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Genes are not information: Rendering plant genetic resources untradeable through genetic restoration practices

Jairus Rossi

University of Louisville, Department of Geography and Geosciences, 217 Lutz Hall, Louisville, KY 40292, USA

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ABSTRACT

Genetic commodification relies on methods that treat genes as information. By representing genes as information, scientists produce standardized and stable objects that are easily tradable. In this paper, I argue that a Midwestern plant conservation science institution (MPCSI) challenges genetic commodification through distinct knowledge-making and social practices. In particular, scientists at this institution treat genes not as information, but as contextual and contingent entities. By employing genetic technologies that deemphasize the code metaphor of genes, these scientists make genes unavailable to trade as information.

I analyze the socionatural implications of this institution's use of genetic technology in native ecosystem restoration. Drawing from interviews and participant observation, I focus on specific techniques used by the MPCSI's scientists to view genes as embodied relational entities, rather than abstract information. I illustrate how these technologies allow the MPCSI to challenge the epistemologies and methodologies that are crucial to producing genetic commodities.

Additionally, I illustrate how the MPCSI serves as a model for plant science institutions to reconceptualize their use of banked plant genetic resources. This model complicates the commodity speculation paradigm common to bioprospectors. At the same time, this genetic restoration approach relies on and produces different engagements with markets. I detail the MPCSI's emerging relationship with commercial seed nurseries to illustrate how decommodification is integral to commodification. Finally, I argue that although the MPCSI's genetic restoration strategy necessitates limited market engagements, their scientific practices and institutional relationships produce drastically different socioecological outcomes compared to institutions that treat genes as information.

Introduction

Dry sand prairies were once widespread along the sandy banks of the United States' Great Lakes. These disjunct habitats contained many species unique to the American Midwest. But as the region grew in economic importance (Cronon, 1992), this already limited habitat was decimated. Many species were threatened by shoreline stabilization projects, beachfront development, Cold War missile defense installations, and nuclear power facilities (Rankin and Crispin, 1994). Despite the region's rapid industrialization, many diverse institutions emerged to conserve and restore ecosystems and rare plant populations.

One group of ecologists began *in situ* experimentation with species reintroductions on public lakefront land in 1991. They chose one rare sand prairie flower species to initiate what became a broader regional conservation paradigm. This species had been extirpated from Illinois, but persisted in surrounding states. The ecologists started this process by identifying, collecting, and banking appropriate plant genetic resources. They collected seeds from the two nearest remaining source populations. One seed source was located in Wisconsin, the other in Indiana. These two populations were chosen based on a perceived relationship between proximity and the genetic structure of populations. Nearer populations likely share common ancestors, pollinators, and historical environmental conditions, thereby increasing genetic similarity (Hufford and Mazer, 2003). The restorationists believed that these similarities would allow the reintroduced population to flourish, since its genetic combinations would be pre-adapted to local environmental conditions (see Holsinger and Gottlieb, 1991). Over the next 3 years, restorationists germinated seeds and planted at least 3000 seedlings in different locations within the site. While initially flourishing, the restored population

E-mail address: jairusrossi@gmail.com

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had declined to ~200 by 2008 with too few plants flowering, setting seeds, and creating seedlings (Personal Communication[1]). Restorationists often attribute this scenario to genetic homogeneity via inbreeding (Huenneke, 1991), yet generally lack technological means to directly evaluate this possibility.

A few years later, a regional plant conservation science institution (PCSI) began developing the technological infrastructures to match ecological observations to genetic data. This institution's administrators were exploring how genetic technologies could make ecological restoration work more detailed (Personal Communication[2]). This approach was novel in both the choice of genetic technology and intended application of genetic resources. Previously, PCSIs had used genetic techniques to analyze collected biological materials for molecules of potential commercial value (Parry, 2004). PCSIs found a niche in bioprospecting's political economy by applying their expertise to collecting, transporting, and storing genetic resources. These efforts, however, yielded very few marketable commodities and funding from venture capitalists, pharmaceutical companies, and biotech firms soon dried up (Firn, 2003; Hayden, 2003). In this political economic context, one Midwestern plant conservation science institution (MPCSI) sought to define alternative applications of genetic technology to banked plant materials.

The MPCSI's administrators initiated this genetic restoration approach by enrolling a newly created plant genetics team in the analysis of the stalled sand prairie flower reintroduction. The team sampled leaves from this restoration as well as many remnant populations in the area. They extracted DNA from each leaf, amplified and visualized specific regions of this species' genome, and then statistically analyzed each sample. These techniques produced data regarding the internal genetic structure of each population as well as the likely degree of similarity between populations.

Their analysis was compelling. One site in northern Michigan displayed the most total diversity, yet had not been used to source seed. The Indiana populations, one of which was used as a seed source, had less diversity, while the Wisconsin site, also used as a seed source, displayed extremely limited genetic diversity. Without suitable diversity, plants do not form viable seed and populations slowly decline. While the restored site contained higher total diversity measures than remnant sites, it also had higher inbreeding levels (Personal Communication[3]).

These measures are consequential. Though the restored population was replacing its current population numbers, and has remained somewhat stable, the high inbreeding levels might eventually decrease the total diversity of the population. The geneticists suggested that the restoration be augmented with seeds from more distant sites, especially Michigan. A larger pool of genetic diversity might provide the restored population with more genetic options for adapting to local variability in rainfall, soil, and disturbance. The restorationists considered these recommendations, yet chose not to add distantly sourced seedlings to the restoration. While the actual reasons are unclear, restorationists in the region often desire to keep seed sources as local as possible (USACE, 2012). This 'local is better' perspective seeks to avoid the risks of introducing more distant seed sources to established populations. Adding additional diversity can disrupt the dynamics of a stable, though not expanding population.

Overview of themes – producing embodied genes through practice and metaphor

I open with this vignette to contextualize the MPCSI's initial foray into using genetic technologies in restoration work. This genetic restoration approach is rather unique. Until the late 1990s, genetic approaches to restoration work were limited to a small network of restoration geneticists (Personal Communication[4]). Additionally, genetic technologies were predominantly employed by PCSIs to make biological resources tradable and commodifiable. The MPCSI's restoration work provides PCSIs with an alternative model for using banked seeds and genetic technology.

I argue that the MPCSI's work is part of a broader shift in how genetic technology is applied to conservation. This redefinition relies on portraying genes as slippery, relational, and contingent entities through the application of particular genetic technologies and methods of analysis. The MPCSI's methodological shift, mirrored by its institutional aims, contests genetic techniques that represent genes as stable, predictable, and therefore economically valuable. By advocating a stronger conservation role for PCSIs, the MPCSI's work has implications for how plant genetic resources are ontologically conceptualized, owned, and commodified. This paper is structured by three arguments.

First, I illustrate how restoration geneticists ***embody*** genes as relational entities through microsatellite techniques. Genes are often touted as objects that reveal unequivocal truth (Heller and Escobar, 2003), yet this portrayal belies the complexity of their functioning (McAfee, 2003). Various actors attribute genes with ontological certainty in order to settle disputes about the nature of things (Wainwright and Mercer, 2011). To most geneticists, however, a gene's particular expression is always contextual (see Stallins, 2012). It is impossible to define a gene's expression without situating it in relation to myriad other factors. Restoration geneticists primarily work with a type of genetic technology that requires a strong consideration of multiple contexts. Microsatellite analyses are particularly well-established techniques that rely on sequencing limited, but specific regions of the genome. They are often used to model species evolution and gene flows across landscapes. As microsatellite regions do not code for ecologically functional genes, geneticists must interpret these sequences in respect to extra-genetic and ecological data to give the sequences meaning. Genetic information cannot stand alone. To translate microsatellite data into restoration practice, restorationists must mobilize genetic information through compelling narratives. I illustrate, through three vignettes, how geneticists use microsatellite techniques to contextualize, or embody, genetic data as they prescribe restoration strategies.

Second, these definitional embodiments destabilize genetic narratives common in the commodification of genetic material. Genes are often treated as stable informational objects with predictable expressions to fit the conventions of intellectual property law (Parry, 2004). I argue that genetic restoration techniques render plant genetic resources unsuitable for trade. I focus on how restoration geneticists methodologically deemphasize representations of DNA and genes as abstract, translatable code. Instead, they situate genes as contingently embodied, unruly, and relational objects that attain meaning through interactions with other genes, organisms, and environments (Levins and Lewontin, 1987; Stallins, 2012). Restoration geneticists' methods challenge the 'genes-as-information' metaphor that is so crucial to trading genetic material and information (McAfee, 2003; Parry, 2004).

Finally, I detail ways in which the MPCSI's methodological and institutional challenges to genetic commodification require a different set of engagements with markets and capital. Just as microsatellite techniques complicate established modes of making plant genetic resources amenable to commodification, they create new sites for producing genetic commodities. To repurpose germplasm collections for ecological restoration projects, the MPCSI's

[1] Geneticist 7/14/2011 & 7/25/2011.
[2] Administrator 8/9/2011.
[3] Geneticist 7/14/2011 & 7/25/2011.
[4] Administrator 8/9/2011 & Geneticist 3/13/2012.