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Saving the gene pool for the future: Seed banks as archives

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ABSTRACT

Ensuring the salvage of future sources is a challenge for plant geneticists and breeders, as well as historians and archivists. Here, this suggestion is illustrated with an account of the emergence, in the mid-20th century, of seed banks. These repositories are intended to enable the conservation of the world's crop genetic diversity against the 'genetic erosion' of crops, an unintended consequence of the global uptake of new high-yielding Green Revolution agricultural varieties. Plant breeders and scientists advocated a strategy of freezing and long-term storage of seed which enabled the salvage of genetic diversity for future users without requiring the continual cultivation of old varieties: seed banking could preserve valuable genetic material and enable agricultural modernisation to proceed. This account of crop genetic conservation therefore shows how breeders and geneticists sought to create their own seed archives from whence the evolutionary history of crops could be made accessible in ways that are useful for the future. This analysis suggests that conservation practices are informed by ideas about the future use of material, indicating that there is value in exploring concurrently the archival and historiographical issues relating to the biomolecular big biosciences.

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1. Introduction

This special issue invites us to reflect on the links between the archiving of historical sources of the big molecular biosciences and methodological and historiographical issues relevant to the writing their histories. This account, that explores seed banks as archives of crop genetic diversity, demonstrates a similar interest in the relationship between preserving records and using them in the natural sciences suggesting that there are parallels between seed banking and ongoing efforts to preserve written and material records of genomic science (discussed by Shaw, 2016).

This account shows how matters of future use value are enmeshed in conservation strategies and structures; so, considering the connections between practices of archiving and the futures of archived materials is a helpful step when contemplating how best to preserve the future archives of the molecular biosciences (on archival collections as the result of forecasting and prediction of the necessities of 'future historians' see de Chadarevian, 2016). Hence, the emergence of seed banks as a method for genetic conservation represents an interesting case study for reflecting on the efforts to archive the records of the large, collaborative biomolecular biosciences which emerged later.

In this paper, I explore how seed banks were imagined as a response to the problem of genetic erosion and argue that seed banking was seen to both preserve and make available genetic diversity so that it could be used within the modern paradigm of scientific breeding, working with the shift to more globalised agricultural methods. Therefore, seed banks can be seen as archives of genetic diversity that made the past accessible as future sources for scientists and breeders by creating 'records' of the evolutionary history of crops through the freezing of seeds. In this way, the potential value of these resources could be accumulated for extraction at a later date through the use of contemporary technology. The case of seed banks demonstrates how strategies of conservation were also determined by the ways in which people expected to use these materials in the future.

Geoffrey Bowker (Bowker, 2005, p. 110) and Waterton and colleagues (Waterton, Ellis, & Wynne, 2013, p. 110) have identified

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seed banking as part of a broader drive to archive and represent biodiversity in databases of data and material in the 20th and 21st centuries. Drawing on Derrida's work in *Archive Fever* (Derrida, 1996), they point to the contradiction between our development of ever-greater memory stores and concurrent large-scale loss of biodiversity. Such repositories promise a comprehensive representation of life in databases of unprecedented breadth and integration, yet do not, and cannot, accommodate a complete set nor represent the complexity of biological diversity (Bowker, 2005; Waterton et al., 2013). As these databases become the source of knowledge for action to protect nature, that which is not represented on the database is beyond the scope of action, resulting in a process of convergence (Bowker, 2005) between the world and its representation. Thom van Dooren develops a similar critique of seed banks, arguing that '[t]heir 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.' (Van Dooren, 2009).

However, understanding the implications of seed banking as a conservation approach requires historical accounts that can show what banks *were* envisioned to do (and how), and contextualise their origin. In order to determine how seed banks have been imagined to do genetic conservation (strategically and in practice) I overviewed the arguments made for and against this approach. I focus especially on the vision of the plant breeder and emphatic advocate of gene banking, Otto H. Frankel (1900–1998). According to the plant geneticist J. G. Hawkes, Frankel 'really invented the concepts of the genetic conservation of plants useful to man' (Hawkes, 2002: xviii). He was central to the efforts to organise 'genetic conservation' from the 1960s onwards and is credited with bringing together the International Biological Programme (IBP) and FAO (the United Nation's Food and Agriculture Organization) 'in the common cause of halting 'genetic erosion' and conserving 'genetic resources' (Crute, 2004), Moreover, '[h]e was prominent in moves to establish a network of regional genetic resource centres under the aegis of the Consultative Group on International Agricultural Research, and the subsequent formation of the International Board for Plant Genetic Resources' (Crute, 2004).

Frankel's publications are sources of historical detail about the imaginary of seed banking: he was a prominent advocate for this strategy, expounded his view of its purpose and practices, and addressed others' critiques of this approach. The aim of this analysis is to bring to the fore actors' narratives about the purpose of genetic conservation, and how seed banking was assessed as a means to undertake such a project. This analysis therefore contributes towards the pool of work on the topic; where historical accounts remain relatively scarce (see Loskutov, 1999; Pistorius, 1997; Plucknett, Smith, Williams, & Anishetty, 1987, for accounts written by actors see, for instance, Scarascia-Mugnozza & Perrino, 2002).

This material indicates that collections of plant material were created in order to ensure that 'old' material would be kept available for future use. It shows historical actors planning a strategy for avoiding global genetic erosion through practices of collection and preservation of seeds that create records of genetic diversity, within the context of rapid changes in plant breeding. In this way, they argued, 'primitive' plant varieties which were endangered by changes in agricultural practices could be preserved by freezing their seeds.

Parry (2004) and Van Dooren (2009) have identified seeds as 'proxies', that is, components that can 'stand in' for the bulkier, more corporeal plants and that contain the essential aspect of the genetic material and thus are a way to record the genotypes and adaptations that would be valuable to future users. My narrative suggests that these proxies are particularly valuable for their ability to bridge the gap between the past and the future: they are, specifically, temporal proxies. Seeds' capacity for dormancy and reproduction was harnessed to ensure the conservation of seeds in a way that they could be used in the future, that is, they provide a way to create a stable record of the evolutionary past of crops. Banking seeds, then, is a form of committing to record important 'historical sources' in such a way that the evolutionary potential of crops is maintained, enabling their potential value to be realised.

In the next section, I introduce the concept of seed banking and genetic conservation. On Section 3, I suggest that the development and uptake of new crop varieties associated with the Green Revolution led to a new appreciation of the value of old, 'traditional' crop varieties, but simultaneously put them at risk. Then, I argue that seed banking was a promising strategy for conservation because it separated 'genetic conservation' from the continued cultivation of crops *in situ* (that is, in their original environment) hence providing a means to enact conservation that was not in tension with agricultural development. The next section details the ways in which ex situ conservation was seen to facilitate future use; and Section 6 shows how banking created 'records' of seeds, therefore enabling the recall of the evolutionary past of crops and its future retrieval.

2. Genetic diversity and its conservation

Genetic diversity, or the variation between different populations belonging to the same genus, resulted from the evolution of crops over millennia, in response to different environments and husbandry practices (Fowler, 2008) worldwide. Nikolai Vavilov's (1887–1943) work on the biogeography of crop plants provided a theoretical basis for understanding the relationship between a crop's 'centre of origin', or region where it originally evolved, and the amount of genetic variation displayed between its populations: he posited that the greatest amount of crop variation was to be found within 'centres of origin' (Vavilov, 1992).

Vavilov also conducted numerous collecting trips around the world. The resulting samples were assembled into a collection of germplasm, which now bears his name, at the All-Union Institute of Applied Botany and New Crops in Saint Petersburg (Loskutov, 1999). This repository stands out by its focus on the systematic representation of the variation *within* crop species. Here were assembled samples of many populations or varieties belonging to the same genus, with different traits, and drawn from the various populations spread around the world (by comparison, botanic garden collections showcase diversity at the level of the species; assembling representatives of many species together).

Vavilov's collection represented the variation between 'landraces' of crops: crop varieties which result from the gradual evolution of crop populations within a specific environment, over long periods of time, in response to artificial selection by farmers and natural selection processes (for a review of definitions, see Zeven, 1998). Because diversification happened as a result of the evolution of crop populations over time, it was the outcome of the adaptation process between a plant and its environment. Since these 'adaptive gene complexes' resulted from the ongoing relationship between a crop and its (physical and cultural) environment, the diversity of a crop's gene pool was the sum total of adaptations between a crop and the varying environments over its geographical range. Landraces therefore demonstrated 'genetic organization for productivity' (Frankel & Bennett, 1970, p. 11) which made them valuable: they would display particular traits—for instance, disease resistance—or characteristics (morphological or agronomical) that enabled them to survive within their environment.

Landraces were valued because they had been developed by farmers over time, and were thought to be 'organised' to be