. The FIG Strategy that I outlined above is a child of precisely this way of relating to and with seeds. It is about adding information to seeds to make them more useful as inputs into breeding programmes. The Network, however, imagines different natures, and in so doing enacts them—it sets about contributing to their maintenance or perhaps rebuilding them where they have been lost. This is not a secondary or minor, crisis-response role of the Network (as with some of the international genebanks mentioned above), but rather its primary method of doing seed and conservation. The natures that it imagines and creates are very explicitly biosocial ones, in which people, crop plants and diverse others come together. Plants are not simply genetic data here, or even just fleshy bodies that nourish, rather, they carry in and with them possibilities for ways of living and knowing the world. Michel Fanton expressed this understanding when I asked him why sharing seeds was so important. He replied that it was vital that seeds be kept amongst the people that grow them in order to:

> . . . keep the culture going. We have to keep the seeds and the culture going because when you lose one you lose the other, they're intertwined. And when you lose the diversity of crops you also lose diversity of food . . . we lose the rich diversity of nutrition (Michel Fanton, 21 April 2006).

Within Fanton's conception of the world, seeds, people and plants are thoroughly entangled and all ultimately emerge out of complex biosocial interactions. The information that travels with the Network's seeds comes in the form of tutorials and a handbook on seed saving and sharing. It is practical advice on how to 'do it yourself', that aims to keep seeds moving and growing in diverse communities. I left the Network's office with a free copy of *The Seed Savers' Handbook* (Fanton & Fanton, 1993), some posters about the importance of heirloom plant varieties, and an invitation to save and share seed with them.

This is an approach to seed that is mindful of the fact that *ex situ* conservation—as the above quote from Bert Vissier *et al.* (2002, p. 13) makes clear—can only ever hope to conserve *genetic* diversity. Whole environments cannot be conserved *ex situ*; the diversity between species and of ecosystems will inevitably be lost. In agricultural ecosystems, however, this is also a diversity of lifeways, of systems and practices of farming and human (and non-human) know-how. The conservation work of the Seed Savers' Network is informed by an awareness of these interactions between people and plants. Consequently, the Network attempts to keep seeds growing, moving and living within these more-than-human environments. They work to keep plants involved in processes of adaptation and change, but also to keep them embedded 'in culture', as Michel Fanton put it.

The Natures of Agriculture

Within this context it becomes clear that seeds are far more than genetic information, in the narrow sense that is relevant to plant breeders. As Haraway has succinctly put it: '[s]eeds are brought into being by, and carry along with themselves wherever they go, specific ways of life as well as particular sorts of dispossession and death' (1997, p. 89). One seed is not just like any other. Rather, seeds come with all manner of 'built in' practices, associations and relationships. It has, for example, been well established that for many communities labour practices are built into seeds—so much so that the adoption of new crop varieties is often in part dependent on their compatibility with available labour.

Varieties with staggered ripening, for example, require fewer hands at harvest (see, for example, Tripp, 1997, p. 20).

In addition to labour, however, whole ways of life and death, along with cultural and spiritual values, are also built into agricultural plants and the practices that surround them. This is particularly clear in many communities engaged in (semi) subsistence agriculture—in the absence of specific crops, whole ways of living and the ecosystems that they produce are no longer viable or meaningful. Narciso Barrera-Bassols and Victor Toledo have analysed these kinds of interactions in terms of a 'kosmos, corpus and praxis (k–c–p) complex':

> [T]he kosmos, the belief system or cosmovision, the corpus, the whole repertory of knowledge or cognitive systems, and the praxis, the set of production practices (Barrera-Bassols & Toledo, 2005, p. 11).

Focusing on this 'complex', they emphasise the co-constitutive and co-nourishing interactions between beliefs, knowledge systems and practices ('culture') on the one hand, and biological diversity on the other. These connections have now been richly documented by ethnoecologists, often under the rubric of 'biocultural diversity' (Maffi, 2001). This literature shows many of the ways in which cultural and linguistic diversity are intimately intertwined with biological diversity, such that the loss of one inevitably leads to the loss of the others. Seeds stored in genebanks, or perhaps even just DNA samples from them, will not conserve the multi-species landscapes that they once populated, nor will their future return to these fields be enough to bring back lost organisms and their ways of living and relating. All of this is not to imply, however, that *ex situ* conservation does not possess a biosocial context of its own. As with all scientific projects, economics, religion and other 'cultural' influences and actors inevitably play an important role in the way in which this banking work is done. While no black and white lines can be drawn here, my point is simply that as a *conservation* practice, gene banking is unable to conserve many of the organisms and relationships that exist in agricultural communities. On the other hand, however, *in situ* methods often aim very explicitly to conserve this biosocial context—this does not mean that a very different set of biosocial relationships cannot exist, or grow up, around banked seeds/genes.

Banking Well

It is clear that international conservation projects are focused primarily on genetic resources and that some important consequences flow on from this reductionist approach to conservation—in terms, for example, of who is able to make direct use of collections, and perhaps also in terms of biases in what is conserved ('valuable' genetic material). In a very powerful way, PGRFA-conservation enacts the nature that it imagines. Through its use of seed as a conservation-proxy it fails to contribute to the maintenance of existing biosocial natures, it fails to adequately conserve and value the other diversities that are still vulnerable (both 'biological' and 'cultural') when genes are banked, and so sees no necessity in a broader sharing that keeps plants growing and their seeds moving in environments and amongst people.

My concern here is with the way in which this somewhat deficient conservation project flows necessarily from a focus on PGRFA in place of real, fleshy, 'thick organisms', embedded and entangled in the biosocial collectives that are agriculture. It is through the specific ways in which genetic information is valued in PGRFA discourses that *ex situ* gene banking becomes a meaningful conservation strategy. If we insist, however, on the embeddedness of genes in plants, and the entanglement of those plants in broader networks of nourishment and meaning, then the diversities that are lost, even when genes are banked, become all too clear. Additionally, it becomes obvious that these *ex situ* conservation projects are only deemed to be adequate because the most instrumentally useful aspects of the vanishing organisms remain in a readily accessible form (for some people—perhaps including all of us who can afford to take advantage of the agricultural resources that these kinds of projects yield).

And yet, despite these difficulties, these banking projects remain incredibly important. We are losing agricultural diversity at an alarming rate. So much so that the future sustainability of human (and crop plant) life on this planet may well depend on banked genes—and perhaps even on more extreme versions of gene banking, like the recently completed Svalbard Global Seed Vault (GCDT, 2008). According to accounts in the press, this bank is a 'doomsday vault carved into a frozen mountainside on a secluded Arctic island ready to serve as a Noah's Ark for seeds in case of a global catastrophe' (Mellgren, 2006). I find this seed-vault fascinating—even if a little disturbing—because of the deep interdependence between people and crops that it imagines. Here, agricultural genetic conservation is not just about keeping plants 'alive', it is also quite explicitly about keeping humans alive. It acknowledges that if something should happen to our crops—a doomsday event that could include nuclear warfare, escaped GM traits or any manner of other sci-fi-esque (but all too possible) scenarios—it would not be enough for people to make it through. Our long-term survival would require that we make it through with at least a handful of seeds, with enough genetic diversity to re-seed agricultural practices. As far as acknowledgements of human/crop interdependence go, one really couldn't ask for a better one than this multimillion dollar project (BBC News, 2006; Mellgren, 2006). Through this tight entanglement of humans and crops, however, an interdependence has emerged that, in this age of 'genetic erosion', requires that we bank, or otherwise conserve, crop genetic resources.

In line with Derrida's thinking on eating (and appropriative relationships more generally), the question is not therefore, nor has it ever been: should one bank or not bank? But, since one must bank, how should one *bank well?* (Derrida, 1991, p. 115). In an agricultural context, answering this question will clearly require a critical dialogue about precisely which natures must be conserved, and why. Genuine conservation cannot be reduced to the banking of PGRFA. If we value the other diversities in agricultural environments—and in addition to ethical reasons there are good agricultural and (long term) economic reasons for doing so (Brush, 1994; FAO, 1996a)—then we will need to do a better job of conserving the diverse relationships between people and their plants.

A novel approach to this issue has been taken by the US organisation Native Seeds/SEARCH (NS/S). Based in Tucson, Arizona, NS/S is a group whose mission is to 'conserve, distribute, and document the adapted and diverse varieties of agricultural seeds, their wild relatives and the role these seeds play in cultures of the American Southwest and Northwest Mexico' (NS/S, 2005). Like the Seed Savers' Network, the primary and long-term goals of NS/S are all centred on *in situ* conservation—on making seeds available to both indigenous communities and the broader public so that they might keep not only biological diversity alive, but also the diverse relationships between people and crops (Nelson, interview, 27 April 2007). NS/S acknowledges, however, that *ex situ* banking is an important part of current conservation efforts and as such they have developed a programme to 'bank' cultural diversity alongside seeds (inspired by Virginia Nazarea's work on the 'cultural memory bank' with sweet potato in the Philippines). Working with Navajo farmers, elders, students and others on the Navajo Reservation, NS/S produced a CD resource—only for use on the Navajo Reservation—that contained a variety of cultural material, from stories and ceremonies to cooking and planting ideas and practices. When I interviewed Suzanne Nelson (the Director of Conservation at NS/S) in 2007, the CD had been completed several years earlier (having been largely carried out with special funding), but NS/S hoped in the future to expand this work to produce an online resource for general public use (Nelson, interview, 27 April 2007).[8]

This memory banking project at NS/S is not, however, simply about 'banking' cultural information. Rather, it is also about sharing that information (at this stage just amongst the relevant community members) so that it might become a living resource and invigorate peoples' lives with their crops. This *use* of crop-information highlights the importance of the connection between cultural and biological diversity. Ultimately, as NS/S staff are well aware, for this connection to be maintained and for both plants and people to grow through it, seeds need to be kept growing (and being harvested, processed and eaten) *in living communities*. For this to happen, however, *ex situ* facilities need to be understood as temporary resting places, single (albeit important) nodes within a larger network of human/crop relating. Ultimately, my position is that this is how we might 'bank well'. Like the Seed Savers' Network that I discussed above, NS/S' approach to conservation is informed by precisely this view, with all of their long-term projects focused on returning or introducing seed to farming communities and home gardeners (Nelson, interview, 27 April 2007). *Ex situ* conservation, therefore, is understood as a single part of a much broader *in situ* project based on an openness and sharing of diversity (which may also one day include an online resource of 'cultural' diversity).

At an international level, however, for *in situ* conservation to really work, *even these seed sharing projects will need to be part of a still broader project*. They will need to be coupled with a critical deconstruction of the multi-faceted legal, economic, cultural, agronomic and ecological reasons why farmers are abandoning traditional crop varieties, as well as the creation of incentives (where appropriate) to encourage (or allow) their continued or renewed cultivation. Some international effort is being directed towards these issues. At present, for example, the 'communities and livelihoods' division within Bioversity International is working on a variety of projects that seek to understand and enhance *in situ* conservation (Bioversity International, 2007). Ultimately, however, actual *changes* will need to be made to dominant, and highly inequitable, trade and property regimes for *in situ* conservation to offer a meaningful alternative to gene banking. As they currently stand, intellectual property regimes (alongside other means of restricting farmers' use of seeds) are greatly reducing the genetic possibilities on offer to developing world farmers (van Dooren, 2007, 2008). Research is increasingly showing that all countries (including economically poorer countries) make use of internationally sourced germplasm and seed lines—although in different ways and to greatly varying extents (Brush, 2005, pp. 6–7, 24; Fowler *et al.*, 2001). Even if not cultivated directly, internationally sourced varieties and germplasm are, for example, used as inputs into breeding programmes that produce locally appropriate varieties (Jefferson *et al.*, 1999). IP and other means of genetic control [like Genetic Use Restriction Technologies (van Dooren, 2007)] reduce the availability of these inputs and, therefore, the competitiveness of locally produced (and appropriate) crop varieties and farming systems. In order to address this trend, restrictive IP regimes must be challenged. In the meantime, however, it will also be vital to find alternative ways to productively share diversity within these regimes, so that locally appropriate varieties for developing world farmers might be more effectively produced.

Within the more non-profit oriented sectors of the crop development community there has been an acknowledgement of the problems that modern plant breeding has often raised for farmers in low-input or marginal farming conditions (Salleh, 2007). This awareness has given rise to attempts to develop more appropriate varieties, sometimes in collaborative projects with farmers, such as 'participatory variety selection' (Musa, 1998; Salleh, 2007) and the 'farmer-back-to-farmer' model (de Boef *et al.*, 1993, p. 6). The International Centre for Tropical Agriculture's (CIAT) participatory research programme (IPRA) offers a very good example of this practice and its potential benefits (CIAT, 2007; IPRA Program, 2006). This production of locally appropriate varieties will, however, need to be coupled with the creation of consumer demand for them. At present, consumer (and corporate) pressure on farmers to produce a limited number of crops and varieties is an important factor in the diminishment of crop diversity. In an effort to turn this pressure into a productive tool, NS/S have, for example, begun working with local restaurants and farmers' markets, and even purchased a bake mix company, to produce commercial possibilities for less well known crops and varieties (Nelson, interview, 27 April 2007; NS/S, 2006, p. 3).

In short, therefore, banking well is about banking in and with more-than-human communities. It is about imagining and conserving biosocial natures through a sharing of diversities. *Ex situ* genebanks must, therefore, be networked into a broader 'fourth bank'—as Michel Fanton has termed it—the bank that exists 'in culture', where human/plant relationships are able to not only maintain but actively produce diversity. This interdependence of people and plants, however, means that conservation is ultimately dependent on how people 'do plants' (and get done by them); how they structure control and access to genetic resources; how they prevent and enable these resources to flow; who they make them available to, and in what ways.

Situated in this way, banking well might become a critical project that deconstructs the very ideas that give rise to it. In contrast to the international agreements and genebanks discussed above, this kind of 'banking' would no longer be about storing, but would rather be about enhancing flows. Additionally, 'diversity' as an object of conservation would no longer be understood in terms of genetic units. Rather, diversity would be re-imagined as a relational concept, as a complex field of ongoing co-evolutionary interactions. Conserving diversity would, therefore, be about the free and productive sharing of seeds and genetic material, a sharing that produces the possibility of nourishing and enhancing more-than-human agricultural communities. In large part, therefore, banking well will require the production of the broader legal, economic and social frameworks that allow this sharing to take place, especially by and for the peasant and indigenous farmers who need it most and who contribute to it most.

Conclusion

In this paper I have explored the way in which 'nature' and 'diversity' are understood in agricultural conservation policy and practice. In a related vein to the way in which Hayden has observed that nature has been revalued as an 'informational' input into various industries in recent decades (Hayden, 2003), I have highlighted the reductionist and utilitarian approaches to diversity and nature that have dominated agricultural conservation since at least the 1960s. In this context, it is only valuable genetic resources that must be conserved. This discussion extends, and perhaps even complicates, Hayden's initial insight by taking it into an historical period significantly prior to the late 1970s and early 1980s—a period which is usually so closely associated with the birth of genetic reductionist approaches to nature and the consequent development of new forms of 'biocapital' (e.g. Haraway, 1997; Parry, 2004; Franklin, 2003). While these earlier efforts to bank agricultural genetic resources took place within very different scientific, legal, economic and political contexts to those that dominate today, they were also clearly rooted in a related approach to nature which prioritises genetic resources as potentially very valuable inputs into human projects. As such, perhaps more work remains to be done in thinking about the diverse *continuities* between current and various historical approaches to modifying, conserving and owning nature/s.

In this paper, however, I have focused specifically on the *consequences* of approaching agricultural diversity within this reductionist frame. In particular, I have drawn attention to some of the many other biosocial diversities that exist in more-than-human agricultural communities that cannot be stored in genebanks. Working with Parry's notion of a 'proxy' (Parry, 2004), I have argued that genetic resources in various forms have been utilised as a 'good enough' embodiment of disappearing diversities, a situation which clearly prompts further reflection on precisely *what* they are good enough for, and for *whom*. Following this line of reasoning, I have argued that gene banking produces some important possible inequalities with regard to which resources are deemed to be valuable and who has access to them.

Drawing on field visits and interviews with staff at a genebank and two seed saving organisations, I have also attempted to draw out what it might mean to do agricultural conservation work within the context of this broader notion of diversity. In particular, I have highlighted a significant difference between stockpiling genes and sharing seeds, and attempted to show that it is only through cultivating seed flows—which will also require appropriate local crop development—that agricultural diversity can truly be conserved. This situation, however, requires that conservation not be thought, or practised, as though it is somehow independent of the broader legal, economic and cultural systems that today often stifle or prevent the movement of seeds between farmers and communities.

While some effort has clearly been made towards these ends over the past several decades—some of which I have mentioned above—it seems fair to say, as Stephen Brush did in 1994, that the overwhelming majority of conservation resources are still directed to *ex situ* banking projects (1994, p. 6). While these banked resources are invariably important for present and future crop development, the loss of other diversities—and with them often subsistence autonomy and food security for local communities—needs to become a higher international conservation priority. Instead this kind of work is usually left to poorly funded community NGOs. I find hope, for example, in the work of Jorge Ishizawa and the Andean group PRATEC. In their *Proposal for a Global Network For Seed Security*, they have outlined a project that might nurture and re-establish 'seed paths' amongst traditional agricultural communities (in the Andes but also more broadly) as a means to both improving seed/food security *and* the conservation of various diversities (Ishizawa & PRATEC, 2005). This is the kind of work that we need.

This is *conservation* in the fullest sense of the term—in which what is left for the future is not genes in a bank, but a nourishing, evolving, more-than-human community of life.

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Notes

[1]I take this usage of Haraway's notion of 'messy, thick organisms' in this context from Parry (2004, p. 52).

[2]Several of the IARCs were actually founded before the CGIAR, which was created in 1971 to coordinate and expand this research/collection programme (Kloppenburg, 2004, pp. 16–161). CIMMYT is the International Maize and Wheat Improvement Centre, based in Mexico.

[3]These 'centres of diversity' were named after the Russian botanist and geneticist Nikolai I. Vavilov who identified various sites around the world that contained the greatest amount of genetic diversity of crop plants. The Vavilov centres of diversity are often thought to have been the sites at which these crops were 'domesticated', but this is a somewhat problematic position (Smith, 1995, pp. 5–6).

[4]The terms 'genetic material' and 'genetic resource' are not technically interchangeable in either the CBD or the Treaty. The important difference between these concepts is discussed below.

[5]While most accessions held in agricultural genebanks take the form of 'true seed' (i.e. seed produced through sexual reproduction), plant tissue culture conservation (especially for vegetatively propagated plants) is becoming increasingly common. Additionally, storage in pollen and DNA libraries (usually involving the deep freezing of tissue samples) is being explored in some *ex situ* facilities (FAO, 1996a, p. 22; Hawkes *et al.*, 2000).

[6]Some important sources charting these developments include Franklin (2000, 2003), Haraway (1997, 2000, 2003), Hayden (2003), Parry (2004, 2005), Rabinow (1992, 1996) and Wright (1986).

[7]In their briefing to the CGIAR on the Treaty, Fowler *et al.* (2003) discuss the possibility of 'direct use' by farmers of CGIAR accessions, noting that 'Article 12.3(a) does not specifically sanction access for the purpose of direct use, but one might assume that such access is acceptable'. While it appears, therefore, that under the terms of this agreement a farmer could (technically) directly use CGIAR seed, it seems clear that a variety of other 'environmental' factors would make this difficult and unlikely. The tone of Fowler's comment also implies that these collections are not really intended for 'direct use'—and certainly that they are not commonly used in this way.

[8]Nelson was well aware of the considerable intellectual property concerns that would surround this project. At that time, however, NS/S had not decided exactly how they would approach this issue.

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