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The Edible Landscape: Plant Breeding, Farming, and Sustainbility in Northwest Portugal

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THE EDIBLE LANDSCAPE: PLANT BREEDING, FARMING, AND SUSTAINABILITY IN NORTHWEST PORTUGAL

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To my mother,
Patricia B. Powell

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ABSTRACT

This dissertation is an ethnographic analysis of a participatory plant breeding project in northwest Portugal. Participatory plant breeding (PPB) is a crop enhancement strategy that brings farmers and plant breeders together in the effort to conserve crop genetic resources in-situ, improve yield, and increase the overall agricultural sustainability in agriculture. One strategy in PPB calls for plant breeders to spend considerable time on working farms to understand better farmers' knowledge and skill, and to survey the existing crop genetic diversity within the existing resource limitations on farms. Although there are clear social implications for PPB, the bulk of PPB evaluative literature focuses on narrow agronomic and technological goals. This dissertation widens the evaluative scope of existing research by drawing upon actor-network theory (ANT) and developing the notion of the edible landscape. The ethnography reveals how linkages between human and non-human actors are formed in the context of the VASO Project, a PPB project in Portugal where famers and plant breeders have been working on-farm to enhance local landraces of maize (*Zea mays* var. *mays* L.) for yield increases and other traits of interest. One key trait is bread flour yielding capacity and culinary quality of local white flint-type maize. Maize flour is used primarily to make flour for the traditional Portuguese bread*, broa*. When viewed from the perspective of food and edible landscape formation, a wide range of human and non-human actors well beyond the spaces of the farm are revealed as critical to the agronomic goals and social reproduction of the VASO project. These actors include traditional grain millers and *broa* bakers to name a few. Conservation of these actors and their livelihoods, as well as sustaining the linkages between them, are just as critical to in-situ maize crop diversity conservation and PPB as are the plants and genes themselves

CHAPTER ONE
ETHNOGRAPHY OF A PLANT BREEDING PROJECT

Introduction

Every dissertation has a unique history, and this study is no exception. I began this work at the University of California, Santa Barbara as an anthropology student and finished it at Louisiana State University in the Geography & Anthropology Department. In the very beginning of this research I had a keen interest in studying what many have called farmers' knowledge as a subset of indigenous, local, or other form of non-specialist knowledge about plants and farm ecology. I wanted to investigate the sources of farmers' knowledge about a range of issues dealing with the growing and maintaining crop varieties. My initial intention was to compare this knowledge with formal plant breeders' knowledge to understand better ways for each to communicate on mutually interesting issues, such as crop improvement (Powell 1999). I chose a participatory maize breeding project in Portugal as a case study (Moreira 2006).

In the course of the fieldwork, I began to take an interest in how knowledge was defined and used within the project in order to achieve certain goals, the broadest among these being "sustainability." Thus, my focus began to shift from an exclusive concern with knowledge to a concern with the entire project as context for the formation of novel knowledges and practices related to improving crops. In essence, I became interested in evaluating the success, or failure, of the project in reaching this goal of increasing sustainability. I decided to set aside the questions of how knowledge is formed to focus on how knowledge is used as resource, how it is deployed, and how it relates to practices and specific people, places, and things. I had read about farmer and scientist knowledge, plant breeding, and crop genetics. However, I had not yet read an anthropological evaluation of a plant breeding project. Therefore, this seemed an opportunity to add to the literature.

To frame an ethnographic study of the project I first drew heavily upon "Actor-Network Theory (ANT) approaches. This seemed an ideal way to frame fieldwork observations into a coherent story of how notions of agricultural sustainability pulls together farmers and formally trained plant breeders into a socially complex goal-directed project. ANT directs attention to the social relationships formed in such projects between humans and non-humans, and whether and how these relationships are durable, expandable, and transportable through time and space.

ANT proved to be excellent for bringing non-human entities like plants and farm animals into the analysis of what makes a project work and succeed, as well as considering the otherwise silent non-human technological artifacts that mediate human social connections between plant breeders and farmers. However, increasingly this study was pulled in the direction of geography, particularly my reading of the geography of science literature (Adler 2014; Allen 2011; Galloway 1996; Jons 2006; Law and Mol 2001; Livingstone 2002; Murdoch 1997; Powell 2007). David Livingstone's acute observations about science resonated with me, "Scientific knowledge is a geographical phenomenon. It is acquired in specific sites; it circulates from location to location; it transforms the world." (Livingstone 2010:18). I found the geography of science literature extremely useful for articulating what I call in this dissertation the "socio-spatial" strategy of plant breeding, following Naylor's "internal cartographies of scientific theories and methods" or the myriad ways in which "science itself creates spaces and places for its own activities and in turn spatializes the world" (Naylor 2005:3). This refers to the way in which there is not only social geography of plant breeding science with laboratories, research centers, genebanks, and test fields, but also how plant breeding reshapes the social geography of the farming and food world as it extends into farms, farming landscapes, and the bodies of food consumers.

A pause in writing up the dissertation at UCSB due to a number of factors allowed time for more studies by the plant breeding project staff to become public, thus adding more "insider" viewpoints to be analyze, and more time for me to consider the geography of science literature. In many ways, my research anticipated much of the geography literature dealing with science such that it allowed more confirmation and stronger footing for the dissertation. I felt increasingly compelled to formally acknowledge this part (the geography aspect) of the research by finishing the writing of this work in a department and degree program that combines geography and anthropology. Louisiana State University was the obvious choice to finish writing as the Department of Geography and Anthropology has both a long history in cultural geography as well as a long collaborative relationship with anthropology, and ethnography.

Ethnography of a Participatory Plant Breeding Project

This dissertation is an ethnographic study of participatory plant breeding, a new form of plant breeding science practice. New developments in any scientific field or practice provide scholars with an opportunity to examine what scholars of science and technology generally call science-in-the-making (Shapin 1992), the time or phase when science is being performed and practices, when the controversies and black-boxes of science are still open for analysis, and the time during which science is revealed as "politics by other means" (Latour 1988:228). Such moments offer a glimpse into a precarious time before things, theories, and paradigms become collapsed, solidified, and taken for granted as the normal background of every-day sociotechnical practice. As one follows scientists in the course of their work during such times, the messy business of constructing science comes into focus, particularly in laboratories that Latour (1987; *passim*) calls "construction sites." Not "social construction" but actual construction of science as one finds commonly in laboratories. No one questions visiting a construction site to understand the construction of a skyscraper, why then Latour ponders, should visiting laboratories (the construction sites of science) be such a strange and radical thing (Latour 1988). There is also a socio-spatial structure to science-in-the-making, as pointed out by geographers of science (Naylor 2005); a movement of information, knowledge, technologies, humans and non-humans from the carefully controlled spaces of laboratories and research centers outward to the messier politicized spaces of society, corporate board rooms, government bureaucrat's offices, and the nebulous "market."

For ethnographers of scientific practice, this back-and-forth movement of things, ideas, and practices between the social spaces of laboratories and those of the larger society dispels any notion of clear-cut or well-defined boundaries between the two.

Laboratories are certainly "in" society, but society is also present in laboratories every step of the way. Boundaries, such that they are, emerge as porous, constructed, and maintained through scientific practice. The question for ethnographers of science then becomes not whether the content of a particular science, the body of hypotheses, technical practices and guiding assumptions, is unduly influenced or perturbed by the social context. Rather, much more to the point is how and to what extent both scientific content and social context are intertwined? Essentially, how, when, and where are science and society *co-constructed* through scientific practice (Callon 1986)? One of the implications of this question is that through scientific practice scientists construct a context, a social world, at the same time as they construct experiments.

In this dissertation, I explore how science and society are intertwined and co-constructed specifically through an emerging scientific practice known broadly as "participatory plant breeding," or PPB. Participatory plant breeding first emerged in the 1980s as plant breeders, social scientists and farmers in different locations around the world began experimenting with new approaches to crop improvement that dovetailed with a mounting concern in the agricultural development community for increasing the sustainability of agriculture worldwide (Cleveland and Soleri 2002; Maurya et al. 1987). In this context, top-down and transfer-of-technology practices gave way to more participatory models of agricultural development theory and practice. The different plant breeding styles that have emerged subsequently under the labels of participatory plant breeding vary widely depending on the particular crop of choice, the geographical and social context of research and the specific goals of the breeding program. However, collectively these new approaches are motivated by three underlying common concerns: 1) conserving and enhancing agricultural biodiversity on farms, 2) developing crop varieties for less environmentally destructive and more equitable agriculture worldwide and 3) increasing the food production capacity among the world's economically and environmentally marginalized farmers (Cleveland and Soleri 2002).

The social spaces of plant breeding

The effort to include these and other technical goals into plant breeding theory and practice has prompted some plant scientists and other interested scholars to challenge key theories, assumptions and practices deeply embedded in the conventional plant breeding process, including the many choices plant breeders routinely make, and assumptions they have, regarding: which plant varieties to improve, the physical environments for conducting plant breeding experiments and who will grow the improved crops in terms of knowledge, skill, capital investment and use of technology. This range of social, economic and technological assumptions that are built into plant breeding is often referred to as the technical package that is assumed to go along with varieties (e.g. farmers who grow variety X will do so with Y amounts of water, fertilizer, pesticides, planting and harvesting technology). Two of the most important themes to emerge in the context of participatory approaches to plant breeding are the interest in working farms as sites for plant breeding research and development, and the importance of farmers as collaborators, or at least active participants, in the formal plant breeding process.

Although it seems logical (to an outsider at least) to conduct plant breeding on farms and alongside farmers, a curious feature of conventional plant breeding is that most of the work takes place distinctly off-farm on carefully managed research stations. Farmers rarely have access to these places and are rarely called upon to contribute to breeding practices in any meaningful sense. Historically, this has not always been the case, depending on how one defines plant breeding. Broadly defined, plant breeding can be thought of as intentional and unintentional human interference (selecting desirable traits, protecting a plant, transplanting, saving seeds, etc.) in a plant's reproductive cycle that produces changes in the plant making it dependent on these interferences for reproduction. The first plant breeders could have been anyone interested in saving, protecting or otherwise impacting a plant's reproductive cycle. Domestication is often taken as evidence for early plant breeding by farmers. Domestication describes an intensification of a co-evolutionary process that began at least 12,000 years ago whereby physical changes in plants correspond to social and cultural changes in humans such that a co-dependency develops (Harlan 1975): domesticated plants need humans to reproduce and proliferate, and humans need domesticated plants to feed growing populations. Thus, as plant breeders themselves frequently point out, for several centuries plant breeding was carried out by farmers on farms. Following widespread acceptance and use of Darwinian Theory of selection in biological science along with Mendelian inheritance principles, a much more narrow definition of plant breeding based on genetics becomes possible in the early to mid 1900s (Klein 2005).

Importantly, changes in the human history of plant breeding did not take place purely at the intellectual-mind level; no new super-brained humans emerged (Latour 1986). Intellectual development and specialization in plant breeding history co-evolved with institutional, political, economic and, for my purposes here, socio-spatial developments. A social geography of plant breeding developed within the profession, a geography that saw the creation of socially bounded spaces of science such as public and private laboratories and research stations where plant breeding was re-situated. Thus, the geography of plant breeding came to include a hybrid mixture of new ideas, entities (like inbred lines), practices, techniques and socio-political alignments that effectively generated a long-standing socio-spatial dyad: the plant breeder – station, and the farmer – farm. This socio-spatial dyad assigns and encodes certain knowledges, practices and ranges of action; it essentially created two sets of actors: a scientific actor, the breeder associated with research stations and a semi-knowledgeable other, the farmer and his/her spatial domain, the farm. The two would be separated even further as plant breeding becomes increasingly allied with (helping to produce perhaps) the accumulation of capital in private agri-business enmeshed in the socio-spatial organization of industrial global agriculture (Fitzgerald 1990; Kloppenberg 1988). Collaborative plant breeding thus represents an attempt by insiders to correct this social and spatial separation through new theories and techniques designed to reconnect farmers and breeders via the improvement of crops that concern both.

Farms as sites for crop development

Within conventional modern plant breeding, the actual farms where crops will be cultivated are considered target environments that are modeled on research stations in the form of test plots. These test plots are set up and managed according to breeders' assumptions about what happens on real farms: such processes as the timing and application of various inputs like water, pesticides and fertilizers, as well as other cultivation practices such as plant harvesting and post-harvest storage of seeds. The research station test plots essentially serve as stand-ins for the world's farms that have been rendered miniature and manageable in order to facilitate the many detailed measurements of plants and the careful monitoring of inputs that are required for the scientific breeding process. This can include the planning of plot plantings, measuring all phases of the plant's life cycle, isolating the reproductive parts to control pollinating, hand cutting and slicing small flowers and hand pollinating others and harvesting and labeling seeds. A plant breeding cycle can take up to five years and often times longer before results can be obtained making precise control over the variables and timing of events critical. One way to achieve this is spatial control over plants and who has access to them. Also, and increasingly important to spatial control over plant breeding, is legal protection over the inbred lines that breeders work with and other intellectual property rights associated with the process.

The guiding assumption in station-based crop breeding is that crop varieties developed on research stations will be able to produce high yields across all environments. That is, there will be a spillover effect from the high yielding environments of stations and farms managed like stations to low yielding environments like the resource-stressed environments of the world's poorest farmers. The argument for this assumption is the underlying widely-adapted genetic diversity of station-bred plants and the heterosis effect—the sudden increase in a desired trait that results from a still-unknown mechanism triggered when two or more in-bred lines are crossed.

Participatory plant breeding confronts the socio-spatial separation between farmers and breeders by calling for farm-based breeding to include actual farms and farmers in the overall plant breeding process as a means to reconnect farming and formal plant breeding. Again, formal plant breeding is intimately connected to industrial farming and breeders regularly work with such farmers. However, from the perspective of participatory plant breeding, the carefully managed research station plots contrast sharply on an ecological level with the world's smallholder farms, particularly farms located in high stress environments where soil conditions, available water and other inputs into the farm equation are dramatically different (unpredictable or non-existent) than conditions on station plots. They argue that the spillover effect is exaggerated, untested empirically or flat-out wrong, that the simplified and controlled conditions of research station plots tend to produce plants that are better adapted to such conditions rather than the diversity of farm conditions found throughout the world.

Thus, advocates and practitioners of participatory plant breeding propose a direct challenge to the underlying socio-spatial organization of the science as it is built around the research station as the socially-bounded place where plants are improved. By moving research on-farm, participatory plant breeding aspires to produce better adapted crop varieties for farmers in less-than optimal conditions by incorporating these place-based conditions right into the plants themselves. In a sense, then, on-farm participatory plant breeding can be read as an attempt to breed place into plants, where place is defined principally in environmental variables and assumed levels of inputs (water, pesticides, fertilizers, labor, capital). As I will argue, because farms are social places embedded in local networks, this narrow definition of place (environmental variables) falls short of the wider socio-material reality that such plant breeding inevitably pulls into crop improvement.

Farmers as plant breeding collaborators

In addition to moving plant breeding on-farm, another component of participatory plant breeding is direct, face-to-face collaboration between farmers and breeders as part of the overall strategy to develop better crop varieties. Farmers can collaborate with plant breeders in the improvement of crops through a variety of means, on-farm or off-farm depending on the goals of the program. If plant breeding cannot be conducted on the actual farms where crops will be grown, another strategy that has been developed is to bring farmers to the research station to take part in various different stages of formal crop development. One strategy that has emerged is participatory varietal selection, (PVS) where farmers assist in the selection of plants further upstream in the process during what is called the segregating population stage (Cleveland et al. 2000). This means that farmers help to identify certain plants that will become the parents of the lines that will eventually be crossed to produce specific varieties (plant breeding with out-crossing plants like maize works primarily by first reducing the diversity of a given population by self-pollinating plants to produce a homozygous population of individuals—a line. Lines are then cross pollinated to produce a hybrid).

The subject of knowledge and its relation to practice within and between farmers and plant breeders has become a major vein of research in the participatory plant breeding literature and in participatory development in general. The assumption with this research is that a deeper understanding of both local or farmer knowledge and plant breeder's knowledge in relation to social contexts and practices can help in gauging the compatibility of getting the two to work more effectively to improve crops. The argument for learning about farmers' knowledge is that this knowledge could be extremely useful to breeders and is otherwise completely overlooked or at best generalized into a disembodied provider of inputs in station-based breeding.

Consequently, any insight farmers might possess about their crops, their environments or the interaction between their crops and environments is essentially lost in the conventional breeding process. In addition to the purely environmental knowledge, there is also a concern within participatory plant breeding to foster more general communication between breeders and farmers and, in some veins of the literature, an effort to empower farmers by allowing them space to direct the research process more toward their individual and community goals.

<u>The Problem: what is participatory plant breeding?</u>

Collaborative plant breeding appears to offer a viable strategy for dealing with crop improvement for many more of world's farmers than has been the case so far with conventional approaches thus widening the benefits of the science and thereby moving to a more sustainable agriculture (crops better adapted to existing conditions can allow farmers to increase their product while using less environmentally destructive practices and fewer economic resources). What, then, does collaborative plant breeding really represent: another way to carry out conventional plant breeding, or another kind of plant breeding altogether?

The literature is unclear on the answer to this. On the one hand, many inside plant breeding continue to argue that they have been doing a kind of collaborative plant breeding all along, albeit among large-scale producers, and they hold to the broad adaptation paradigm in which plants bred through the conventional station-based approach will outperform varieties bred through any other process (Duvick 1996). On the other hand, many practitioners of collaborative plant breeding are careful not to push their agenda too hard by suggesting their approach is complimentary or otherwise non-challenging (institutionally or pragmatically) to conventional plant breeding suggesting the practice is more or less same old wine in a new bottle called collaborative plant breeding.

Nevertheless, it is clear that collaborative plant breeding does pose serious challenges of a paradigmatic kind to conventional plant breeding by challenging the underlying socio-spatial organization of the science that is constructed around the dyads breeder-station and farmer-farm. By placing plant breeding research on-farm and by including farmers as breeding collaborators, collaborative plant breeding brings into question the underlying *socio-spatial* strategy of plant breeding science in general. That is, the way in which plant breeding sets up a socially defined and bounded landscape of social spaces and positions and calibrates the flow of entities through these spaces. It is, in essence a matter of the social geography of a science. For example, the research-station-scientist socio-spatial dyad juxtaposed to the farm – farmer dyad and how certain farms and farmers become associated with and identified by industrial scale production as a socio-spatial dyad intimately connected to (networked into) conventional plant science. Did this peculiar socio-spatial dyad just pop into existence through a series of rational processes? Or, does plant breeding somehow create these dyads, spatial relations, material and social flows? The formation and evolution of this socio-spatial strategy are the central issues we confront when dealing with collaborative plant breeding.

We see for example how collaborative plant breeding not only brings in new sets of actors, like the farmer, to crop improvement but how this new style of breeding also creates new socio-spatial hybrids like research farms that function as both sites of intensive scientific research and also places where farmers must live their lives. By bringing farmers and farms into the plant breeding process, collaborative plant breeding effectively widens the socio-material landscape of plant breeding. The three-part question that arises, then, is; what drives this expansion, how wide does or can it go, and what are its limits?

In this research, I argue that farmers and farms do not exist in a socio-spatial vacuum waiting to be pulled into plant breeding networks. Rather, farms and farmers are already enmeshed in plant breeding and other networks as integral players and places of a larger food geography, or edible landscape. An edible landscape is simply the overlapping zones food production and consumption that bracket the more specialized spaces of social interaction that organize the flow of materials and actors involved in producing, processing, selling and eating food. The socially-defined boundaries of these zones and spaces are dynamic and their precise location at any one given time is less important than the socio-material flows and exchanges that link them together. Thus, when plant breeding involves farmers and their farms, the socio-spatial organization of the science must necessarily adjust to, and be calibrated with, new hybrid spaces and entities within the larger edible landscape that is always under construction. I call this the edible landscape.

All landscapes are edible, differing only in degree. An edible landscape is a hybridization of the material and the social: it is a physical setting in co-evolution with the social relations between humans and non-humans that are co-produced in dialectical relationship with this setting and which render it consumable through food. An edible landscape is thus a relational construction, a hybrid of nature and culture grounded in the materiality and geography of farms and the web of social relations that are organized around producing and consuming food.

The Edible Landscape

In this dissertation I use the edible landscape as a theoretical framework for a socio-spatial analysis of plant breeding science, in particular maize breeding science in Portugal (Figure 1). Plant breeding, the modern techno-science of developing new and improved crop varieties for agriculture, has long been a key force in the formation of edible landscapes worldwide by playing an important role in producing crops that are grown on farms around the world and that are consumed in one form or another by billions of people. Plant breeding is also the principal medium through which abstract agricultural development policy is translated into specific practices and, eventually, into food. In a very real sense, then, one consumes plant breeding as much as plant breeding plays a role in producing what is consumed (Fitzsimmonds and Goodman1998).

Although these connections between plant breeding and food, and the broader landscape of production and consumption, are clear enough, research in what can be broadly considered the plant breeding literature rarely makes this connection explicit. Indeed, although there are numerous studies of plant breeding from an ecological, behavioral, historical and political perspective, there is thus far very little research that takes the s*ocio-spatial* development of the science, the relationships between spatially arranged and socially connected actors in the broader geography of food, as a problem for study (McGuire 2008).

This ethnography documents how one collaborative maize breeding project takes shape as a socio-material formation around the effort to develop a new maize science in Portugal. The ethnography reveals how this effort is best understood as an attempt to calibrate the socio-spatial organization of plant breeding and the material exchanges and flows of maize in northwest Portugal. This involves, specifically, attempting to forge an irrevocable link between the social spaces of maize production and consumption and the social spaces of maize science—a task considerably more difficult than simply breeding plants.

To frame this study, I draw upon ideas and terminology from actor network theory (ANT) and, to some extent, feminist critique of technology. I draw upon this theoretical language only where necessary to explain and organize what I observed in the field and not as an arbitrary or pedantic borrowing of ideas.

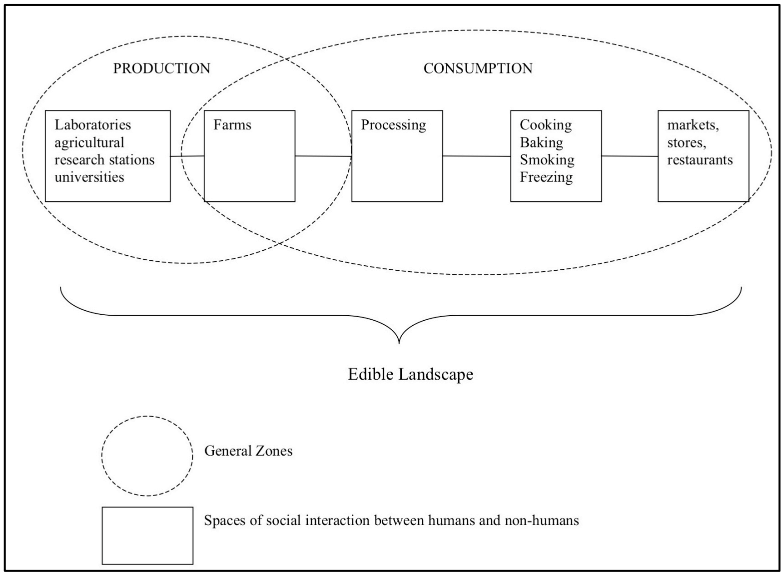

Figure 1: Theoretical model of the edible landscape.

In fact, where ANT provides an insightful lens on the practice of science-as-politics by other means, it is considerably weaker on the role of space and spatially situated relations and practices. In a sense, ANT empiricism looses ground when it comes to the materiality of spatially situated practices. Likewise, the feminist critique of technology and the design process effectively reveal the co-construction of technologies and their users. That is, how technologists script gender assumptions into the technologies themselves (e.g. women and men will naturally prefer and use certain technologies over others). This literature helps to problematize the relationship between plant breeders and the crop varieties they design relative to the targeted user of crop varieties, the farmer. So, it is the combination of these theoretical ideas and field observation data that I use to form the idea of the edible landscape, a socially defined geography of production and consumption relations co-constructed with a new style maize breeding science.

Food landscape of northwest Portugal

People in northwest Portugal have been converting the physical landscape of steep hillsides and verdant river valleys into a striking food landscape of small family farms for well over five hundred years. Travelers, historians and social scientists alike have all commented on northwest Portugal's small farm landscape, the center of which has long been the *campo-prado* farmstead, an often disjointed space of less than five hectares that are intensively cultivated year around by the resident family (Bentley 1992, Black 1992, Firmina 1999, Pina-Cabral 1986, Pires 1992, Ribeiro 1998). These small farms reflect the historical high value that people place on land for food production in one of Europe's most densely-populated rural regions. Here, even the air is cultivated with ubiquitous *vinho verde* (green, young, wine) grape vines seen trained high over meandering footpaths and property boundaries. The vines are supported by a network of wire trellises affixed to sturdy granite posts that stitch together thousands of irregular-shaped fields like patches in a massive green crazy quilt blanketing the northwest Portuguese countryside.

Within the past two hundred years, the edibility of this landscape has revolved principally around a single crop, maize (*Zea mays* L.). Known as *milho* in Portuguese, maize was introduced to Portugal soon after Columbus returned from the Americas soon after 1492. Many questions remain as to where, when, and how maize actually entered Portugal and subsequently spread throughout all parts of the country. In any case, the plant quickly became the main field crop in northwest Portugal by at least the 1600s (Pires 1992, Ribeiro 1971). As a field crop, maize initiated widespread socio-economic and environmental changes such that Portuguese geographer Orlando Ribeiro refers to maize farming as constituting a socio-ecological revolutionary event ushering in, among other things, the smallholder farming system still evident throughout the northwest today (Ribeiro 1971, 1998). It is clear from contemporary uses of maize in the northwest, the crop would have offered early Portuguese farmers an opportunity to expand small scale farms beyond the large estate system by offering a relatively high yield of grain per unit of land and labor input, and by fitting well into the preexisting viticulture and rye-grass seasonal pasture farming system. The pattern of intensively cultivated small maize farms, together with limited animal husbandry and intensive viticulture, formed a distinct northwest agro-landscape fingerprint in the broader landscapes of Bacchus described by cultural geographer Dan Stanislawski (Stanislawski 1970). A testament to the maize crop's socioeconomic importance, well into the 1970s farmers in the northwest continued to evaluate the value of farmland on the ability to yield a maize crop, and the term *milho* became almost synonymous with agricultural land parcels (Pina Cabral 1986).

Maize agriculture, and the maize plant, are no less important agronomic and culinary facts of life today in northwest Portugal where practically all forms of commonly consumed food are based either directly or indirectly on maize. Local cheeses are produced from the milk of dairy cows fed maize silage. Highly prized smoked pork meat or *presunto* is derived from maize-fed hogs, and even local oxen and beef cows are fed with entire maize plants, grains and maize flour. By far the most important form of direct human consumption of maize is the traditional maize bread *broa*. There are many types of *broa*, the type most common in the northwest is a dense *boule* loaf said to have been the staple food of farm families sustaining many rural people during the many and infamous periodic famines and economic depressions of the past (Bentley 1992, Black 1992). Although long considered by many contemporary Portuguese as a famine food, and a reminder of harsh histories, today *broa* has enjoyed a resurgence in popularity as one of many specialty boutique foods.

The maize plant, and its cultivation practices, are each a critical symbolic presence in the rural tourism economy and the emerging cultural politics of regional identity that revolves around local food production and consumption. Many regional political identities, such as parishes use the maize ear as a symbol of their region (Figure 2).

Figure 2: The banner of *Lousada* Parish, showing maize ears surrounded by grape vines, photo by author.

Although rural agri-tourism in the northwest region is essentially structured around viticulture and vinification of the effervescent demarcated regional wine *vinho verde* (Marques 2006), the tourist gaze is nevertheless directed toward a traditional rural landscape of maize fields with the characteristic piles of drying maize stalks, *medas*, maize threshing floors and the widespread maize corn cribs, *espigueiros*, that have come to symbolize vividly and tangibly the rural landscape and culture of northwest Portugal (Firmina 1999). Thus, maize is both a living thing in farmers' fields and a critical nexus of production and consumption processes and relationships that span the social landscape of politics, economics, and regional identity all centered on food. Likewise, maize farms provide a social interactional space in the physical landscape that connect notions of sustainable futures with a mythical cultural past that is a consumable, idyllic, landscape for tourists. In many ways, then, as a food, as a symbol, and as a living entity, maize both embodies and allows for the embodiment of, the production and reproduction of a northwest Portugal food landscape.

A hybrid landscape

The food landscape of northwest Portugal is an example of what scholars increasingly refer to as a hybrid, or *socionatural*, landscape: a physical setting that co-evolves within the social relations between humans and non-humans interacting in dialectical relationships with this physical setting, and which render it consumable and reproducible through food. Hybridity refers to the emergent, or relational, quality of landscapes, the notion that the interlinked and co-constitutive socio-material spaces for production and consumption that collectively make a landscape are always in the process of being formed (Cloke and James 2001; Murdoch 2003; Rudy 2005; Swyngedouw 1999; Thrift 1996; Woods 2007). The formation of landscapes is therefore first and foremost a hybrid process because of the mixing, mingling, and associations of material and social resources and process that combine nature, culture, society and technology at any given moment. However, ontologically fixed categories such as nature, society, and culture, are not, in themselves, appropriate or adequate to the task of understanding or explaining the formation or shape of hybrid landscapes as such terminology is rooted in fixed and pure notions of identity that fail to account for the dynamic mingling of technological, scientific, political, cultural and material processes in the category of food. How, for example, ask Fitzsimmons and Goodman (1998, *passim*), does one adequately describe an industrialized farming landscape without simultaneous reference to science, technology, labor relations, and global politics and, of course, farmers, soils and pests?

Because humans everywhere continue to produce food terrestrially, all landscapes are theoretically consumable, differing only in the extent to which the material and social relations of food production map onto the social geography of food consumption. A consumable landscape thus is a true example of a relational landscape, or one that emerges through the interaction of consumption and production processes and actors all of which are grounded in the materiality and geography of farms, and the web of social relations that are organized around producing and consuming food. These hybrid landscapes emerge through the interaction of the biophysical forces of sun, soil and water, and the social forces, the social organization, of production and consumption that transform plants into crops, and crops into specific edible products. Farms and gardens are thus key, but not the only, nodes of hybrid consumable landscape formation by serving as condensed spaces of social negotiation among the wide range of human and non-human entities located in intersecting geographies of food.

Research Goals

This dissertation explores the relationship between maize science and society in northwest Portugal within the framework of the edible landscape. To many, an edible landscape is the product of *edible landscaping*, or the conscious design of a home garden or other landscape feature so as to make it more edible for humans. This essentially means planting more herbs, edible fruit-bearing plants and vegetable crops in the landscape surrounding a house or other structure. In this work, however, I develop the notion of the edible landscape as hypothetical space in which to map the *socio-spatial* strategy of plant breeding science, the ways that plant breeding acts as a medium for organizing the socio-material organization and flow of food through the zones and spaces of production and consumption in a given locale. In short, this is a study of how food production and consumption is socially and spatially organized through plant breeding science.

Strangely, even though plant breeding science has clear relevance to how food is grown (produced) and consumed around the world research on plant breeding rarely considers the science explicitly from this perspective. Plant breeding text books and articles for example scarcely mention the word food or even consumption. The food-eating public on the other hand frequently reacts negatively to plant breeding when things like genetically modified (GM) crops arrive on the scene. Suspicious of the role science plays in breaking down and altering what is natural about food and transforming it into Frankenfood, public sentiment over GM food reflects an uneasy sense that science somehow manages to attach onto the food that is consumed.

When viewed from the perspective of food, plant breeding science appears to involve many more actors and processes than might initially seem to be the case than if we were to assume that plant breeding is only about plants. We find, for example, that plant breeding is present in both the material landscape of food production in the form of laboratories, research stations, genebanks and farms, and also in the social landscape of food consumption in the form of crop varieties that are transformed into food. When we consume the products of a process, be it agriculture and / or agricultural science, we take these processes into our collective and individual bodies and thereby play a role in the reproduction of the science-mediated process of food production. Fitzsimmons and Goodman (1998) provide a classic example of science-mediated food, hybrid corn.

Thus, the motivation for this research: to uncover the processes by which plant breeding science manages to adhere onto food and become reproduced in the social and individual bodies by organizing specific ways for people to grow, process and consume crop varieties. I explore this topic through an ethnographic study of the Sousa Valley Maize Breeding Project, or VASO as it is know in the acronym-laden world of crop science and agricultural development discourse.

I first encountered the VASO Project in 1999 through its director, Dr. Silas Pêgo, Portugal's chief maize breeder. A lean, intense figure, Dr. Pêgo greeted me at his offices located then on the Quinta Sao Jose, an agricultural research station just outside the city of Braga in the heart of northwest Portugal's Minho region.

Dr. Pêgo was raised on a small farm in northwest Portugal before pursuing maize breeding training in Lisbon and, later, in the United States at the University of Iowa where he earned his doctorate under the tutelage of Dr. Arnel Hallauer, an eminent figure in maize breeding. Pêgo has since used plant breeding to pursue a life-long passion for helping small farmers across the Portuguese speaking world including Africa, Asia and Brazil. Although Pêgo was trained in conventional research station-based plant breeding, he has never been comfortable with these methods as a means to help small farmers like his own father and like those with whom he has lived and worked. It is clear that by working with small farmers directly on their farms, Dr. Pêgo is not simply experimenting with another way to breed plants; rather he is trying to re-define maize breeding altogether. His project, VASO, is more of a philosophical critique of conventional maize science which he argues has been developed for more industrialized agricultural systems that are not appropriate models for northwest Portugal or anywhere else smallholders live.

In 1984 Dr. Pêgo and a handful of other social scientists and farmers in the Sousa Valley formed the VASO Project, so named after the Vale do Sousa region where Pêgo established a headquarters in a local elite farmer organization called the Centro Gestao Agricola Vale do Sousa (CGVAS) (Carvalho et al. 1986, Pêgo 1984, 1997).

At the time VASO started, and continuing to today, national demand for maize was vastly outstripping national production of the crop (Black 1992, Finan 1987, INE 2000; Monke et al. 1993, Pearson 1987,). Since northwest Portugal is the center of maize agriculture and also the region of predominately small family farms, it has been common for economists, bureaucrats and planners to blame the low yields of maize on the backwardness of northwest farmers, particularly their use of traditional or farmer's varieties of maize (Black 1992, Finan 1987, Monke et al. 1993).Modernist- minded planners also look to the small, dispersed, plots of land and generally low-technology of such farms as an impediment to progress in rationalizing maize farming in the northwest (Bentley 1987, 1990, 1992, Finan 1987, Unwin1988).

Although numerous anthropological studies document the rationality of these farmers and their way of farming that has persisted for centuries in the northwest (Bentley 1992,Black 1992, Pina Cabral 1986), the opinion that smallholders are anachronistic impediments to progress is still widespread in the country except within new organic and sustainability discourses.

As a Portuguese-born maize breeder, Dr. Pêgo feels a strong personal and professional obligation to help increase the domestic production of maize by developing new maize varieties or by somehow increasing the yields, the yield stability and the grain quality of existing maize varieties. The problem, for Pêgo, was in how to achieve these goals. This would require not only a new method, argues Pêgo (1984), but a whole new philosophy of plant breeding which he calls an integrated philosophy that he contrasts with the American style "productivist philosophy" that does not fit the social, environmental and agronomic conditions of the northwest (Pêgo and Antunes 1997).

Fieldwork for this dissertation took place mostly in the Sousa Valley (around the cities of Paredes, Penafiel, and Lousada) (Figure 3). From the very beginning of the project, VASO's scientific staff discursively linked the proximate technical goal of improving maize varieties for northwest farmers to a broader philosophical critique of conventional maize science in general and specifically its development and application within Portugal.

Claiming that conventional maize science is based on imported models of large-scale commercial agriculture that are inappropriate to much of Portugal, the VASO staff argued for an alternative style of maize science that would be more attuned to the specific needs and constraints of local northwest farmers and, by extension, would also play an important role in fostering agricultural, environmental and economic sustainability throughout the region. Sustainability in the context of the VASO proposals refers to three specific problems identified by the VASO Project: a demographic trend toward rural village abandonment for increasingly crowding coastal urban areas, a general decline in farming as a way of life throughout the rural northwest and the concomitant loss farmer-management of local environmental resources including local plant and animal varieties, irrigation systems and communal forests. Under the assumption that increased domestic maize production on local farms would help to increase the economic viability of small farms, the VASO Project team embarked upon an ambitious program of on-farm participatory maize breeding. This participatory plant breeding methodology developed by Pêgo is based on three contrasts he makes between the conventional or productivist methodology (all from Pêgo and Antunes 1997 and reviewed by Moreira 2006, et al. 2008 and Vaz Patto et al. 2004, 2007, 2008).

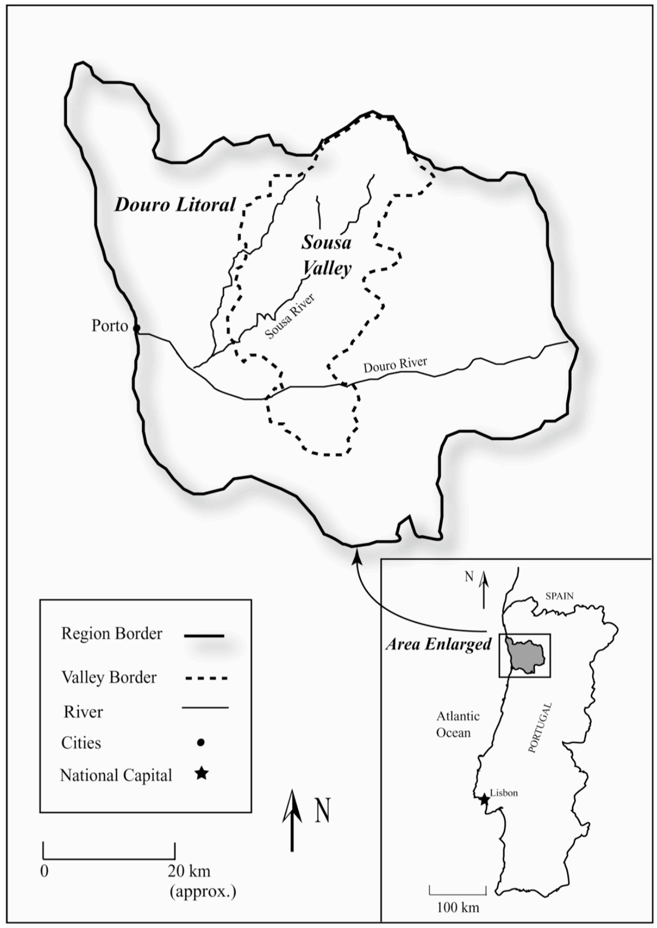

Figure 3: Map of Portugal and the Sousa Valley, map by author

First, there is the notion of what plant breeding is (ideally) supposed to achieve, according to Pêgo. Because plant breeders are concerned with plants, Pêgo argues that the seed is the center of research. Everything else, the farms and particularly the farmers must adjust themselves to the seed that breeders produce. In other words, the seed is the king as Pêgo puts it. The VASO Project's philosophical position is that the farmer should be the king and that breeders need to take account of farmers and breed seeds for them, not vice versa. If there are changes or adjustments to be made, these should fall to the breeders and the seeds and not the farmers. Again, one has to keep in mind the farmer in this instance is the smallholder Portuguese farmer. Dr. Pêgo readily concedes that industrial-scale farmers are what he calls "the king" of conventional approaches to maize breeding (Pêgo, interviews).

A second principle in the VASO philosophy focuses on yield and what this means in a breeding program. In conventional plant breeding yield is a measure of the output of plants and populations of plants across time and space (yield stability over time and space is as important to breeders as total yield). Pêgo raises the important point that for smallholders the yield of the entire farm has to be considered such that one does not loose sight of the relationship of maize to other crops grown at the same time or sequentially. In short, one has to appreciate the farm as an entire system and not as means to simply produce maize. This focus on the farm as a system allows Pêgo to claim success with only modest increases in the maize yield if the yield of the farm as a whole does not decrease as a result.

Lastly, one of the most important principles of the VASO breeding philosophy is the role of biological diversity both within and between crops. All plant breeding is based on genetic diversity as the raw material of the trade. Conventional plant breeding draws most of this diversity from cold-storage collections maintained ex-situ (outside the farming system) in gene banks located around the world. However, for thousands of years, genetic diversity of domesticated crops existed only in farms and gardens. With the modernization and simplification of farms, however, genetic diversity on farms has dramatically decreased to the point of alarm among some scientists. There is continuing debate over the causes and implications of farm-level diversity, however there is also unanimous agreement among scientists that genetic diversity on-farms is of positive value to farmers and society alike (Brush 2004; Cleveland 1993, 1998; Smale 2006; Zimmerer 1996).

Pêgo believes that breeders should try to work with the farmer's own maize varieties and the diversity on-farm should be as high as possible, and certainly not diminished by plant breeding or breeder's varieties. Thus, one of the guiding principles of VASO is to work with, enhance or otherwise increase the useful genetic diversity within crops and the biological diversity between crops on farm.

The VASO Program is not too different than a plethora of other similar projects of participatory plant breeding initiated in 1984 by diverse groups of plant breeders around the world. By placing plant breeding research on-farm and by including farmers as breeding collaborators, collaborative plant breeding brings into question the underlying *socio-spatial* strategy of plant breeding science in general. That is, the way in which plant breeding sets up a socially defined and bounded landscape of social spaces and positions and calibrates the flow of entities through these spaces.

By aggressively engaging the locality of farming as a socially embedded production-consumption site, collaborative plant breeding not only brings in new sets of actors, like the farmer, to crop improvement but it also sets up new socio-spatial hybrids like research farms that function as both sites of intensive scientific research and also places where farmers must live their lives. In bringing farmers and farms into the plant breeding process, collaborative plant breeding effectively widens the socio-material landscape of plant breeding. Farmers and farms do not exist in a socio-spatial vacuum waiting to be pulled into plant breeding networks. Rather, farms and farmers are already enmeshed in other networks as integral players and places of a larger edible landscape. Thus, when plant breeding involves farmers and their farms, the socio-spatial organization of the science must necessarily adjust to, and be calibrated with, new hybrid spaces and entities within the larger edible landscape that is always under construction.

Methods: From Knowledge to Actor-Networks

My initial interest in the VASO Project was in researching the relative contribution of farmer and scientist knowledge to maize breeding and sustainable agriculture in Portugal (Powell 1999). Rather than approach knowledge as something abstract and theoretical (e.g., as lists of things in farmers or plant breeders heads), I proposed to study the practice aspect of knowledge construction and daily use. I was interested specifically in conducting research in regions of the world where the small-scale, subsistence agriculture of the smallholder type persisted (Netting 1993). The reasons why such agricultural systems persisted, and the lessons they might hold for future agriculture intrigued me. Also, I had developed an interest in plant breeding, and the curious relationship between plant breeders and farmers that scientists had begun to document in their work with smallholding farmers around the world (Ashby 1986; 1997; Eyzaguirre and Iwanga, eds, 1996; Maurya et al. 1987; Sperling and Loevinsohn 1995). There was also a critical social science perspective emerging on this issue of farmers' and scientists' knowledge in the context of agricultural development and sustainability (Brush 1985, 1995; Bellon 1995; Cleveland and Murray 1997; Frossard 1994; Kloppenberg 1988, 1991; Orlove 1996; Scoones and Thompson, eds.1994; Sillitoe 1998; Soleri and Smith 1995; Soleri, Smith, Cleveland 1999). I selected the maize plant for intensive research, and I became interested in the convergence of agricultural science, primarily classical plant breeding, and smallholder maize farmers.

The maize plant itself interested me for several reasons. First, maize is one of the world's major crops in terms of production quantity, and dietary importance. Secondly, it seemed that there had been a tremendous amount of scientific research conducted on the maize plant (it even has its own scientific journal, *Maydica*). Maize was one of the first organisms that modern scientists selected for genetic research (Fitzgerald 1990, 1993; Hallauer and Miranda 1981; Keller 1983, 2000, Kloppenberg 1988). As with rice and wheat, maize is one of the main players in the famous Green Revolution. So there is a great deal of literature on the position of this plant in global scientific hegemony (Kloppenberg 1988). Lastly, being a student of diffusion, I was compelled by the implications of the importance of maize agriculture, and the associated uses and knowledge of maize, around the world from Africa (Smale et al. 1995) to Portugal (Bentley 1992; Black 1992; Unwin 1988).

Thus, my initial focus of research was narrowly restricted to propose an ethnography of plant breeding knowledge which specifically focuses on the procedural or working knowledge which is common to both farmers and scientists. My goal was to document and explain how farmers and scientists construct their respective knowledge about crop biology and farm ecology in relation to daily work routines and technical practices, the physical processes involved in acquiring experience, and the social and material contexts in which theoretical, empirical and intuitive knowledge is produced.

My reading of the farmer knowledge literature is that much more is known about what researchers *think* is farmer knowledge, rather than what farmers themselves think about their own, or others', knowledge, and how farmers learn and *practice* this knowledge. This is not only a function of un-reflexive methodology, but also a problem stemming from an exclusive concern with knowledge *content* to the virtual exclusion of knowledge *formation* and *practice*. For analytical interpretations of farmer knowledge, most studies continue to rely principally on descriptive-narrative accounts gained second-hand from farmer interviews, questionnaire responses, or directly through limited observations of farmers' practices (Brush et al. 1992; Bellon 1995; Sumberg and Okali 1997).

Instead of a list-based knowledge approach, I proposed to examine these processes from a more dynamic practice perspective using a combination of visual and other descriptive data that included detailed photographs of people actually performing the many tasks in farming and plant breeding followed by structured interviews using the photos as a guide. Douglas Harpers' visual-ethnographic approach (Harper 1979; 1987; 1997) provided a model for my visual analysis of farmer and scientist knowledge. In his study of the working knowledge of a rural car mechanic in New York State, Harper (1987) develops a methodology for combining visual images of daily work in the shop with running narrative descriptions by the people pictured who describe activities transpiring in the images. This has been called photo elicitation and is a standard technique in visual anthropology (Collier et al. 1986) and sociology (Becker 1986) for guiding interviews and achieving in-depth emic perspectives.

These particular methods were put in the context of a grounded theory, described by Strauss and Corbin (1990). The process involves building theory in the field through a continual refining of research questions and hypotheses moving in stages from: a) intensive personal immersion in the phenomena under study, b) sorting and coding detailed descriptive data and grouping this data into larger theoretical categories based on observable patterns, and d) formulating hypotheses explaining the patterns. Informants are more like collaborators in the research process that cross-check continually for emic evaluations and perceptions of the data organization. Finally, hypotheses that help explain patterns in the data are tested in the field to develop a wider theory grounded in the ethnographic reality.

The main methods for collecting data were (initially): 1) my participation in select activities (planting, maize ear shelling and harvesting) and naturalistic (not externally planned) observation of scientists and farmers carrying out their daily activities, whatever these might be, on the plant-breeding project farm; 2) documenting through detailed photographing (over two thousand images) and audio taping, and later coding these data, of farming practices and skills; and 3) open-ended and focused interviews with selected farmers in the surrounding area, relevant scientists and genetics resources professionals located throughout the region and nation, and related persons (including periodic personnel of the plant-breeding project case study).

My intention in this research has been to achieve more ethnographic depth at the expense of breadth, and also my intention of following the actors where they go. Frequently, the actors did not go very far! Other times they traveled to other countries and cities. Hence, there is de-centeredness or multi-sited quality to this research, as it is not tied specifically to any specific location, or particular village in the sense of a traditional ethnography. Ethnographic movement consists of following specific people and their networks, to wherever they extend. In addition to this live data, I collected and analyzed data on farmer entries in a local annual best ear of maize competition over a six-year period. This information, which includes 210 individual entries of separate ears, proved helpful in establishing a base line for understanding, in a locally recorded manner, maize crop variety use in the region over time.

On-farm

The VASO Project is often labeled an on-farm program, meaning the majority of breeding activities are designed to take place there. The farm of Francisco Meireles was selected by Pêgo in 1985 to be one of the main sites of the breeding program (Pêgo and Antunes 1997).

The Meireles farm (Figure 4) is located just off a bustling road that connects a major highway (A5) with the city of Lousada. Reflecting the patchwork uneven development of this region, the heavy, squatty tile-roofed stone buildings that make up the small farmhouse, detached kitchen area and animal corrals is flanked on one side by a mansion with tennis courts and an four-story apartment building with shops and a café on the first floor. One can have an espresso drink and play tennis while later working behind a couple of Meireles's oxen plowing a field of maize. The farm (as well as the neighboring mansion with tennis courts and the pink-tiled apartment building) is located (descending order of political organization) in the Parish of Lousada, the *Freguesia* (town) of Lodares and the *Lugar* (neighborhood) of Sequeiros. Nearby to this farm is another experimental farm of Pêgo's, located adjacent to a new Shell gas station (that also contains the requisite small restaurant and coffee and alcohol bar).

Meireles and his constant working companion Dona Carolina have lived on this farm of less than 4 hectares for over thirty years, more than half of Meiereles's life (at the time of this research, 2000 – 2002). Together they raised five children, all of whom worked daily on the farm until marrying and forming their own households. During the time of my research, although not when Pêgo's VASO Project started, Meireles and his spouse Dona Caronlina were the only full-time human residents of the farm.

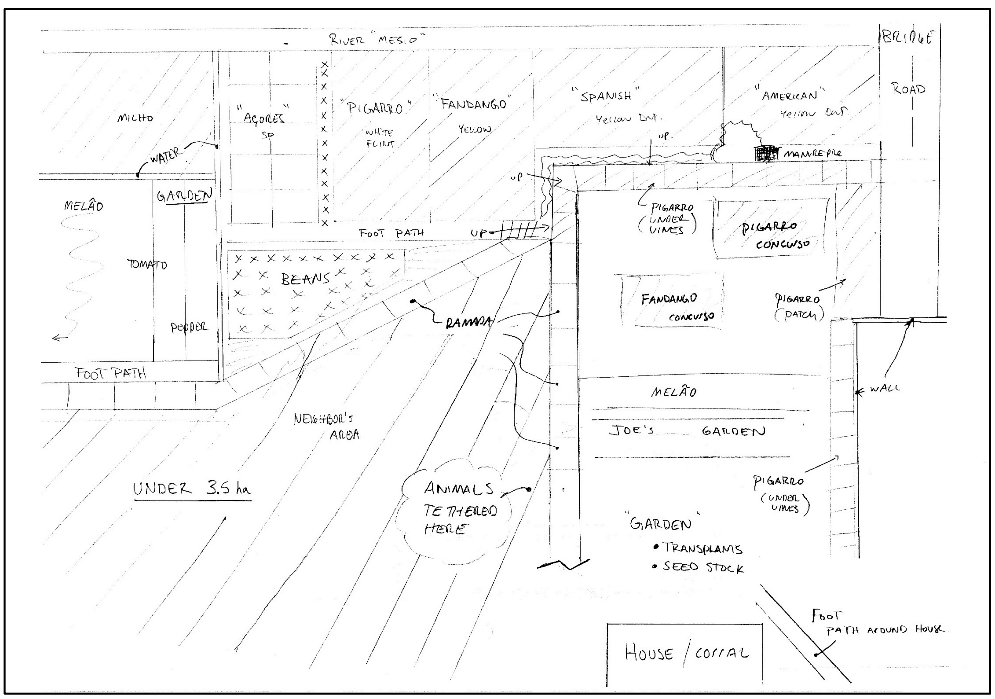

Figure 4: Sketch of map of Meireles farm, by author.

Although Mr. Meireles refers to himself simply as an *agricultor* (farmer, roughly translated) he in fact would be considered by census enumerators as a *caseiro* because he does not own the land that he has continuously farmed for thirty years. Rather, to farm his 3.5 hectares of farmland and to live in the stone house on the property, Meireles pays modest cash rent combined with a share of maize and grape harvest. Meireles is widely known by farmers in the Sousa Valley and he has had many opportunities to sharecrop others' farms. When I asked Meireles why he doesn't move on or buy his own property, he explains that he likes this spot for the sun and water availability and, most importantly, the wine grape vines that he says are very old and produce an excellent wine.

The Meireles farm is actually a collection of adjoining fields that vary in size and quality of soil. The entire farm is intensively cultivated by the pair with a seasonal rotation of summer maize and winter rye grasses intercropped at various times with potatoes, beans, cabbages, onions, peppers and melons (*melao*). Ever present are the carefully tended *vinho verde* (the effervescent regional wine) grape vines in the traditional *bordadura* style, tied to wire trellises supported by sturdy granite posts of about 10 feet in height. These trellises form meandering leafy tunnels over footpaths in the summer time and during winter appear to support tall dead sticks (the dormant vines) stuck into the ground. The small farm comprises an economic enterprise that would impress the most sophisticated bookkeeper. Under continuous cultivation the farm produces a continual flow of products from garden vegetables for transplanting or eating, smoked meats and even trained oxen.

The farming year is punctuated economically by income from two high-vale crops, the smoked pork that takes a full year to cure above Dona Carolina's open cooking fire and the *melao* that resembles a cantaloupe. Other high-value crops are the many garden vegetable plants cultivated for sale and the onions that are a staple in Portuguese cooking. In addition, Meireles raises and trains oxen for sale as work animals, or occasionally for slaughter as meat. However, people come from all around the Valley to buy Meireles' smoked presunto meat, he claims is due mainly to the food he feeds them (only high quality feed like ground maize flour). The melon is by far the most valuable single vegetable crop. Carefully tended and guarded throughout the spring, the *casca do carvalho* melon only ripens in August and will fetch upwards to 30 Euros a piece. A fungus invades the melon at a certain point in the growth cycle thus producing a delicious fermented champagne quality to the fruit. The process can go terribly wrong, however, and result in a sour melon. Thus, always the astute businessman, Meireles says take three for one good one!

Meireles's expertise in all things farming truly emerges in maize (referred to as milho in Portuguese). At any given time the small farm will contain three to four different varieties of maize planted to match varying soil and water conditions as well as maturity. Farmers in the Sousa Valley and northwest Portugal generally recognize two types of maize: yellow and white. Within these two types are numerous varieties that farmers either simply call *milho regional* or if purchased the specific corporate name such as Pituxa. Yellow maize is generally used for animal feed and white maize for human consumption in the form of the traditional maize bread *broa*. Sousa Valley farmers have found numerous uses for maize from bread making to green fodder for cattle.

Other than wine, there is probably no single food item with more cultural and historical importance than *broa* in northwest Portugal. Farmers in northwest Portugal would customarily evaluate farmland in the yield of maize, often referred to as the yield of *pao* (bread). Indeed the local expression for walking in a field of maize is to walk in bread (Bentley 1992). Small farmers like Meireles consider the quality and quantity of flour in selecting their maize varieties for planting (Pires1996).

Pêgo chose Meireles as a partner for breeding maize in part due to his farming experience in the Valley, his continued use of local maize and his curiosity about scientific plant breeding or *melhoramentos*. In terms of representativeness of the Valley, Meireles was a good pick. The latest Agricultural Census shows the continuation of a pattern for northwest Portugal: the average size holding is 3.2 hectares, renters continue to remain the second largest category below owners and 63 percent of farmers are over 55 years of age (Agricultural Census of 1999). Numerous other studies document a similar widespread patter of smallholding and renting in the northwest (Avillez 1994; Baptista 1995; Bentlety 1987, 1990, 1992; Black 1992; Brettel 1986; Finan 1987; Monke 1993; Moreira 1989; Pearson 1987; Pina Cabral 1986; Unwin 1988). Since the beginning of the best ear of maize contest held each year at the nearby farmers' cooperative, Meireles has won several trophies for his maize (Figure 5).

Figure 5: Farmer Francisco Ribeiro Meireles with Best Ear trophies, photo by author.

Off-farm

During the course of research, it became clear that the farm where VASO had focused much of its work, while typical of what one would expect from the ethnographic literature on Minho (a neighboring region, but similar in farming styles) had nevertheless become transformed from just another farm to a virtual plant breeding laboratory of sorts. Today I refer to the farm as a center of translation (explained below). For over twenty years, scientists, technicians and affiliated VASO staff from around the world had visited the farm to observe and participate in the breeding going on there. Francisco Meireles, for one, was linked to off farm networks through his family, the acquisition and maintenance of water-rights, his landlord, purchasing of equipment and constant selling of products from small plants for transplanting to the prized smoked presunto (smoked pork). Interestingly he knew very few other full time farmers in the immediate vicinity of Lodares, often claiming to be one of only two full time farmers within miles. All the others, he claims, are either dead or retired. Pêgo, I found, was linked to far-reaching circles of people and institutions within and outside Portugal, Europe, Portuguese-speaking Africa and Asia and the United States and Brazil.

To discover more about maize, I decided to follow its social pathways in the Valley--to move off the farm and to identify the range of actors involved in shaping the broader maize landscape. This meant tracking down the various varieties of maize in the area, and particularly the white maize being grown for grain used to make the traditional broa. I found this maize linked many people to the farm, as it did to the plant breeding project itself. I also needed to trace the strategies and arguments (verbal, on paper, or in practices) made by Silas Pêgo in defending and extending his project to farmers and others. How did Pêgo expect to spread the findings and products of his project? What kinds of resistance did he encounter?

I observed other farmers in action, and photographed and interviewed them much in the same way as I did with Meireles. However, most of my off-farm activities involved standard structured interviews or open-ended discussions (only one with the visual aided photography). In elaborating an interview schedule I developed a scheme connecting various people and agencies to the project farm, Meireles's farm. I developed different sets of questions, both narrow and broad based, on issues relevant to the person and their connection (either current or historical) to the on-farm project. I wanted to know what connected these people, and how they understood the project and whether or not they supported it. For the farmers group, I used a list of maize varieties known in the area (I obtained from these from lists of seed sales by the farmers' cooperatives) and I asked questions about the use and agronomic requirements of the varieties. I also asked what constituted a good maize plant, and ear, and whether the farmer knew any of the varieties being produced by the Pêgo's project.

Other groups of people were asked questions related to their role in the project's history or current form. Again, the people I interviewed were all connected to Pêgo's project in some way, either directly or indirectly. I became interested in the world taking shape around the project. Farmers, for example, were connected to the VASO Project through their entrance in the *Concurso* (competition for the best ear of maize) that Silas Pêgo had become involved (see Chapter 3).

Encountering *Pigarro*

One of the most important actors in the VASO Project is a variety of white maize dubbed *Pigarro*. In Portuguese, the word *Pigarro* translates into English as something caught in one's throat, but in the lexicon of farmers in the Sousa Valley of northwest Portugal *Pigarro* can also refer to the thick tube-like shaft that supports an ox-cart in a horizontal position.

In 1985, yet another meaning for *Pigarro* emerged: an unusual variety of white maize, or *milho branco* (*Zea mays* L.), that has a tendency to produce similarly tube shaped ears—a trait in marked contrast to the cone shape that maize plants normally produce. Farmers in the northwest have been growing white maize like *Pigarro* for centuries mainly for the production of flour used to make the traditional maize bread, *broa*. It is the tendency of *Pigarro* to produce fat ears of many kernels that attracted the attention of maize breeders interested in increasing the yield of white maize in northwest Portugal (Figure 6).

The VASO Project staff took an early interest *Pigarro* because white maize is important to local farmers as a source of bread flour and because the irregular "fasciated" ears offer a potential increase kernel yield per ear (and hence per plant) over the more regular cone shaped ears. This is sometimes called pé do porco or pig's foot.

Figure 6: *Pigarro* ears with pen, photo by author

Dr. Pêgo has been interested in the potential of this trait to increase yield by increasing the kernel row number. Pêgo's dissertation focused on the potential of this trait and his conclusions on it are the following (Pêgo and Hallauer, 1984: 39-53):

> Six Portuguese open-pollinated varieties were identified that had a high frequency of fasciation expression of the ears. Fasciation expression was influenced by the environment and inherited in a quantitative manner. …Heritability estimates on a progeny-mean basis were high for all traits….Correlation analyses showed that increased ear fasciation increased ear diameters and kernel-row numbers, but tended to decrease ear length and yield….Fasciation expression would be a useful trait for improving yield only for specific situations of intermediate expression….Because of its genetic complexity and specific situations under which it could be useful to enhance yield, fasciation expression should be considered in long-term breeding programs.

Pêgo reports finding a high percentage of this fasciation trait in samples of Portuguese germplasm indicating to him that some farmers somewhere must be conserving the trait (otherwise the trait would not persist in such a high frequency). Hence, the VASO staff began experimenting with increasing the incidence of this year in the populations of the *Pigarro* variety. It is hoped that an increase in yield could be matched by an increase in the quality of the white maize for the purpose of flour used to make the traditional farm bread, broa.

As I began to move around within the network of laboratories, farms, research stations, gene banks and farmers' organizations that VASO had contacts with, I quickly discovered that the *Pigarro* plant variety was a common denominator. The plant appeared in different forms in a variety of contexts: as a referent in grant proposals, as a population in farmers' fields, and as a First Place trophy for the Best Ear of Maize in the Sousa Valley competition held yearly at the local farmers' cooperative. The VASO project includes other maize varieties of interest, but it became clear to me that VASO had staked its hopes and future on the success of *Pigarro* alone. Consequently, *Pigarro* began to present itself as something more than just a plant in the conventional sense, as natural object for human contemplation and manipulation requiring nothing more than water, soil, and other *Pigarro* plants to reproduce. In fact, *Pigarro* appeared to obtain a social identity and agency within the networks woven together through the VASO Project.

Thus, I came to realize after conducting ethnographic research on the human-side of VASO that a complete, symmetrical, analysis of the project must include the non-human component as something more than mute Nature represented by *Pigarro* as an unusual plant variety. I had made the mistake of accepting crop varieties like *Pigarro* as biological organisms, the explanation of which can only be found in biological-botanical terms. I had overlooked *Pigarro* as a complicated social actor because I had accepted the concept of crop variety in pre-defined terms embedded in the historically and culturally situated sciences of botany, biology and genetics. I soon realized, however, that I had missed an important side to the VASO Project by overlooking one of its most important constituents in a social sense.

Consequently, I began to re-imagine the *Pigarro* variety not as something already defined, but as something that is in the process of *being* defined. In this vein, I began to consider *Pigarro* more as an ensemble of things and processes of a natural and a social character. *Pigarro* appears to be a perfect example of what some variously term a socionatural hybrid, or quasi-object: something that defies simple characterization as either natural or social. Much of *Pigarro's* socionature revolves around food and consumption and it is through conceptualizing *Pigarro*-as-food that connections can be made between plant science and food, farming and landscape in the Sousa Valley.

I argue that a complete, symmetrical, analysis of the VASO project must include the non-human components like *Pigarro* as something more than a passive, mute, non-human object of nature---a crop variety in the conventional sense. *Pigarro* appears as a perfect example of a socionatural hybrid, or quasi-object. In fact, the VASO actor-world and *Pigarro* appear to have become intertwined, and to some extent, indistinguishable. The fate of VASO appears to rest upon *Pigarro* being planted, grown, harvested, processed into flour, baked into bread and consumed by humans. If there was any breakdown in this chain, the VASO actor-world could crumble. For the VASO Project to mesh with the spaces and activities of the edible landscape of northwest Portugal, it must become naturalized as a part of the taken-for-granted background, an unquestioned solution to food, farming and sustainability problems in the northwest. To do this, the *Pigarro* plant variety must be socialized, that is, increasingly connected to a wider social group of humans and non humans all growing and eating maize.

The Maize Network of Northwest Portugal

Graphically represented, this network of people, places and things involved in or at least implied by the VASO Project can be sketched out (Figure 7). There are nodes, or socially defined spaces of production-consumption enmeshed in the maize network, that are of a functional and central importance in the flow of maize from seed to bread.

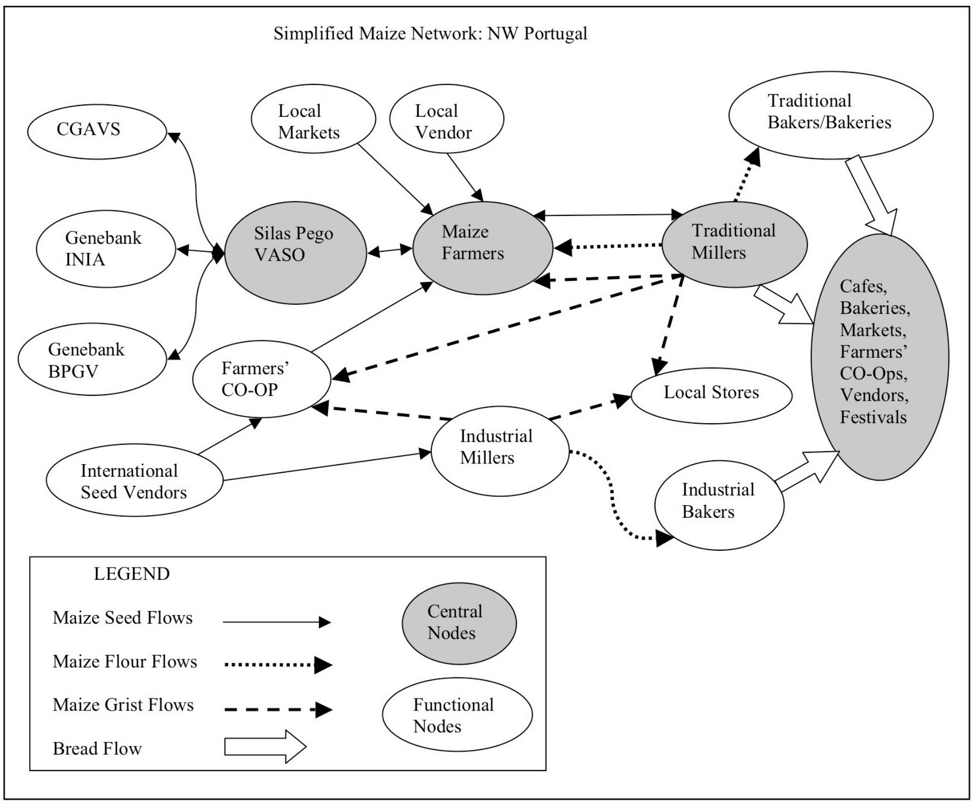

Figure 7: The simplified maize network of NW Portugal

This network describes the socio-spatial flow of maize and its change in form from seed to flour and from flour to bread. This network reveals that maize exists in many different forms within the social geography of food in the Sousa Valley, as a seed, as a plant, as ground-up flour to make bread. By focusing on *Pigarro* Silas Pêgo has linked his personal career and the fate of his project to this network operating smoothly (Pêgo 1997). Take away one small piece, or redirect one flow and the VASO Project becomes less viable in the real world, remaining just a series of diagrams and arguments embedded in a proposal that will never be funded. To make this flow work will require the management of many human and non-human actors including scientists, anthropologists, unruly plants, independent minded farmers, seeds, traditional grain millers, large sacks of flour and water mills, and bakers to name just a few.

In order to account for the many actors, processes, problems and contradictions that come into play in the social space generated by the VASO Project, and to re-connect production with consumption in the analysis of plant breeding, it is imperative that these linkages be made explicit in the unfolding ethnography of VASO. The short answer to the question of how the VASO Project relates to the edible landscape of northwest Portugal is that plant breeding has very little to do with plants, at least plants conceptualized as biological or genetic forms of an asocial and ontologically pure Nature. Rather, this science-society relationship hinges upon a re-conceptualization of plants as forms of socionature.

Theoretical Framing: Socionature and Actor-Networks

Socionature refers to an admixture or hybrid entity that defies classification as belonging exclusively to either Nature or Society and the existence of which cannot be reduced to a pure natural essences or a purely social process (Fitzsimmons and Goodman 1998; Jons 2006; Latour 1999; Murdoch 1995). To envision and problematize the link between plant breeding and edible landscapes anywhere one has to first understand that plants are forms of socionature while keeping in mind that this socionature refers to a *relationship* among human and non-human actors and not an obdurate stand-alone thing like a plant. Thus, plant breeders breed relationships between things and people, spaces and places where food is produced and consumed. More precise questions can then be posed with respect to the relationship between plant breeding and society: How does one breed socionature? And, how are landscapes rendered into edible forms of socionature through plant breeding science?

Socionatural things have always populated the social world of humans, yet it is only recently that scholars have begun to grant such things license to act in, and constitutively shape, human society. After a century or more of relegating non-human entities like plants, animals and machinery to the realm of nature or technology and thereby excluding them from social analysis, scholars have begun to reconsider the social agency of these formally mute actors by inviting them back in to social theory.

Actor-Network Theory

Karl Marx led the early effort to understand the social nature of non-humans through his re-conceptualization of the commodity as congealed capitalist relations of production. Marx, and subsequent social scientists, argue that common everyday items conceal the social process of their construction, and that seemingly simple, self-explanatory, objects in our midst are anything but simple or self-explanatory if one begins to question how such things came into being and how human societies are organized around their production and consumption (see Kloppenberg 1988 on the seed). This trend of studying things as relationships represents an important philosophical tradition that situates the analysis of things in terms of social interaction where non-human entities obtain and accumulate social identities, social power and a social life of their own through, among other avenues, circulation and exchange among humans but also as legitimate participants in action and identity (Callon and Law 1995, Murdoch 1997).

Non-human social identity and agency has been described by scholars in the Actor-Network Theory (ANT) perspective. ANT is most famously associated with the philosophical writings of Bruno Latour (1986, 1987, 1988, 1999) John Law (1992; Law and Hassard 1999), and Michel Callon (1980, 1991) and has emerged as theoretical means to deal with identity and, particularly, the formation of social identity in the context of scientific projects. Importantly, actor-network theory is not a coherent body of theory, but rather a methodological approach that follows from underlying theoretical assumptions. Nor is ANT a theory of the "actor," but rather the actor-network (hence the hyphen) which is an assemblage of actors. It is a co-constitutive perspective on agency, meaning actors can only act in concert with other actors. One example of this is the role of guns in crime: gun crime is in effect the human + gun actor-network, not just a human or a gun acting separately.

ANT scholars generally eschew a Modernist ontology that they claim conceptualizes the world in terms of dichotomies, most notably Nature, and Society. Such dichotomous thinking, ANT scholars contend, obligates one to assign identity a priori such that some things are deemed natural and some are social at the onset of analysis. This purification of an entity's identity, however, belies the complex, heterogeneous social nature of the many things in our midst today that do not fit so neatly in pre-defined categories: such things as mad cows, laboratory produced clones, genetically modified organisms, humans with pig heart-valves and thinking computers to name just a few. These entities constitute hybrids of nature, culture, and technology, rather than purified forms of any one conceptual category.

ANT research makes three claims about such hybrid things: they are black boxes concealing carefully constructed and orchestrated networks of association, and secondly, they are often lodged in the comfortable background of nature, (e.g. they are naturalized) unquestioned, until something goes wrong in their proposed role (cows going mad for example) and, lastly, they are full-blown social actors. In the latter sense, as social actors, non-humans achieve their reproduction and social amplification as they multiply and deepen their interactions with their human social counterparts. This has happened with the entity gene, for example. Genes have gone from being obscure entities in laboratories known to but a few, to being wrapped up in social discourses and practices of human health and identity (e.g. human genome). Over the preceding century of the gene this non-human entity has collected more and more humans into its unfolding universe and in the process it has become increasing socionatural in character.

Thus, rather than assume that there are pure, discrete ontological categories to which entities and processes naturally belong (or can be assigned), ANT scholars suggest that the world is simply composed of humans and non-humans that form assemblages, or actor-networks. *actor-network*s are the webs of social relationships that entities find themselves enmeshed in at any given moment and that give rise to socionatures. Networks of association between people and things (humans and non-humans) are proposed and held together by a network-initiator's strategies of convincing and compromise such that when, and if, a network is established, certain power relationships and identities are also formed.

The implication for identity within an ANT framework is clear: all the properties that are commonly assumed to inhere in individual entities themselves, things such as knowledge, power, agency, and so on, are seen as the properties of actor-networks: the thing becomes its relationship to other things. For example, the entity prion can only be understood in relation to the entity mad cow and a host of other entities enmeshed in networks of laboratories, industrial feed systems, government ministries of agriculture and a fearful (meat-eating) public. ANT scholars are thus interested in understanding and documenting how these assemblages, or actor-networks, form, the particular shape they take and what results from their formation; how a cow becomes mad has less to do with cows per se than the networks in which cows find themselves enmeshed.

An ANT approach to sustainability would describe the relative endurance or congealing power of a particular social arrangement, configuration, or collective, of humans and non-humans involved in mutually defining relationships. This is to say, for example, that the effort to restore a river (to a less-polluted state) is more a measure of the social relationships that define the river as an actor, rather than a measure of physical changes to the natural river itself. A restored river is one that is networked into different relations with humans and non-humans; its materiality has not changed but its social identity has, e.g., it is a restored river that takes on a new identity and agency *in relation to* its new associations with laboratories, technologies, scientists, government ministries and other humans and particularly non-humans (Eden et al. 2000).

Three studies from an ANT perspective illustrate the comments above. First is Michel Callon's investigation of a scallop over fishing problem in France. The second study describes the failure of a scientific network to extend into a Cumbria farming community, and the last outlines the difficulties of local people's objection to being defined by scientists in a plan to manage a marsh in England.

In this study, Callon (1986:196) describes a "scientific and economic controversy about the causes for the decline in the population of scallops in Saint-Brieuc Bay, northwestern France, and the attempts by three marine biologists to develop a conservation strategy for that population." The actors assembled around this issue are: three scientists (marine biologists), the scallops, local fishermen, and scientific colleagues in France and around the world. Callon sets out to trace the process of network building and extension, the actors involved in this and the resulting conflicts and crises ensuing. a better understanding of the establishment and evolution of power relationships….[and how] the capacity of certain actors—whether they be human beings, institutions or natural entities—to comply with them depends upon a complex web of interrelations in which Society and Nature are intertwined. Tracing the evolution of this network, the study hopes to see the simultaneous production of knowledge and construction of a network of relationships in which social and natural entities mutually control who they are and what they want (Callon 1986: 203).

Each actor is assigned a role in the three scientists' forming network. The three scientists charged themselves with defining the nature and the problems of all other actors and suggest problems will be solved if the actors negotiate through their program. Scallops are a cherished commodity for the French consumer with a largely unknown life cycle. To comply with the network, they would reproduce themselves with some predictability. The fishermen are economic maximizers who would over-fish the scallops if not convinced to stop and take part in the scientists' program. Scientific colleagues are sources of legitimization and funding. The outcome of this study is a network failure. The three scientists did not correctly identify the scallop life-cycle, scallops did not comply with scientists' expectations, scientific colleagues became increasing skeptical and loss of funding loomed. The fishermen betrayed the scientific network, became angry, and over-fished the scallops in one season. The project failed not because of a single technical problem or social or natural cause. Rather failure here describes an effect of an actor-network.

Wynne (1992) gives more credit and attention to pre-existing networks of local actors, hill farmers of rural Cumbria in this case. The study details the origin and development of the ambivalent nature of the local actors (farmers) towards a locally imposed science and an imposition of roles on them in the extension of a scientific network to a local place. The actors assembled in this drama are: scientists, the discoverers and controllers of a radioactive cesium chemical spread in rural Cumbria, the radioactive, non-human, whose properties are unclear and the hill farmers, who tend sheep.

Following the Chernobyl nuclear power plant explosion, radioactive cesium isotopes fell on the uplands of Cumbria. At first, radioactive fallout is declared as negligible. Six weeks later, a ban on sheep slaughter and flock movement is put into effect. Scientists (clearly with government sanction) impose knowledge and practices on the sheep farmers to understand and contain the problem (of cesium spread). Scientists ignored local knowledge and practices (suggestions made by local farmers) in dealing with the problem. In this context, scientific certainties about containing the cesium spread become less certain over time. After farmers see clearly that the scientists' assumptions are wrong according to the scientists' own models and predictions, scientists and their knowledge loose credibility among farmers. Farmers end up developing a deep ambivalence towards scientific knowledge on the subject (cf. Clark and Murdoch, 1997: 48-49).

The science network failed in this case because cesium doesn't conform well to scientists' expectations and assumptions due to locally distinct socio-material features (the soil). Farmers' knowledge of the locale on the behavior of lambs that condition soils is not collected or processed by scientists leading to a subsequent failure of experiments to determine the absorption rates of cesium in soil. Science thus looses credibility with farmers who are and remain ambivalent towards scientific knowledge, and this causes a negative feedback loop.

A final example considers whether the farmers see their enrolment in different terms than those proposed by scientists. How science runs into stocks of local knowledge and to highlight the specificity of place, in which a more intimate, and so more complex, relationship between generalized scientific knowledge and contextualized local knowledge is implicated (Clark and Murdoch 1997: 50). Here the actors are farmers, scientists, and nature itself.

The setting is Pevensey Levels, England (Pevensey Marsh). A tract of 3,500 acres of Pevensey Marsh is declared by scientists at English Nature as a Site of Special Scientific Interest (SSSI). Scientists of English Nature have become concerned that many areas defined as Site of Special Scientific Interest (SSSI) were deteriorating through lack of adequate management. English Nature develops Wildlife Enhancement

Scheme (WES), which aims to maintain and improve the wildlife interest on selected SSIs by paying landowners to adopt specified practices (of conservation).

Management guidelines are developed locally and private landowners (mostly farmers) who (voluntarily) joined the Pevensy WES agreed to comply with its instructions on grazing patterns, pasture management, ditch maintenance, ditch water levels, and the use of agricultural chemicals. They are paid £74 per hectare. Farmers are cast in the role of technicians, whose interests are primarily financial: they own a rich wildlife habitat, but they are (unknowingly) degrading this habitat in the course of their everyday agricultural practices. The farmers will continue to despoil nature unless paid to change their ways. The farmers, it is proposed, possess agricultural skills (stock management, hay cutting, ditch cleaning, and so on) and they know about the area in terms of farming, but they know little about nature.

Scientists play the role of discoverer of local nature through turning wild nature into standardized categories such as species, populations, communities, habitats and ecosystems whose behaviors are expressed in [general] principles and theories. Finally, nature is expected to conform to scientists' typologies and expectations—the expectation is that species will reproduce themselves in the network.

The outcome of this project is that farmers' knowledge is restricted to knowledge of farming practices (not nature), and farmers are cast as financially motivated technicians capable of carrying out specified tasks. Scientists' knowledge is equated with knowledge of wild nature. Scientists develop a ditch typology and a management scheme that includes a periodic cleaning out by the farmers every six years. Farmers contest this fixed cleaning schedule that contradicts their experience with ditches. It is within the rigidity of the demarcated roles that the authors of the study find the greatest weakness in scientific practice; by enrolling the farmers as one-dimensional economic actors the scientists neglected stocks of local knowledge which, had they been more sensitively handled, could have facilitated the easier dissemination of scientific knowledge (Clark and Murdoch 1997:53).

The tension in the relationship between Pevensey farmers and the scientists derives from the seeming inability of the scientific network to be constructed in such a fashion that non-scientists are enrolled in ways which allow them to see that their understandings of the natural world are being valued in their own right (Clark and Murdoch 1997:54).

Reflecting on ANT- inspired research, Clark and Murdoch 1997 suggest that local people are not docile consumers of science, and science is not automatically imperialistic. Scientific hegemony is extended as science networks insert themselves into diverse contexts and situations, a process made difficult by local recalcitrance or diffidence (Clark and Murdoch 1997). An important point made by ANT is that science need not be viewed as intrinsically special, somehow apart from specific socio-spatial contexts. Clinging to this notion might impede development of more symmetrical relations between various forms of knowledge, those called science, and the others. When scientists are viewed as other, albeit highly trained, actors who mix and match things, a vision of more inclusive networks of association opens up.

By far the most important concept to be developed within the ANT approach is translation. Simply put, translation refers to the steps, activities and tactics an initiating actor uses to construct an actor-network. Callon and Law describe translation as, "a process in which sets of relations between projects, interests, goals and naturally occurring entities - objects which might otherwise be quite separate from one another - are proposed and brought into being" (Callon and Law 1989: 58-59).

Translation

Translation is a world-building exercise as the translator is building a world of interacting and inter-defining entities that, by virtue of being a part of a network, obtain agency and identity. By enticing entities into relationships and prescribed roles, the network initiator (the translator) establishes a certain power to act and to speak on behalf of the entire network. Translation ascribes characteristics and acceptable ranges of behavior to entities; it is a process of defining and distributing roles. This defining and distributing is messy work requiring not only verbal arguments but the constant movement of material resources, the inscriptions, or reports, memoranda, documents, survey results, scientific papers and so on. Through translation an infinitely complex world is reduced and simplified through inscriptions and the limited roles assigned to juxtaposed entities.

Translation is thus about attempting to gain rights of representation, to speak for others and to impose particular definitions and roles on them. To achieve success, other actors' worlds must be colonized. Actors become powerful through their abilities to enroll others in a network and to extend their network over greater distances. Building networks depends on actors' capacities to direct the movement of intermediaries such as texts, technologies, materials and money. The achievement of action-at-a-distance is as much dependent on mobilizing such resources as it is on persuading other actors to become enrolled. But success does depend on what these other actors do: whether they conform, and continue to conform, to their allotted roles. Actor network theory makes it possible to explain how actors 'define their respective identities, their mutual margins of manoeuvre and the range of choices which are open to them' (Callon, 1986).

If plant breeding is a social network building process the result of which is the production of socionature---the plant varieties that are breeders' stock and trade, then it is important to understand how these networks—these plant varieties---are socially constituted as a web of social relations. Translation is thus concerned with making connections between actors where there were none and pulling together relationships that may not come into existence without the effort of a world-builder. Translation breaks this process down into observable tactics and strategies.

Actors gain power and interest by translating the interests of other entities into their own and thereby enrolling others in their actor world. The concept of translation recognizes that the content of texts, conversations, objects and so forth is not simply transferred unchanged between actors, but may be transformed as things pass from hand to hand (Latour 1987). In building its network, the actor translates the other entities, giving each 'an identity, interests, a role to play, a course of action to follow, and projects to carry out' (Callon 1986). The actor decides their attributes, links them together, and draws up the scenarios in which they take part.

Importantly, translation is not a linear or predicable process because actors bring with them other actors and other networks, translation can be contested, thwarted or unsuccessful. A successful translation of a network is the formation of a black-box, a thing of uncontested materiality and identity that encodes processes and guarantees and outcome, and can be mobilized or easily transported to other contexts. A toaster, an automobile, a computer are all examples of black-boxes. An airplane can be considered an actor-network black-box of successfully translated entities that all can be mobilized. Although commonly understood to fly themselves, airplanes require the mobilization of many other entities and resources to actually accomplish the act of flying. In addition to the non-human nuts, bolts, gears and valves, there are the human mechanics, pilots, air-traffic controllers, airport maintenance staff as well as business managers and customers who fly (if one is talking about commercial airplanes). Thus, Latour (1999) writes that airplanes do not fly, but airlines do. And, what is the key difference between military aircraft and commercial aircraft? In terms of actor-network theory, one would point to the different makeup of its actor-world.

Translation is not always successful, however, as entities can refuse their prescribed identities and revolt. This causes a break-down and fundamental shift in the developing actor-world. As far as being a passenger, one's identity and agency is defined and bounded to certain roles and behaviors when participating in the airline's actor-world. Failure of the translated network airplane can be achieved by rejecting these prescribed roles outright, as in the example of a recalcitrant passenger who complains about legroom, or a terrorist. The important point, however, is that to in order for planes to fly all actors participating in the airplane / airline actor world must adhere to their roles as they have been defined by the network. If nuts, bolts, and passengers refuse, or air-traffic controllers, pilots or mechanics go on strike the (intended) network fails (or at least morphs into another kind of network). The September 11th attacks on the World Trade Center in New York City, for example, is case in which a passenger airplane was converted into a missile by being networked into the goals of Al-Qaeda network. This re-networked identity of a passenger jet-as-missile had not occurred to many in the United States, and thus constituted a surprise.

Translation is always a process achieved through a wide range of material and social devices such as rules, procedures and other forms of black-boxed enforcements to keep entities defined and aligned in their roles (in the case of airplanes, there are anti-union policies to keep workers from revolting and ticketing and detecting devices to enforce passenger compliance for example). Thus, if an airplane crashes this is not just a matter of technical non-human failure (the nuts, wires, bolts, valves) or the human failure of pilot error. Rather, planes crash because some constituents of the actor world have not complied with their socially prescribed identity: a crash is socio-technical failure, a product of network failure. In this dissertation I interpret the VASO Project as an actor-world under construction and I examine how entities are defined, enrolled and react to their identities within this ordering process.

Callon's four moments of translation

How are actor-worlds, the concatenation of actors and actor-networks, composed and articulated through translation? Callon (1986) and subsequent scholars have defined four moments of translation that overlap in the translation process, these are: problematization, interessement, enrolment and mobililzation. Here I briefly describe these movements with reference to plant breeding in general as a means to construct a framework for a study of the VASO Project. It should be kept in mind that translation describes a movement from the VASO Project, an idea on paper, to the VASO actor-world, lived social order. Thus, if translation is successful an actor-world is ordered, black boxes are formed and controversies are closed. The VASO Project thus disappears into the background of every-day science.

Problematization

The problematization moment of translation is where the world builders define and set up a scenario that posits a range of actors and their problems and that suggests that these problems could be solved only if the actors adopt the world-builder's solutions. Problematization is a displacement or diversion of preexisting interests into one interest, that of the world-builders. In essence, this is the stage at which the world-builders set themselves up as indispensable as an obligatory passage point through which all the other actors must pass if they wish to solve their problems in the context of the network of relationships that constitute the emerging actor-world. This moment of translation is a defining moment that proposes a problem and defines the range of actors and solutions possible. This is the moment when world-builders set up a proposed world of associations, but this is a world yet to be constructed and actualized. Importantly, to problematize one has to reduce the world of complexity into manageable forms of manipulation, such as words, numbers, graphs, maps and so on.

Callon identifies two important facets of the problematization, the interdefinition of the actors, and the definition of obligatory passage points (OPP). In terms of plant breeding, this is the stage of grant proposals and other types of arguments used to gather funding. A single question or problem, then, is enough to involve a whole series of actors by establishing their identities and the links between them, (Callon 1986: 205). In this case the problem is sustainability, however the term is defined. The question for would-be world builders is how to define actors around this problem. Problematization requires site visits, preliminary surveys and other forms of data collection by the world-builders to ascertain what the range of possible actors will be in terms of the uniqueness of localities and cultures. Many actors have been pre-defined, such as farmers, scientists, and plant varieties. The way in which these actors are configured, however, can be tweaked into various forms as plant breeding projects set down in specific geographies and cultures. Thus we have Indian, Andean, Mexican and Portuguese farmers, for example, and local and modern varieties of crops. Further refinements to level of farm-size, capital intensification and gender can be made to define the actors in plant breeding worlds.

Defining the actors to populate the emerging actor-world is not enough, however, as Callon points out, …researchers do not limit themselves simply to identifying a few actors. They also show that "the interests of these actors lie in admitting the proposed research programme" (Callon 1986:205). In essence, the world builders construct a narrow passage way through which all the actors are linked in their pursuit of some important goal or problem, a kind of, if you want to achieve your goal, you must pass through us. In effect, the world-builders' project becomes a center of translation in both a conceptual and physical sense, through the conceptual apparatus of proposals that are just strings of words on paper and in real, physical, laboratories and other institutions.

There is thus a certain geography or spatiality of obligatory passage points that underlies the problematization moment. This is not a quality of translation that other researchers have examined, but which becomes a significant part of the VASO Project ethnography because in plant breeding one has to account for the physicality of farms, research stations and gene banks that are all part of any plant breeding actor-world.

In the case of the VASO Project ethnography, then, we have specific processes to observe and account for in the quest for breeding sustainability: What is the problem, series of problems or scenario being proposed, and who is doing the proposing? Who are the world builders and who are the other actors and how have they been defined vis-à-vis the problem / scenario being proposed? What and where are the obligatory passage points and how are the actors aligned through them? Through the conceptual lens of problematization we can describe the fundamental components of an actor-world as it has been proposed by the world-builders themselves. There is thus no need for a-priori assumptions or judgments as to status of the actors: whether or not the problems, actors and passage points endure or take hold is determined by the actors themselves and not the ethnographer. Who, exactly, the Portuguese farmer is, in this context, does not matter as much as the extent to which such an actor called a Portuguese farmer can be defined by the VASO Project actor-world. If the VASO Project is not successful in defining a farmer to grow its varieties, then it is possible to only breed plants but not sustainability.

Interessement

Whereas it is easy to propose a world on paper, in grant proposals and scientific papers, it is not so easy to actualize these representations and reductions of reality, "Each entity enlisted by the problematization can submit to being integrated into the initial plan, or inversely, refuse the transaction by defining its identity, its goals, projects, orientations, motivations or interests in another manner" (Callon 1986: 207). Rather, interessement is the group of actions by which an entity attempts to interpose and impose the identity of the other actors as they are defined through its problematization (Callon 1986: 207-208). Actors' identities and capacities for action are always enmeshed and defined by competing associations in other networks and actor-worlds. Therefore to successfully interess actors requires material work and various kinds of devices. These devices can be tangible technologies such as laboratory equipment, towlines in the case of Callon's study (1986), but also can be practices, formulae, computer programs and other means of diverting actors toward the obligatory passage point(s). For all the groups involved, the interessement helps corner the entities to be enrolled. In addition it attempts to interrupt all potential competing associations and to construct a system of alliances (Callon 1986:211).

Plant breeding is full of interessement devices, the tools of the trade so to speak. These devices include not only the tools of measurement and notation, but also the practices and routines. There are pamphlets describing how to plant seeds, apply fertilizer and harvest crops. There are ways to measure plants and methods to fertilize individual plants to achieve a desired result. All these technologies and techniques are ways to insert plant breeders and their projects in social space between plants and other actors, such as between farmers and their crops. When describing the VASO Project, then, we have to look carefully at the interessement devices: what are they? How are the devices channeling the actors away from other goals and to the goals of the world-builders? Are the devices successful? In the case of VASO, we need to look at specific recommended practices and how the actors who are supposed to undertake these practices respond.

Enrolment

The moment of enrolment refers to the success of interessement, that is, Interessement achieves enrolment if it is successful (Callon 1986:211). This is the moment of negotiation and outreach. It is a dangerous moment for the translation of an actor-world because failure can occur here as negotiations between diverse actors can easily break down. A key question is do the interessement devices actually work? That is, do the devices achieve what they set out to do? Here, multiple actors have to be satisfied: scientific colleagues have to see the data of success, bureaucrats have to keep going along with, and funding the project, and other actors have to behave with predictability. In the final analysis, the world that is being shaped has to appear to make progress toward the prescribed goal within the self-described parameters for success.

In the case of plant breeding projects, this will depend on how well the measurements were collected, how well the farmers participated and how predictable the plants behaved. Fissures can begin to appear if any actor decides to revolt or otherwise refuse to interact within the project-world. We see this most clearly in the Green Revolution actor-world in which many farmers either rejected the plant varieties ostensibly developed for them, or farmers cultivated these varieties in vastly different ways and in different agronomic conditions than prescribed by the plant breeders. Moreover, in the case of VASO a critical question is: are all the pertinent actors defined? That is, have some critical actors been inadvertently left out? Here, I argue, one needs to take full account of the spatial strategy that inheres in plant breeding. This is the spatial strategy that links research station plots to farms and farms to food eating consumers (outlined briefly above). This geography of eating, or geography of consumption, links together many more actors and processes than simply farmers, scientists and plants. It is when VASO enters the enrolment moment of plant breeding implementation that the project encounters difficulty. This difficulty is largely due to the many key actors have not been defined and therefore have not consented to their enrolment in the VASO actor-world.

Mobilization

In terms of building a world, as I argue the VASO Project is attempting to do, it is one thing to put words on paper in an office or coffee shop, it is another activity of an entirely different order of difficulty to try and enlist actors into the emerging world ordering and to then try and solidify their respective relationships through tactical means and instrumentation. However, the final and most crucial moment of translation is the mobilization of the entities into a smooth running, seemingly natural, world. This is a world full of black boxes that contain condensed networks, and it is the surfaces of these black boxes that we take to be reality. The strings of black boxes of closed controversies and solidified relationships must be mobile, able to travel to many contexts and situations with out breaking. The atomic bomb is an example of a modern mobilize able actor-world contained in a small metal casing we call bomb. These feared and despised black boxes can be quickly mobilized for their intended purposes of destruction, but recall that the series of actor-networks (the chains of translated entities) enclosed in the black-box atomic bomb can revolt, resist or otherwise not comply, thus causing impediments in mobility. Thus, mobilization describes solidity and predictability; it is a moment of translation rarely achieved for long, but must be achieved if an actor-world is to take shape.

Organization of the Dissertation

The remainder of this dissertation is organized into four chapters roughly around Callon's (1986) four "moments of translation." Chapter two specifically deals problematization, or the moment when the VASO Project can be distinguished from the VASO actor-world. It is at this moment, or during this moment, that all the actors are defined, assigned roles and ranges of action and behavioral expectations within the forming context of the project. This sets the stage, so to speak for the VASO actor-world to be worked on. To guide this discussion, I present a model of the edible landscape diagramming its socially constructed spaces and then filling in these spaces with what exists in the Sousa Valley Maize Breeding Project. The main issue here is to first understand the rudiments of the VASO socio-spatial strategy—how it creates socio-spatial dyads--and then, in subsequent chapters, details how this soico-spatial strategy plays out in the Sousa Valley—or rather is made to play out.

Chapter three charts the social trajectory of VASO actor-world through the moments of interessement and enrolment because the two are so closely linked in space and time. Interessement focuses attention on the actions of translation, the physical maneuvers and activities, the practices that pull actors together in a place and in a role in the actor-world that is VASO. Chapter three, then, outlines the procedural tactics of plant breeding that provide the glue between actors and associations proposed in chapter two. Here we see, for example, the strategy of selection of plants and the recommended procedures for farmers to practice if they wish to go along with their proscribed interests, and goals in the project. Tugging at this process are other networks, such as the broa actor-network and its associations that might pull farmers in another direction away from VASO.

Chapter four details the *broa* actor network through the activities, spaces of interaction, and materiality of the traditional grain miller, or *moleiro*, and the baker of bread. Both actors and their existing socio-material networks present a challenge to VASO's actor-world by enmeshing farmers and seeds into different economic relations of production and consumption. Bakers buy flour from millers who buy seeds from farmers and therefore farmers must adjust what varieties they grow to sell to millers. If *Pigarro* seeds are too costly, too coarse for milling in an industrial mill, then there is a potential snag in the edible landscape that is constructed around traditional white maize like *Pigarro* because all these actor and actor-spaces have to be aligned.

Chapter five concludes with a recapitulation of the edible landscape and what lessons the VASO Project / actor-world in the making holds for plant breeding and for the understanding of spatial relations in actor networks. This chapter also deals with mobilization and a social assessment as to the how effective the VASO Project has or has not been in bringing about a VASO actor-world which I have called the edible landscape of associations. Here I briefly present what the VASO Project must do in order to become the VASO actor-world, in a nutshell: successfully translate the miller and the preexisting *broa* actor-network. A new generation of Portuguese is more urbanized, and the countryside is seen increasing in terms of tourism and other amenities such as sports recreation and leisure activities. In this context water mills are being restored as second homes, country residences, or as non-functioning tourist relics in the landscape (Powell 2002). The trend toward the loss of functioning traditional mills and the loss of milling expertise represent two threats to the chain of actors and spaces that link the VASO Project to the consumer in the edible landscape. The Project can increase and stabilize yield of *Pigarro* on farms, but VASO must also contemplate a way to either re-translate and enroll other millers or new types of millers.

In a very real sense, then, the reproduction of participatory maize breeding in the Sousa Valley is directly tied to the reproduction of traditional water mills and millers. Increases in yields of grain have to be coordinated with the stability of the wider food landscape through which *Pigarro* undergoes transformation into bread, a landscape that embeds local farmers, millers, and bakers and all the knowledge, expertise, and skills of these actors as well as scientists, genetic resources professionals, technicians, and a host of others.

CHAPTER TWO
PROBLEMATIZATION: FROM PROJECT TO ACTOR-WORLD

Introduction

This chapter describes the Problematization moment in the VASO Project, or the moment when one can begin to speak of a true VASO actor-world in addition to a VASO Project. Problematization begins at home, so to speak. Before I had arrived in Portugal on October 18, 1999, I was in fact already there in a translated sense. Through a process of textual translation I had been transformed into a spokesman on paper for the University of California. This translated entity (me) appeared as an X placed in several columns of a VASO funding proposal. The columns promised the amount of time and energy, or the total commitment, an entity would offer the project. Importantly, these entities have only been *proposed* in relation to one another, and it would be up to all of us to work at building of the collective, or actor-world envisioned by the proposal.

Essentially, in twenty-five double-spaced pages I, the University of California, and several Portuguese institutions were simplified by acronyms such as the National Institute of Agronomy (INIA) and placed alongside one another in the context of a three-year long project which bore the title: *On-farm breeding of local maize landraces…in the general improvement of the traditional sustainable agricultural systems* (Pêgo 1999).

At first I felt apprehensive by this all, perhaps as any translated entity in an emerging collective might feel. I had my own grant, my own actor-world that included the National Science Foundation and the University of California. What would be my role in this on-farm project? Would this role contradict my own research plans? Or, as I would put the issue now; would this new role contradict the way in which I had formulated my own identity as well as the identities of those in the emerging network I had *translated* on my own, months before and thousands of miles away at the University of California? My reading of the social studies of science had not prepared me for a personal translation experience, the politics of doing research (and not just thinking about doing research). Latour and others do not discuss the feeling of being translated, the jumble of anger-confusion-despair-excitement in the mind and body of the translated. There was some kind of project in the making at that moment in a small office in Lisbon, Portugal, and I was surely going to be a part of it whether I liked it or not.

On October 19, 1999 the four researchers, one anthropologist-graduate student one professor of horticulture, the Coordinator of plant genetic resources in Portugal [center], and Portugal's only publicly funded maize-breeder convene a meeting to go over, among other things, drafts of the project proposal *On-farm breeding of local maize landraces…in the general improvement of the traditional sustainable agricultural systems* (Pêgo 1999). It is important to point out that this proposed project ostensibly is not about *discovering* something, but rather it is about *making* something happen: which is, to use plant breeding to support local farmers and to bring about sustainability. It is the job of Silas Pêgo to make himself and his project indispensable to this process. My main objective in this chapter, and dissertation, is to trace the steps, strategies and consequences of this project. I will use the proposal for sustainability-through-plant breeding as my main benchmark and tack between other, prior and post-proposals, and the physical constellations of entities which these proposals seek to bring about. In short, I my strategy will be to move from paper to entities back to paper again, charting the process of *circulating reference* (Latour 1999).

The meeting takes place at the Genetics Department of the National Institute of Agrarian Research, or INIA (described in more detail in chapter 2). Acronyms are critical, the project is filled with them: DRAEDM, UCSB, INIA, EAN, CAP, CGAVS. It would take a full scale institutional biography of each to really understand them because the acronyms are merely signs that stand in for complex networks in themselves that cannot be taken for granted. Acronyms appear many times in the VASO story because acronyms are good examples of an actors' simplification. The presence of acronyms (in a grant proposals and reports at least) signifies acquiescence to being simplified and enrolled--for the time being. Put simply, actor-network builders (like Dr. Pêgo) simplify diverse heterogeneous entities and set them alongside other entities in relationships that form a potentially mobilize-able network. Once assembled, Pêgo can speak for an entire network of institutions encompassing thousands of people and non-human resources through a short string of acronyms (Latour 1999).

The entities being represented in the project proposals are not-yet fully formed in the context that is being built for them. That is, entities become as they interact with one another, and their interaction forms a context. Consequently, identity is formed in the process of interacting within networks of association, a process of inter-definition (Callon 1986). Of course, initially, before the VASO project seeks to put them all together, the entities previously have obtained some kind of identity. This is so because all entities are parts of other on-going networks and projects. I am part of the University of California (so long as I pay tuition and pass my exams); Silas Pêgo is a scientist on the payroll of INIA-EAN, the national agricultural service. The proposed VASO project will only refine and perhaps radically alter these identities by putting them all into play in novel configurations. Here my task is to explore how such simplified entities are mobilized and put into action; how entities become lined up with one another in a plant breeding project with their goals for sustainability.

Our brief meeting takes place in the Genetics Department at INIA-EAN (National Institute of Agrarian Studies – National Agronomic Station). I am still confused about the meeting, something that will happen many times during the fieldwork. I listen attentively to what sounds like spirited arguing, but seems in hindsight to be a fairly common way in which Portuguese scientists reach compromise. Pen-in-hand, Dr. Silas Pêgo, the maize breeder, listens attentively to Dr. Joao C. de Silva Dias as the researchers move from words to paper: a very serious jump from the abyss of abstraction closer to reality. What ends up on paper is much more of a commitment, a slightly firmer reality that is taking shape.

Dr. Silva Dias, who has vast experience in collecting and breeding the *Brassicas* in Portugal, is concerned that the project is too jumbled and takes on too much. The project compresses too much too soon, it pushes a kind of non reality. "This is more like three projects…I think…." (Dias, author field notes). Pêgo looks concerned and jots some notes. My notes from the meeting are not clear, and my tape recorder stopped working. Only general impressions and the text of the proposal itself remain. I could ask my associates, but their recollections are after-the-fact. One thing is certain; the researchers are concerned to fit the proposal to the granting agency. They have to clarify goals and make them seem reachable within the project's time-frame, three years.

Money for the grant comes from the European Union and time is important. The proposal, and the world it builds, must take shape today, we cannot leave until it is finished (only remaining to be written).

Soon the discussion comes around to me, the anthropologist-in training-in making. What are his plans, they wonder aloud? They seem a bit concerned, having read parts, if not the whole, of my own research proposal (my own version of the world) there is concern that I have budgeted an unrealistic (too low) amount of money for survival: US$ 10.00 dollars a day for food. That I am too thin already (a constant theme while I am in Portugal) I assure them that this is merely to meet the requirements of my granting agency, which only allows so much, and that I have my own funds to supplement that amount. This small issue actually represents a big problem later on, which is the different cultures of social-science research and the harder sciences that my plant-genetics-breeding colleagues belong. They will be at odds to understand my identity throughout the story. For now, at least, they seem willing to go along with my role in the project, roughly defined by Pêgo as a doctoral thesis about the communication between farmer and scientist in the context of participatory plant breeding.

The meeting at the Genetics Department was important to settle several things, among them is to illustrate how a scientific project actually works to enroll entities and to set boundaries. If, as researchers of sustainability, we restrict ourselves to the study of documents only, then we run the risk of studying after-the-fact formulations of the world offered up by such projects. Further, we run the risk of criticizing projects for their misconceived notions, or their unquestioned hidden values, recalling the internalist vs. externalist science debates. We might be tempted, then, to think that projects can be fixed by altering sentences, by adding new words or catchy phrases. But words alone are not enough to understand the project-building process if one really wants to dig into the various layers that comprise scientific projects. As researchers of the *process*, I argue, we have to understand the multitude of steps taken both rhetorically and physically to bring projects to the point being printed out on printer in an office. We have to re-trace the world being built at every step in the making of this vast store of gray literature of project proposals.

If Pêgo's VASO project is successful it would generate an amalgamation of hybrids: farmers-who-grow-improved maize, scientists-who-work-on-farms, agencies that fund and support this work and anthropologists-who-study this entire process. Together, several of the entities might unite into a tenuous association in the form of a scientific paper to be published in a peer review journal. This would add some solidity to the emerging project.

So, how exactly, does Silas Pêgo become indispensable? How does Pêgo connect himself to more and more entities, thereby extending his influence over more and more things? Or, more to the point, how does he become indispensable within the world that is forming around the project? This is a different way of approaching the issue of sustainability than asking, for example, Are farmers rational? Will they accept the project or reject it? We want to know, here, on what terms the farmers were approached in the first place, and then ask whether or not they will go along with the project given their (always limited) understanding of these terms. I had tentatively agreed to go along. Perhaps the farmers would be duped, coerced or simply just paid to go along. If the farmers do go along, however, then they will, by default, produce a new world if even for just a few months in one year and in one publication. The project thus becomes real, something referred to and that will (possibly) continue to be referred to.

The primary means by which Silas Pêgo can establish indispensability is through interests and defining is by not only identifies actors, but also "showing that the interests of these actors lie in admitting the proposed research program" (Callon 1986: 205). In this case, all the actor's interests in: farming for living (farmers), enhancing genetic diversity in Portugal's crops (scientific colleagues), and achieving sustainability (communities and colleagues) rest upon whether or not the maize varieties Silas Pêgo have identified and painstakingly fostered for years can increasing their yield under farmers' conditions as Pêgo has (modestly and carefully!) claimed (Pêgo and Antunes 1997).

Thus, the proposition that the odd-shaped ear of *Pigarro* can lead to sustainability in the region serves to re-align actors' interests so that to achieve sustainability they have to go through *Pigarro*. If the local and national governments fund the project, and if colleagues support the project by letters of reference and through publication, and if the other entities supply resources to VASO, all the actors will be committed to the success of *Pigarro* in the test plots on Meireles' farm. This action / displacement of entities through *Pigarro* to sustainability implies, then, that the Meireles farm becomes a center of translation, the socially bounded space of translations.

The VASO Project is an idea, a reference point in academic papers and government documents. The VASO actor-world is composed of material entities and forces. An actor-world is a social assemblage of networked and co-defined entities focused around a central goal that can be achieved through some person, agency, technology, practice, or institution. This is a process largely, but not entirely, carried out at the discursive level through verbal and written argumentation, or transcriptions as Latour and others call them. Two things must happen during this phase: actors and their roles in the forming actor-world are defined, their interests are aligned viz the new main goal or problem (Callon 1986). Problematization is a simplification process whereby large, immobile entities and networks like the Amazon rain forest are reduced to mobile and reproducible graphs, charts and other images that can easily travel, be assembled on a table, and be used to render visible the actor-world under formation. This moment sets the stage, so to speak, and makes up a list of the actors—keeping in mind that actors can be human, non-human and hybrids of humans and non-humans (like certain technologies or institutions for example).

During the problematization phase the network builders, carefully define the identity, the goals and the inclinations of their allies. But these allies are tentatively implicated in the problematizations of other actors. There is thus a competition for identity, to interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise (Callon 1986:208). The purpose is to bring out the hybrid nature of such a project, to amplify those spaces in between the boxes of a project's flow chart, the painful part of getting from A to B. Recall that Michel Callon and colleagues (Callon 1986 a,b; Callon and Law 1989) break down the translation concept into workable phases, or moments. These four moments, which Callon labels problematization, interessement, enrolment and mobilization, are the successive stages through which science moves from ideas, arguments and papers to the world of things. These moments offer a framework, a conceptual language, for organizing the vast array of complex entities and places swept up in the trajectory of a scientific project. A project can accelerate through several stages, or be stalled in one. Whichever the case might be, as Callon points out, translation is a process, never completed, and it may fail (1986a:196).

The VASO project, I argue, is more than just another technical innovation to an otherwise conventional plant breeding process. Rather, VASO as project is a proposal, or dress rehearsal, for an actor-world consisting of novel entities intertwined in new relationships that do not yet completely exist. They are entities and relationships that must be formed and tied together, coaxed into existence as Latour (1999, passim) might say. If the entities were already formed and locked into relationships there would be nothing to study: the work of combining and articulating would have been black boxed. In this sense, the VASO project can only be successful to the extent that the entities and relationships it proposes in the VASO actor-world take hold and stretch far beyond the individual farms and research station plots where actual breeding of plants takes place.

Silas Pêgo and his colleagues are certainly breeding plants, but they are also struggling to bend the preexisting actor-worlds just enough to insert the products of their efforts in seamless fashion. VASO does not aim to produce plant varieties for use by farmers, but rather it sets out to produce both farmers and plant varieties together. In essence, the VASO project can be read as an extended process of co-construction of plant breeding science and society: new maize varieties and the people who grow them, farms to reproduce both farmers and new varieties, seed purveyors to buy and sell the new varieties, people to process the new varieties, and finally people and/or animals to eat new varieties. It is a useless endeavor for VASO to produce maize varieties in purely abstract sense without an entire social world ready to accept them, a world that stretches well beyond the boundaries of farms. Without this world in place, plants will wither in the fields, grains will not be turned into flour, bread will not be made from local maize (recall Chapter 1), and Silas Pêgo will have nothing to show for his work but packages of seeds, and bags of maize ears sitting in a gene bank freezers.

Through a careful study of the VASO Project's documents, grant proposals, reports, publications and the words and actions of its builder, Silas Pêgo, it is possible to glean the problematization moment that inter-defines the actors, defines obligatory passage points, and sets up a center of translation, the social and physical place(s) where translations are focused (Callon 1986). Problematization is about representing, and being represented in an emerging network. It is a process that always involves simplification of entities in terms of interests, abilities and willingness to go along.

For Callon et al. problematization concerns power and how power emerges in the relations between actors as they come within each others' social orbits. It is helpful to remember here that entities usually considered things in social or cultural analysis, e.g. plants, animals, a fuel-cell, etc…are granted agency as actants in networks. This means simply that things have to be taken seriously as agents in social action; that things have more agency in social relations than serving simply as inert things to be manipulated, designed or tossed away.

Things can *defy* or *revolt*, they can resist or re-define their own identity thereby causing havoc in the forming network which is struggling to take shape (Callon 1986:207):

> Each entity enlisted by the problematization can submit to being integrated into the initial plan, or inversely, refuse the transaction by defining its identity, its goals, projects, orientations, motivations, or interesests in another manner. In fact the situation is never so clear cut…it would be absurd for the observer to describe entities as formulating their identity and goals in a totally independent manner. They are formed and are adjusted only during action.

Callon (1986:203-206) describes three main processes involved in problematization. Briefly, these are: 1) becoming indispensable, 2) interdefining actors and, 3) defining or delineating the obligatory passage points (OPP). The fist step, becoming indispensable, is largely a logical exercise and consists mainly of manipulations of entities on paper through the posing of research questions in reports, articles and proposals. A situation has to delineated, relevant entities identified, and actors assembled into forming networks of association. The second step is delineating an obligatory passage point, or an idea, proposition, practice or thing that solves a problem or sets of problems for all the proposed acgtors. All the actors and actor-networks are pulled through this passage point from their own trajectories in other actor-worlds into a new trajectory and a new actor world-in-the-making. Here we are talking about the white maize variety *Pigarro* that is a socionatural thing, a black box under construction and an obligatory passage point for the VASO actor-world and by extension, sustainability.

In the case here, the problematization situation is clear enough: small-scale traditional farmers of Portugal are facing the impossible-to-resist wave of modernization in agriculture and the situation is bleak for them, as is the fate in store for their diverse plants and animals upon which the farmers and much of the rest of the country has fed for generations. Many issues are on the table, so to speak, and literally: the future of small farmers, the future of biodiversity in farming, the quality of food, national pride, and the ever-present market. Something has to be done. A variety of white maize called *Pigarro* is the answer to all of these problems: it can offer farmers increased yields of maize (plant and grains), it can offer millers a valued grain for making the traditional bread, and it can offer bakers the chance to make this bread for a hungry and appreciative public. Finally, *Pigarro* can offer traditional white maize varieties a chance to survive as living entities and not just bags of seeds in cold storage. *Pigarro* itself is not yet *socially* real, rather it is *becoming* because *Pigarro* cannot reproduce itself without the VASO actor-world coming together.

Indeed, as I will discuss throughout, *Pigarro* is not a crop, or crop variety, but rather it is social landscape of associations, or the VASO actor-world made edible. Before the VASO Project there was only a variety of white maize that had tendency to form odd-shaped ears found locally in the Sousa Valley. The VASO Project begins to define this white maize as *Pigarro* which is a network that embeds and implies the coordination of many more actors and processes aligned (ordered) into a specific material food landscape of breeding stations, farms, mills, bakeries, shops, and social landscape of breeders, farmers, millers, bakers, anthropologists, and so on. At the time of this research, the VASO Project was still attempting to become the VASO actor-world. When this world eventually takes shape, there will be no more VASO, only *Pigarro*. The next section describes the main problematized actors and their ascribed interests, goals, and identities as prescribed in the forming VASO actor-world. I also describe what could be problems and competing interests for the actors who are always involved in other networks.

Pêgo's Problematization

Pêgo's problematization (Figure 8) is one of first defining actors, defining an obligatory passage point and diverting these actors through this passage point in order to satisfy their (ascribed) goals.

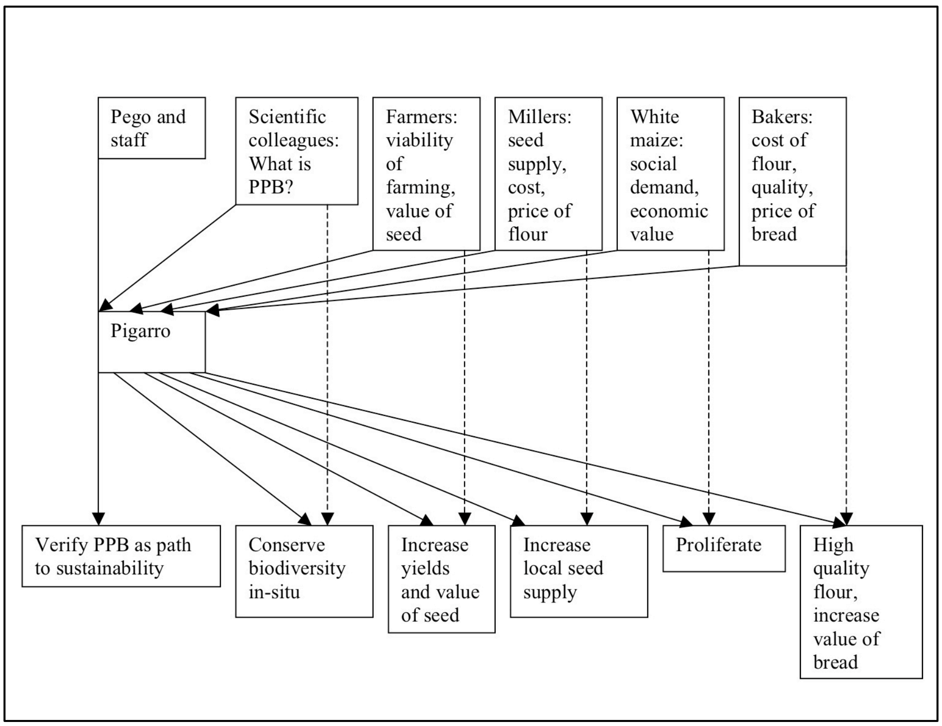

Figure 8: Pêgo's Problematization: actors' goals redirected through the obligatory passage point of *Pigarro*.

Actors and concerns are imputed: Pêgo and colleagues want to verify participatory plant breeding as a legitimate practice and philosophy that is a path to sustainability through plant breeding. Scientific colleagues need to know what PPB is, how is done, and how can it lead to conserving biodiversity *in-situ* (on-farm). The conservation of crop biodiversity is of concern to all plant breeders as the main source of their trade. Next are farmers, who are naturally concerned with the viability of farming as a way of life, much of which depends on the value of seed. Then there is maize itself, the concern of which is to achieve social popularity and the assistance of humans to proliferate. This chapter focuses primarily on Pêgo, *Pigarro*, scientific colleagues, farmers, and white maize itself. Subsequent chapters delve more into depth on traditional grain millers and bakers. Millers are concerned (again, according to their role in VASO) with seed supply, the price of flour and the price of seed, as well as the availability of different types of seed for milling. Lastly, bakers of the traditional *broa* are concerned with the cost of flour (the price they must pay) the quality of this flour, the price of bread and value of both flour and bread. Pêgo and colleagues have set up a project so that the interests of all actors can be met through *Pigarro*

Goals formulated by the VASO Project may or may not reflect what the actual existing goals of the actors may be, from their (emic) point of view. We simply know that farmers, bakers, scientific colleagues, etc. certainly have many goals outside of VASO, but to bring them into line into a novel social ensemble (assemblage as Latour and other might call it), specific goals have to be imputed. Again, the model in Chapter 1 is mine, and it describes a process that Pêgo and his colleagues view as merely a project proposal. Significantly, the model was formed after my fieldwork, not before, and thus represents a grounded theoretical frame for connecting the data that is based on ANT inspired work. This problematization model represents the work that Pêgo and colleagues have to do to produce crop varieties like *Pigarro*.

The solid lines in problematization define the new path proposed by VASO and the dashed lines represent another, alternative path to these interests other than through the passage point set up within the VASO actor-world. Should the actors all accept their interests and roles, the VASO actor-world becomes a reality. Should any one of the actors seek a different path this world loses shape. The actors in the top boxes of the model (scientific colleagues, farmers, millers, white maize, bakers) have to be displaced and diverted from their pre-VASO paths through *Pigarro* as the obligatory passage point to their ascribed goals.

Taking these sets of actors one by one, first there is Dr. Silas Pêgo and his colleagues. As the initiators of the project, this group of actors is well defined: they wish to verify participatory plant breeding as a path toward ecological, economic, and social sustainability in the Sousa Valley, and that this path leads clearly through the improved *Pigarro* maize crop variety. This relationship and proposed outcome is well defined in the project proposals, reports and articles, as well as the material practices and spatial organization of the project. To solidify this linkage between actors and outcome, Pêgo has a variety of techniques at his disposal including traditional plant breeding methods to transform the local white maize into *Pigarro*. These techniques interrupt the life cycle of the plant and interject more humans, more breeders and farmer colleagues, at various stages with the result of increasingly socializing the natural life cycle of the plant. These techniques of plant measurement, seed yield, and statistical evaluation allow Pêgo to peer inside the nature of white maize in order to direct this nature toward the social goal of being *Pigarro*, the maize variety that will help save small farmers, small farming, and increase rural sustainability in the Sousa Valley. The transformation of white maize with an odd ear shape into *Pigarro* thus occurs through hybridized material collaborative breeding techniques and the increased social interaction among the actors simultaneously and concomitantly with the movement from VASO Project to VASO actor-world.

Although agricultural research stations and so-called gene banks are distinct social spaces of agro-scientific research and development, the VASO Project attempts to pull together these disparate spaces into its new program as a single mobilize-able socio-spatial dyad of sorts. Silas Pêgo unifies these spaces and the constituent social identities under the banner of pre-breeding. This notion of pre-breeding is the first I had ever heard expressed from either a plant breeder or in the published literature, but it is critical to understand in terms of how the concept exposes—yet again—the socio-spatial strategy of plant breeding science. The notion of pre-breeding builds on the tension between those who curate seeds and those who breed plants. A key factor in pre-breeding is time: plant breeders have precious little time in which to work as it can take five to ten years to really see the results of one's work. This is due in large part to the time it takes from generation to generation in plant evolution. Therefore, breeders rely on a vast network of places to work (research stations) and frozen storage facilities to store the raw material (seeds, tissues) and to catalogue the diverse plant materials.

Modern plant breeding depends on access to biological diversity, now assessed in terms of genetics. Plant breeders build their careers both on their access to genetic diversity (often called crop genetic resources CGR) and time and space to work with this diversity. Genetic diversity in the world's crops is stored in two types of places: farms, often called in-situ and places called gene banks, often called ex-situ and are so called because they are vaulted bank-like cold-storage facilities that contain accessions of seeds that even bagged and labeled like coins in a conventional bank. On farms, genetic diversity is represented by crop variety diversity within and between crops (e.g. several varieties of wheat grown on a given farm and several different kinds of other crops grown alongside the wheat).

It is unclear when and where the first gene banks emerged, but suffice to say it was most likely within settled agricultural society (however, gardens of horticultural societies can be considered kind of gene banks but not in the sense of an organized site of exclusive interest in maintaining genetic diversity for its own sake). Gene banks can be thought of as sites devoted specifically to the preservation of genetic diversity in crops implying a society that recognizes the importance of the entity called a gene or a genetic society Fox Keller 2000. Gene banks are thus complex actor-world themselves in which genes, humans, machines and techniques are juxtaposed in form of collectors, collections and accessions in freezers.

There are many methods for collecting germplasm, and collecting missions are frequently carried out by gene bank (genetic resources personnel). In Portugal, and with maize, this collecting has occurred several times since the early 1900s. Traveling to distant places, mountain villages and other isolated farming contexts, collectors acquire seeds and as much information as possible from farmers and other knowledgeable folk about the plants produced from these seeds. This information is then recorded and becomes part of a new hybrid identity—the accession. Usually given a number, the accession (which can be simply a bag of seeds) is then labeled, entered into a data base with preliminary descriptor data and stored. Seeds have been stored in paper or burlap sacks for a hundred years, a practice that continues. Collections, and hence, gene banks can be massive is size and scope, and for nation-states they are often considered treasures. (There is the story of starving gene bank officials in Russia during WWII that refused to eat or disperse the stored seeds as food).

After WWII the race to collect, identify and store the world's biological diversity accelerated and there emerged a new class of scientists: genetic resources professionals. These are the people who staff the gene bank and carry out its many directives: storing, maintaining, collecting and sharing the world's diversity. A major function of these places is to not only store the seeds but also to periodically grow them out to carry out extensive descriptive studies and to maintain the collection. Seeds loose their viability over time, even when stored at extremely cold temperatures, and it becomes necessary to produce more seeds. This is where the story becomes institutionally and professionally complicated.

When collected seeds are grown out, two things happen. First, because the ecological setting is likely to be very different than where the seeds were originally produced (different soil, light, insect predators, etc.) there is inevitably some change (scientists call it selection pressure of the growing environment) in the genetic make up of the collection. Thus, each time the collection is grown out the underlying genetics are reshuffled which is a major argument for in-situ or on-farm conservation. The second phenomenon, and more relevant to the story of VASO, is the kinds of measurements, the kind of data, recorded during the grow-out. As Silas Pêgo would constantly point out during my fieldwork, the kind of data recorded by crop genetic resources professionals is, in practical terms, meaningless (Pêgo, interviews). Breeders need two kinds of data on crops: their tolerance of in-breeding depression, the ability to withstand several generations of self pollination that eventually leads to homozygosity, and the plant's combining ability, or the potential to produce desired traits with predictability based on the underlying genetics (Allard 1979; Pêgo interviews). Importantly, neither of these concerns or data is explicitly measured or noted by crop genetic resources personnel.

Rather, genetic resources professional focus is more on descriptive phenological data (stages of the growth cycle, emergence from the soil, days to flowering, and days to maturity and color of parts). These data are certainly interesting to the breeder, but not essential in choosing what varieties to spend a dozen or more years working with! Within the science and practice of plant breeding itself, there are socio-spatial networks and practices that still need coordination: breeders and stations, gene banks and genetics personnel, and gene bank regrowth plots—a potentially productive area of future ethnographic research. My goal in this research is to understand how and if these spaces and actors are translated into the VASO actor-world.

The BPGV stands for *Banco Portuguese de Germoplasma Veget*al (Portuguese Gerrmplasm Bank). This state of the art facility was formed in 1977 through funding the Food and Agriculture Organization (FAO). Originally, the facility was intended to house only maize collections from Portugal and Europe. It has since branched out to other crops. Silas Pêgo and colleagues put forth the idea and Pêgo helped to design the structure itself. He did so with the principle idea of collaboration between crop genetic storage professionals and breeders. First, there would be office space for a plant breeder, something apparently not thought of before. Having a plant breeder on the premises, Pêgo thought, would increase the needed communication between those who conserve and those who breed crops. Thus, in addition to spaces for cold storage (giant freezers), there would be laboratory space for breeding purposes, measurements and data collection for breeding purposes (inbreeding depression and combining ability). Today the BPGV houses at least 900 accessions of Portuguese maize seeds representing dozens of different varieties collected from all over the country (Farias 1996).

For a variety of personal, professional and broader political reasons, Silas Pêgo eventually left BPGV and moved his offices to Lisbon, to the National Institute of

Agrarian Research (INIA). BPGV eventually became a part of the regional agricultural services of the Between Douro and Minho (Entre Douro e Minho) region. Pêgo, however, maintains connections with the staff at BPGV and he also deposits seed collections from his VASO Project. Although the tensions are palpable, there are nevertheless important ties between BPGV and VASO (and INIA) that, I argue, constitute part of the broader work that goes on in VASO. The BPGV was constantly present in the project, through messages, trips to the gene bank, or through personnel that VASO would loan. Although his dream of BPGV was never realized, Pêgo continues to write about and motivate others to take up the pre-breeding idea as way to merge the spaces and social organization of plant breeders and crop genetics professionals (Moreira 2006).

I would argue, also, that the BPGV is a integral part of the edible landscape that Silas Pêgo is attempting organize through maize science. Simply as a presence in the physical landscape of farming and the professional landscape of crop genetics professionals and also as sizeable center of calculation and translation of maize diversity, the BPGV has to be translated into the VASO actor-world. In short, that the BPGV would have to be translated and mobilized with predictability by facilitating and allowing Pêgo's pre-breeding process. The problem is that national politics, professional identities and simple personal disagreement threaten to undermine a simple translation of the BPGV. With scientific colleagues then, their ascribed interests are in the conservation of crop germplasm in-situ or on-farm. The relationship between breeding and conservation, however, remains a professional-institutional culture question that is problematic. If the VASO actor-world depends critically on this linkage between breeding, in-situ and ex-situ conservation and the translation and enrollment of BPGV, then there could be problems.

Farmers of the Sousa Valley

Over the twenty-three years that VASO has been active, a small network of participating farms has emerged. The vast bulk of the research and development has taken place, however, on the small farm of Francisco Meireles. Mr. Meireles was in his late 60's when I conducted the fieldwork for this research, and he like so many full-time farmers in the Valley was on the verge of retirement. How can the VASO actor-world take shape without farmers? VASO has ascribed to the farmers an interest in the viability of farming which is partly based on the value of farmer-produced seed in the Valley. The VASO Project assigns farmers the straight-forward goals of increasing yield and the value of seed.

The Sousa Valley is a hybrid place that is not easy to describe. It is increasingly a zone of rural industry, primarily furniture making and clothing piece-work in small fabricas (factories). Alongside these industries are a few scattered large estates and small farms like Meireles'. The extreme modern and pre-modern conditions coexist uneasily (visually) in the Valley as tall new shiny apartment buildings and supermarkets (supermercados) sprout up almost monthly right next to ancient stone farm buildings. Modernity seems to be winning out, new roads, bridges and construction makes travel easier and non-farming jobs more available. Farming full-time is clearly not the first choice for many young people in the Sousa Valley, and Meireles always laments of being one of two farmers in his *Freguesia* (Parish). Strange place to situate a plant breeding project, I thought. However, Silas Pêgo purposely chose the Valley for a number of reasons, one of them being direct competition with modern farming. The champion maize farmer of Portugal lives in the Sousa Valley (determined by the yield per hectare) indicating that if Pêgo can establish his project (actor-world) in such a place he can do it anywhere.

Portuguese social scientist and fellow VASO Project colleague António Fragata conducted the most detailed study to-date of farming in the Sousa Valley. His two-year long survey of farmers in the Sousa Valley is written up as Diversity and rationality of farmers of the Sousa Valley (Fragata 1992). In 1992, the same study was published under the changed name: *Agricultural Politics, Diversity and Strategies of Farmers: Cases in Minho and Sousa Valley*. The study is based on data derived from 1983 – 1985. Pêgo and colleagues are interested in the choices farmers make regarding crops, what they do with these crops, and what the basic economic context for rural families means for growing maize varieties like *Pigarro*. Early on in the VASO Project, Pêgo collaborated with Fragata to assess the social and economic context of the Sousa Valley. The farm survey summarized here formed the basis for many assumptions that subsequently have become the black-boxed farmer to which the VASO Project is principally aimed. Although I conducted my own, comparatively cursory study of farming in the Sousa Valley by visiting a sample of farms, I want to understand what the VASO Project considers to be a farmer. There in fact is no typical farm in the Sousa Valley as such, there are only constructions and translations of humans and non-humans that agree (tacitly or aggressively) to be called a farmer for a given time in a given situation. For example, the post-man who works full time at the post office but maintains a farm or works every weekend on his family's farm, may be considered as much a farmer as Francisco Meireles in the purview of VASO.

The Fragata study covered two *Freguesias* (Parishes) in the *Concelho* (County) of Lousada. VASO is located about 1 - 2 miles from both of the *freguesias* that Fragata intensively studied. The study is dense with micro detail on crops, animals, watering systems, household economy, land-use, labor, and even some data on diet. It is a truly remarkable piece of work, and from what I can see today it remains valid in its findings.

Fragata's main concern was to challenge the dominant development model being implemented at the time in this region by the Regional Directorate for Agriculture in the Douro – Minho region (DRAEDM). This model was founded on the idea of one kind of farmer, and one kind of rationality. The development goal, Fragata claims, was to reduce the number of irrational and economically un-competitive farmers and create, in their place, new commercial and productivist minded farmers. This strategy had to do with Portugal's impending merger with the European Union (today a Portuguese former prime Minister now heads the EC, the legislative body of the E.U.). Fragata claims that this kind of monolithic model is grossly inappropriate for the Sousa Valley. The reality, he claims, is that there is a wide range of farmers engaged in various different forms of agriculture, and it would be better to target these different types.

Fragata identifies six types of farms: A, B, C, D, E, and F, within which are eight subtypes: A1, A2, A3, C1, C2, C3, D1 and D2. To construct these types, Fragata uses a combination of household economics, land-use and size of farm, and relative time dependence on farming (full-time, part-time).

All of the farm types can be considered in three main groups. The first group comprises the As, Bs, Cs. They are part-time farmers with very small farms (up to about 2 hectares, but mostly less than 1 ha) and they vary in their raising of pigs, and cows for meat and dairy. These types make up most of the local socioeconomic (class?)—91.9% of the families, but collectively they only work 37% of the agricultural area. The A group consists of the basic house-and-garden families of employed [household heads], retired people, and older residents of the village. These people usually own their own house and adjacent yard. The B group is composed of people with green houses. The C-types are part-time farmers with a small yard and maybe one or two rented fields. The C's raise cattle for meat and dairy.

The Type D consists of D1-D2. The D's are the *caseiros*, or traditional farmers. They are full-time farmers with medium sized farms of 2-7 hectares. They make up 7.5 % of the families but work 52% of the agricultural land. These farmers rent land by verbal contracts and most pay in produce (but some pay in cash equivalent of maize and beans. Fragata explains that these farms are polycultural and centered mainly on a seasonal rotation of maize x beans consociation (maize either intercropped or interplanted with corn) and rye grass. This describes Meireles farm (he is a type D). These farmers have rights to the water, forests and woodlands of their landlords. Fragata differentiates the Ds by their relative reliance on financial remissions from children. The D1's pay rent in crops, the D2's pay in cash. The Type E is the modern farmers, full time farmers and owners of their farm (mean of 4.5 ha). The E's grow and use silage for dairy production. These farms have tractors and other forms of mechanization, but use family labor as much as possible.

Lastly there is Type F who live in the bigger cities but maintain a farm in the countryside. They are highly educated (by Portuguese standards) and make most of their money through their profession as managers in industry, architects or other profession.

The Fragata study provides a good context for understanding small farming in the Sousa Valley, and for situating the VASO project. I have met all of Fragata's types in the course of my fieldwork, and none that I would say fall outside of his typology. I suspect that the stability of Fragata's model until present is likely due to fact that 15 years has not been enough time to see the full transition to the quintal. For example, Fragata's study puts the mean age of *caseiros* at between 43 and 54 years old. By now the range would be 58 – 69. This is exactly the age group the farmers I have met and worked with. Their children, however, have had time to get factory employment, marry, and build the many new houses in the surrounding area.

Farms and farmers clearly play a critical role in the forming VASO actor-world, and it is not clear that this strategy will be able to compete with other actor-networks (like fabricas and furniture making) that pull younger farmers off farms and into wage labor. Yet, for VASO to be a success, someone has to grow the crop varieties like *Pigarro* and thus agree to become a part, farmer-breeder-of-*Pigarro* maize, a node in the socio-spatial configuration being proposed by VASO.

Both farms and mills are closely linked economically and geographically, and both are located at the intersection of consumption and production as they are spaces organized around the flow of food through the biophysical and social, or the edible, landscape. Farms and mills are thus hybrid forms both socially and spatially: mills convert grains of maize into flour, bakeries purchase the flour and convert it into an edible product, broa which is purchased in markets, restaurants and bakeries. That is, in the context of what VASO is attempting to accomplish, a mill achieves identity and agency in relation to a farm and a bakery. If the VASO Project cannot perform this connection and make it adhere to and inhere in the crop varieties it produces (like *Pigarro*) then there will be no VASO, and no participatory plant breeding path to sustainability in the Valley. Success depends on merging plant breeding content, the theories, practices, and knowledge, with the larger social context. An act of orchestrated co-construction.

One of the key points to make with respect to millers is that set the price for seed they purchase from farmers and hence millers exert tremendous influence over what types of seed farmers produce. Traditional white maize, for example, may produce the finest quality flour for bread making, but this type of seed is very durable due to the toughness of its kernels. Large scale millers do not like this type of seed and prefer the more industrial varieties that are softer. Thus, with fewer and fewer outlets for their traditional seed, farmers are less likely to grow traditional varieties like *Pigarro*. Millers thus constitute a considerable impediment to the VASO actor-world in the making. Thus, in order to convince farmers that growing *Pigarro* is advantageous, there has to be more than a biological argument that the yield of such varieties has been raised through collaborative plant breeding. The biological / genetic component of yield has to be matched by a social construction or orchestration of millers willing to buy certain types of seed at prices that guarantees them a modest profit.

In effect, the VASO Project presents a *conceptual* challenge to plant breeding-as-usual, but more importantly I argue throughout this work that the VASO Project also constitutes a *socio-spatial* challenge to conventional pant breeding by attempting to re-situate plant breeding *practice* to include new spaces (real farms) and new social actors (farmers) into the formal development of crops.

Here I present a model for understanding how the VASO Project's hybridized style of plant breeding science takes shape as a social formation through specific strategies, logics and a variety of social, intellectual and material resources that must be brought to bear. Some key questions to begin with are: How does one adapt a global science like plant breeding to a local place like the Sousa Valley? What happens to the conventional social and spatial organization of plant breeding practice when plant breeding moves on-farm and incorporates places like the Meireles farm and social actors like farmers?

I have put forth the argument in the previous chapter that moving plant breeding onto farms entails more than a mere technical move. It is, literally, re-placing plant breeding and, in essence re-configuring the underlying socio-spatial organization of the science. Within CPB, farms are no longer abstract models fashioned into test plots on agricultural research stations. What happens in effect is that the farm becomes the center of translation, that is to say the socio-physical place that anchors the emergent actor-world under construction. This center was previously located on agricultural research stations in far away places like Braga and Lisbon (Figure 9).

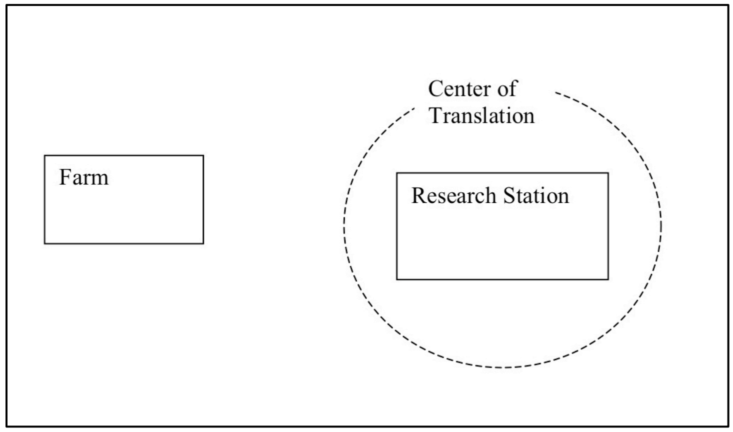

Figure 9: conventional station-based plant breeding: research station = center of translation

What is important to underscore here is that whereas the farm in conventional plant breeding has long been something that is translated and black-boxed. By relocating plant breeding to actual farms (from research stations) the farm then becomes a party to translation, i.e. it is no longer a space that is translated but rather becomes a center of translation (Figure 10).

This has the interesting effect also of reversing the black-boxing process built into plant breeding so that the research station replaces the farm in the new actor world of collaborative plant breeding. More importantly, however, is the way in which the social space of the farm is related to other spaces in the overall edible landscape that is the output of the VASO actor-world. A farm in this sense only has meaning as a social space in this wider world that spans zones of production and consumption within which are more tightly organized spaces of social interaction organized around maize-based food.

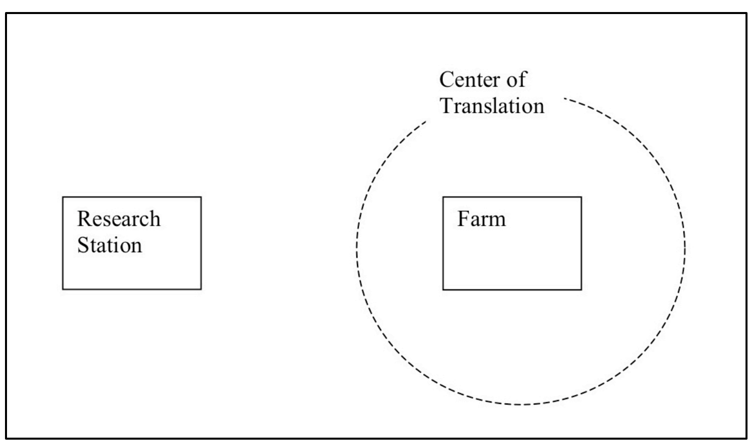

Figure 10: farm-based CBP: farm = center of translation

Each of the spaces in this model are themselves relational in the sense that farms are defined in relation to research stations and gene banks, which are defined in terms of mills and restaurants.

Summary

In this chapter I have presented the primary human and non-human actors being enrolled into the VASO actor-world, and hence into mutually defining social relationships that will generate new identities: white maize becomes *Pigarro*, farmers of the Sousa Valley become growers of *Pigarro*, millers become pulverizers of *Pigarro* seeds and so on. This is a fundamentally different socio-material-spatial organization than the VASO Project in the sense that the VASO Project is a technological solution to the Sousa Valley's environmental, social and economic problems centered on plant breeding as articulated the documents and transcriptions of the Project. The VASO Project is the means by which Silas Pêgo is building the VASO actor-world. To accomplish this much more powerful and enduring social formation, Pêgo has to conduct politics by other means (Latour 1989). This politicking is the process of moving actors into alignment with one another so that they are all connected by *Pigarro* and its promise for more yield, more flour and value-added farming through value added bread.

One of the more glaring problems with an actor-world, however, is that certain actors are missing or incompletely problematized. I placed millers in Pêgo's problematization because they are implied, but during fieldwork I did not once see Pêgo talk with a miller. Playing the role of an interested (and *interessed*) observer, I organized a visit to millers with Pêgo. This intervention, however, did not seem to lead anywhere. Perhaps Pêgo had too many other activities to keep up with (it certainly seemed so). Regardless, I have not seen mention of millers in subsequent reports and articles published about the Project (Moreira 2006, Moreira et. al 2008; Vaz Patto et al. 2007, 2008). My reasoning is that Pêgo, like so many plant breeders, is still operating within the VASO Project and not the VASO actor-world. Nevertheless, chapter three takes up the issues of interessement and enrolment, where again the millers, and to some extent bakers, remain tied much stronger to other networks of associations orbiting in and around other competing actor-worlds. This presents a potential problem for Dr. Pêgo and his colleagues.

CHAPTER THREE
BECOMING INTERESTED IN SUSTAINABILITY THROUGH PLANT BREEDING

Introduction

Following the formation of obligatory passage point(s) through a series of propositions that link all VASO's potential allies, Silas Pêgo then has to ensure that everyone, and everything keeps in line with their prescribed roles. Colleagues can be kept in line through constant communications in the form of telephone calls, letters, (emails) and faxes. The plants and farmers, on the other hand, present real problems for Silas Pêgo. If either plants or farmers decide they can take their own paths to sustainability without passing through the established obligatory passage points OPPs, then the networks, and hence the collective, comes under lethal strain. Signs are one method for collapsing the identity of a complex entity and associating it with other entities, such as an institution like the Portuguese maize breeding (improvement) center (NUMI) (Figure 11).

Figure 11: On-farm sign designating *Pigarro* test field and aligning it with NUMI, photo by author

The topic of chapter two is the problematization of actors in the context of the VASO Project. The word context is important here as once problematized, that is defined as having an identity and range of possible action within forming networks of association, and actors become part of a new collective. It is this collective that becomes the context of VASO's plant breeding content, its theories and practices. This context includes human and non human actors and preexisting networks (the large agencies and the silent college scientific colleagues). After problematization, then, it is possible to speak of two sides to VASO: the pre-made scientific VASO Project that we encounter in articles, reports and grant proposals and the maize science-in-the-making, the VASO Collective.

This chapter focuses two moments of translation of the VASO Collective, that of interessement and enrolment. They are considered together here because the two moments bleed into one another for if it is successful interessement becomes enrolment. To inter-esse is to be in between or interposed between,the group of actions by which an entity attempts to impose and stabilize the identity of the other actors it defines through its problematization (Callon 1986:207-208). During the problematization phase, network builders carefully define the identity, the goals and the inclinations of their allies. But these allies are tentatively implicated in the problematizations of other actors. There is thus a competition for identity, to interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise (Callon 1986:208). For all the entities, "interessement helps corner the entities to be enrolled…it attempts to interrupt all potential competing associations and to construct a system of alliances. Social structures comprising both social and natural entities are shaped and consolidated" (Callon 1986:211, 214).

Interessement and Enrolment

To interest other actors is to build devices and practices that can be placed between them and all other entities who want to define their identities otherwise. A interests B by cutting or weakening all the links between B and the invisible (or at times quite visible) group of other entities C,D,E, etc. who may want to link themselves to B. The properties and identity of B (whether that is a mater of scallops, scientific colleagues, or fishermen) are consolidated and/or redefined during the process of interessement. B is a 'result' of the association that links it to A. This link dissociates B from all the C, D and E's (if they exist) that attempt to give it another definition (Callon 1986:208).

Two key points to reiterate from this extended quotation from Callon is that, 1) identity and agency of actors is a product of relationships with other actors, and 2) actors are always involved in competing relationships (what Callon calls the problematization of others). Interessement can take many forms from seduction to other forms of persuasion or brute force. Whether or not an actor acquiesces, simply doesn't care or rebels is a question for research. It may be the case that B is already close to the problematization put forth by A. In any case, interessement is the technical means by which collectives are populated with entities that define each other.

In this case, interessement focuses heavily on the technical practices and devices in relation to the physicality, or materiality of the maize plant and its seeds. When, in chap. 2, maize has only to be defined as something that will produce a yield of white kernels with some predictability, the interessement phase (here) describes the techniques of making this happen. What this chapter describes then, is how Silas Pêgo attempts to create new identities out of dyads of humans and nonhumans; first there is *Pigarro*-the-understandable and predictable deliverer (yield) of seeds that produce quality flour (indeed the creation of *Pigarro* itself as a hybrid of all its relationships proposed in the project), the farmer-*Pigarro* grower, and the baker-*Pigarro* flour user. Pêgo has to negotiate and calibrate these new associations over space and time and against the backdrop of other potential relationships actors might be involved in. Hardly anyone grows *Pigarro* (they might grow white maize however), and very little is still known about this plant and its seeds either among scientist colleagues or farmers.

To negotiate with *Pigarro*, Pêgo uses standard plant breeding methods to document how the plant performs on-farm, essentially merging the place (farm) with the entity (white maize), so that the entity *Pigarro* becomes a local white maize that produces a funny shaped ear (fasciation) that can be used to make flour for broa + small farms + small farmers + (millers) + bakers. I have millers in parentheses because Pêgo leaves them out of his problematization, they are hidden and unaccounted for in the VASO Project, and hence the VASO Collective (the subject of chapter 4). So, *Pigarro* = local white maize + small farms + small farmer knowledge and practice. Pêgo has to dissociate white maize varieties that he has called *Pigarro* from all the competing alliances this plant has with other actors. This will create a new hybrid of nature-culture known as *Pigarro*.

To negotiate with farmers Pêgo has to construct a black box: the knowledgeable farmer. The farmer then becomes a translated entity, describable by certain practices and knowledge. Thus Pêgo is trying to dissociate the small farmer from all his/her competing alliances…in particular the alliance that small farmers have with their maize varieties and with other actors, like the miller and other networks like broa (chapter 4). Through VASO, and *Pigarro*, Pêgo is attempting to insert his goals and interests in sustainability between the farmer and other actors and associations. He does this by two means, the concurso (contest for the best ear of maize in the Sousa Valley) held each year and a device of embodied practices Pêgo calls the selection kit.

Certainly one the main actants in the VASO Collective is the maize plant. chapter two discussed how the VASO Project defines the maize plant as an actor that can be planted, measured and manipulated to derive data useful in predicting its behavior. Since this chapter is concerned with how *Pigarro* is interested and aligned with other actors it is important to sketch out its materiality (not nature). Numerous books and journal articles have been written about maize, certainly among the world's top five crops. An academic journal, Maydica is devoted only to maize botany, genetics and breeding. Here I do not attempt to summarize this vast literature, but rather highlight how maize is translated within VASO (project and collective), and by extension plant science in general.

We begin with the most important terms breeders use to refer to maize, and all plants: the phenotype, and the genotype. These terms are a perfect example of how the complexity of plants is reduced and made mobile. Scientists refer to the observable form (and the form that scientists, farmers and other humans and non-humans interact with) as the plant's phenotype. This identity is separate from, but always related to by inheritance, to the plant's genotype, or genetic makeup. Prior to the advent of genetics, of course, these two identities were not possible. Thus, once genetics emerged and we humans began to live in, or be problematized and enrolled in, a genetic world in which two different forms of the same entity emerged, the 'genotype' and the 'phenotype' (Fox Keller 2000).

Classical plant breeders, like Silas Pêgo, are the leathery-skinned people like farmers who spend most of their time outside in fields and who deal mostly with the physical plant, or phenotype. The underlying genetics are modeled mathematically based on the known and hypothesized strength of inheritance of traits and the role of the environment in the expression of these traits over space and time. Today, breeders universally operate on one the most fundamental relationships in plant breeding expressed as the variation in the phenotype being a function of variation in the genes, environments and genes interacting with environments. This biological framework makes several reductions of note, mostly the translation entities into some genetic element or element that impacts genetics. Environments are thus described by their impact on genes, nicely encapsulated in the term selection.).

A fully-grown maize plant can reach over seven feet tall. The basic components from bottom to top are subsurface roots, surface roots, stalk, leaves, ears, silks, and tassel. All of these features listed form the phenotype and all are considered traits of interest to humans, both breeders and farmers alike. The root system of maize has evolved to support a large, heavy plant. Above the surface, roots radiate from nodes on the stalk like flying buttresses. The strength of these roots is critical to prevent lodging of tall plants because the extraordinary leaves of maize act like tiny wind sails. Maize stalks are thick and carry water and sugar to and from the large leaves. Farmers around the world use maize stalks to feed cattle, and stalk quality. Hence stalk quality is of great interest to both breeder and farmer alike. A maize plant can have one or several ears depending on man factors of environment, genetics and what humans do at critical stages in the plant's growth cycle. The most widely known part of maize, however, is the ear. Humans have taken an interest in all aspects of the ear, from its size, placement on the stalk above ground, type of kernel, type and quality of husks that protect it, and the color and time of emergence of silks.

Botanically, maize is considered a monoecious plant, a plant having male and female unisex flowers located on the same individual. The male, pollen bearing, flowers are located atop the plant and separated from the female flowers where fertilization of the ovules takes place. Male flowers are bushy and shed thousands of pollen grains that are dispersed by air. The female flowers of maize emerge from nodes on the stalk and are deeply embedded inside an outer sheaf of leaves known as the husk. The silks are stigmas connected to ovaries and once emerged from the husk allow pollen to fertilize the ovules. There is what botanists call a double fertilization that occurs and that makes maize and plants like it so important to humans. The double fertilization produces both a small embryo and the larger starchy endosperm. The seed that develops has a hard outer coat, pericarp, with a thin layer of cells that give the seed its color. The precise timing of silk formation, pollen shedding and fertilization are important data for the breeder and farmer alike.

The maize plant is an out breeder meaning that the male and female flowers on individuals develop at different rates thereby largely, but not completely, avoiding self fertilization. There is some overlap that offers a small chance that pollen shed only a few feet above will alight on the same plant's silks. This timing difference and wide separation of male and female flowers insures primarily of cross fertilization. Pollen can travel wide and far, a major concern in the GMO debate (that nearby GMO pollen will fertilize non-GMO plants and weeds). The maize ear fills in from the bottom to the top, thus seeds that develop when male flowers shed pollen are the most likely to be self-fertilized. In terms of this research, I observed farmers choosing planting seed from the middle of the ear so as to avoid the possibility of selfed seed as they believed the bottom seeds were mostly likely to be selfed. The seed at the tips of the ear were often exposed to the elements and bugs, and therefore likely not selected as planting seed. Also, there is the belief generally in the Valley that seeds at the tip are old or "tired" having formed last.

It is important to sketch out these basic physical characteristics because breeders and farmers alike interact with each individually, and all collectively as the plant. To bring the plant's reproductive cycle under control, for example, breeders will place bags over the female and male flowers to avoid any selfing. Or, conversely, breeders will purposely self a plant or series of plants to reach a state of 'homozygosity' in the plant, a means to determine what traits are dominant in the genome of a plant variety (Simmonds 1979). Breeders as well as farmers will try an isolate populations of maize plants from each other to try and breed true to the type. Plant breeding and farming are thus two types of socially organized intervention in the life cycle and sexual reproduction of a plant that introduces human values as the altering mechanism, and as such farming and plant breeding transform the plant's nature into socio-nature (or nature-culture).

Maize Becomes Portuguese

The modern-day corn plant likely coevolved with natural and conscious human selection pressures in central Mexico several millennia ago (Harlan 1975). By the 1500s, Europeans and evidently the Chinese agriculturalists had detailed knowledge of the maize plant and nearly every aspect I have described above. This is evidenced in detailed drawings in herbals of Europe and gazetteers of China depicting the maize plant showing ears, silks, tassels and roots (Bray 1984).

There is still a lot of uncertainty about precisely when, where, and how maize arrived to Portugal and how it subsequently diffused throughout the country to eventually become the most important crop in the northwest (Redbourg et al. 2003). Various pathways of diffusion are suspected, but nevertheless the plant had been described by 1533, and by the 1700s maize had become a major crop in the Portuguese marketplace (Pires 1992). Maize would have offered early Portuguese farmers a high yield of green fodder and grains per unit of land. The crop also matures (viable seeds are produced) within 80 to 130 days. Over time the Portuguese farmers developed their own varieties based on a number of social, cultural, economic and environmental factors.

Beginning in the 1800s and through today, Portuguese agronomists and later maize breeders have been collecting, documenting, storing and developing their own varieties of maize for two main uses: green fodder and grains used to feed farm animals (dairy cows, meat cows, oxen, pigs and chickens) and humans alike (bread flour). During my research I documented many different varieties in use in the Sousa Valley of the flint and dent kernel type and varying colors but mainly yellow and white (orange is popular in other regions). These varieties, reflecting the hybrid nature of the Sousa Valley, are of farmers or folk variety (FV) modern variety (MV) and improved folk variety (IFV). Modern varieties here simply mean that the variety is listed in the National Catalogue and is commercially available for purchase. Often they are imported from the United States or France.

Until the 1980s, Portugal was self-sufficient in maize production to the point of being an exporter of seed. That changed with new policies aimed at specializing the market, increasing the need for silage maize (ground up green maize plants and ears) and interfacing with the European Union which Portugal joined in 1986 (Portuguese Agricultural Survey Statistics 1999).

Making *Pigarro*

The tall unruly-looking maize plant called *Pigarro* did not exist before the VASO Project began in 1984. It is my contention that no crop variety simply exits as a self explanatory thing. Rather, they are hybrids of nature-culture-politics-economy and therefore are always under construction, whether sitting in a gene bank in the Arctic Circle or in Braga, Portugal. Crop varieties are different kinds of hybrid entities; some have more science crammed into them than others. Prior to VASO, there were only local varieties of white maize (milho branco) that produce fattened ears of hard, smooth, kernels (flint-type kernel). After VASO, there would be *Pigarro*. The interest in *Pigarro* is twofold; first it is known to produce a strange-shaped ear that is actually more like two intertwined ears, a trait known as fasciation. Fasciated ears contain many more kernels per ear than the more common cone-shaped ears of maize (see figures below). Thus, Pêgo took an early interest in discovering the genetic component of this trait and how it might be manipulated and controlled to raise yield (through more kernels per ear) per plant. The second interest in *Pigarro* is the type of maize kernel it produces, a pearly white, smooth kernel (called flint) that contains just the right amount of moisture and starchy endosperm to produce an ideal bread making flour (chapter 4). I have already discussed how plants are relationships not just between molecules of DNA but also between human and other non-human actors. Thus, to form the variety *Pigarro*, Pêgo has to dissociate it as local white maize and re-associate, interest it, to join with other entities to become *Pigarro* in the VASO Collective.

Improving *Pigarro*

Fortunately for Silas Pêgo, plant breeders have developed sophisticated means, or devices of interessement, deployed in a methodology called S2 line recurrent selection (Figure 12). Generally this is a process of reducing the population to promising individuals that are then recombined to hopefully alter the gene pool in favor of what the breeder wants, usually yield. It takes time, as well as space, to carry this out.

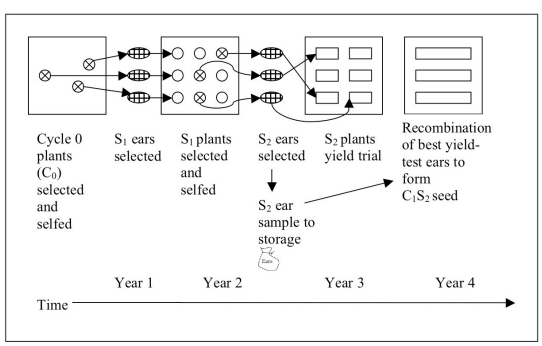

Figure 12: Silas Pêgo's recurrent selection method through space and time

Dr. Pêgo begins the cycle of selection in year 1 (see Moreira 2006 for a breeder description of this process). The initial cycle of *Pigarro* selection was started in 1984 and it is identified by the symbol (C_0). These are the seeds that are collected from the farmer, and they are the result of farmer's mass selection. Mass selection is the short hand way for breeders to refer to the farmer practice of seed selection. The assumption being that basically farmers select what looks good to them without any written data or statistical models and practices guiding the process. The breeder identifies best looking plants for self-pollinating (selfing). Selfing is accomplished by placing a paper bag (about the size of a lunch bag) over the developing tassel to collect the pollen—it is important to do this before pollen begins to be shed. Silas's method is to place a clear plastic bag (the type of bag is important) over the developing ear to protect it from contamination, a constant threat. This work requires skill as plant parts can easily break with all the bending required---it is important to move quickly and efficiently because there can be several hundred plants to cover in a day---usually a very hot day. Silas also slices across the top of the ear so that all the silks will be of the same length when they develop---this helps to even the chances of all the silks being pollinated: this is accomplished using a knife that dangles from a string tied around the wrist. The bags are kept in the breeder's "apron" which is worn around the waste and has several pockets. At harvest the plants are again examined and ears from good plants are collected and husked. The best looking ears are then selected for seed and labeled. The ears are shelled (by hand, there might be 500 ears selected. These are the seeds that will move on to the next season.

Seeds from last season (S_1) are planted according the ear from which they are derived (ear-to-row). There might be 50 kernels or 100 from the 600 or so kernels on the ear which are used to plant a row. The kernels from the ear are selected at random, because they are selfed it does not matter. A row is equivalent to a "family." The breeder then decides which families (rows) look good—he/she selects the families (selection among families). Those rows which pass visual inspection are then bagged for selfing you don't self all of them… (SP). Among the families (rows) that remain, the breeder performs selection of individuals within families. This is called advancing selected plants to the $\mathbf{S_2}$ generation. These are $\mathbf{S_2}$ seeds. At harvest ears from good plants are collected and husked. The good ears are then selected and labeled: Ear 1, Ear 2 and so on. A percentage of kernels from each ear are sent to cold storage and the remainder are sent to yield trial in season 3. The purpose of yield trial is to identify the best ears in a more (statistically) rigorous manner.

Seeds from the selected ears in season 2 are planted in rows corresponding to their ear number. Several blocks of these rows are planted; these are called replications. There should be at least three replications. The idea is to randomize the planting pattern. The breeder collects data: root lodging, stalk lodging, and kernel weight at 15% humidity—to name a few. These data will be compared to determine the best plants (remember the ears correspond to cold-storage ears). The breeder goes back to the remnant seed in cold storage, identifies the best ears (from yield trial data) and plans a recombination method for restoring diverse gene combinations to the population.

The idea is to ensure cross pollination and remove any chance of selfing. Silas uses a method in which a block is planted to; let us say Ear 1, which is made female by de-tasseling. Alongside this block is planted Ears 2 – x. In the next block, Ear 2 is planted and the plant is de-tasseled. Alongside this block is planted Ear 1, and Ears 3 – x. In this manner, the plants are controlled as much as possible: the breeder has made it difficult to reproduce outside his/her interests. What about the farmers? Can they be interested as easily as the plants? The short answer is no, but this does not prevent Silas Pêgo from trying. The farmers have their own instruments of interessement, for controlling maize.

Pigarro is a short-cycle plant, maturing very early (90 days) and able to tolerate high stress (low water and acid soils). For this reason, Meireles likes the plant as both a continual feed for his cows and for grains. *Pigarro* can have a very red stalk, something which Meireles claims is a trait form one of the lines making up *Pigarro*. The *Pigarro* plant itself is also useful as green fodder (see earlier report on maize uses in Vale do Sousa). *Pigarro* has been taken to the third cycle phase of Pêgo's methods on-farm at Meireles's, this takes 20 years to achieve. *Pigarro* also expresses strongly the fasciation trait, which is a fusion of two or more ears and something with which Pêgo is very interested to possibly increase yields. Pêgo uses the existence of the fasciation trait to gauge whether or not the farmer has a sensibility for the potential usefulness of this trait (increased kernel row number, primarily). Meireles tells me that adding a few fasciated ears to the seed lot to be planted is like "making a salad…you add some of this, some of that, presto!" (author's field notes). Mr. Meireles means that he maintains a small amount of the trait in his populations.

During my fieldwork on the farm, there emerged what I call a *Pigarro* identity crisis, something which revels differences in how breeders and farmers monitor the plants throughout the growth cycle, and how Meireles' understanding in particular changes with this cycle. If this crisis of identity had not occurred, it would have been difficult to get this kind of information as it naturally occurs; being an example of how important is observations of daily activities on the farm itself.

On Meireles' farm, there were two plots of *Pigarro*, one planted for Silas Pêgo (by Meireles using his planter) and one plot for Meireles (Meireles also planted early *Pigarro* plots around the boarders of his fields for use as green fodder, e.g. not for seeds). When I was on Meireles farm one day, I had noticed a cotton bag of seeds with a paper label *Pigarro* C_3 written on it. Meireles and I discussed the bag which led into a discussion of plant breeding (from Meireles' point of view) and Silas's work in general. I took a quick picture of the bag and label. Later I watched as the seeds were planted by Meireles and his wife. The label was cast aside onto the ground where it remained for most of the season. Later I took a picture of this ragged label as it rest on the ground near the knee-high *Pigarro* C_3 population. I wanted a clear idea of where specific populations were being planted, and I had thought that I might be confused later on when all the different plant populations were in full growth.

Much later, as the *Pigarro* plants reached the point of forming ears and other visible parts, and the plant began to reach a mature stature, Meireles pulled me aside and said: "Silas made a mistake, he is wrong…this is not *Pigarro*." I asked how he could have such an opinion, stating that I saw the bag labeled *Pigarro*. Shaking his head, and saying something to the effect that it does not matter what I saw, these plants were definitely not *Pigarro*! Meireles explained that under these conditions (watering, weeding and soil) and after this much time (after planting) the *Pigarro* plant should be much taller and the ears should be much higher up (ear placement). He explained other details of the physiology backing up his claims. Later, no another day, he would also show me the shank, a part which connects the ear to the stalk. The shank on *Pigarro*, Meireles said, is much longer. He then professed not knowing what the plant is, "could be anything" he said.

When I met Silas, I relayed this information, that probably there was a mix-up with the seeds or something. Silas said he would check it out. I then explained that I had photographic evidence that at least the bag labeled *Pigarro* C_3 had indeed been planted there. Surprised at this, Silas then went into a detailed explanation of why Meireles might think there was something amiss, "We have improved the population, you see! So much is the improvement that he does not recognize *Pigarro*!" Silas then explained how *Pigarro* varies widely in height and ear placement and with a very long shank. Through his selection over the years, Pêgo has been able to reduce *Pigarro*'s height making it more uniform, and to lower the ear placement and decrease the shank size and length. The idea is to devote more energy to the ear (not the useless shank) and to make it easier to harvest (uniform height and lower ear placement). "You see," Silas remarked, "Meireles does not recognize it as his own!"

The two met at the *Pigarro* C_3 field and discussed the matter. There was some animated discussion, after which both left the question of the plant's identity (mutually) unresolved. Later, after some weeks had gone by and Meireles could see clearly the ears he admitted that it could be *Pigarro*. Perhaps, he said, the plant has changed due to Dr. Silas's (he refers to him as Dr. Silas with me) melhoramentos (improvements). I used this as an opportunity to ask Meireles to characterize his many years working with Dr. Silas, and he said, among other things: "it hasn't hurt!" Thus, indicating that since no perceived harm as come to the farm, or the yield, it is worthwhile to experiment with plants in this, at times time consuming, way.

The *Pigarro* identity crisis was an opportunity to explore a range of related issues (other than the resolution of this particular issue) such as how does one knows what one has planted (other than by the name, which could be erroneous). Also, this was an opportunity to ask pointed questions of both Meireles and Pêgo about how they each think the VASO program has been going, and what it has achieved. *Pigarro*'s identity is not fixed, but reveals itself in stages to the farmer. Silas is more assured, relying on his notes, labels, and data from years past (he can retrace *Pigarro*'s identity through a circulating reference of signs).

Selecting *Pigarro*: The Selection Kit

Over the years, Silas Pêgo has developed a human interessement kit (my term) of procedures for farmers to follow (Figure 13). This kit effectively ties together farmers and *Pigarro* through a series of prescribed practices designed to get the best ears. He has designed the kit as the best use of mass selection, a form of selection breeders assume farmers practice. Also, the kit is designed to be of low technology, requiring a focus of the senses more than a sophisticated array of machinery. It is designed with the harvest-by-hand farmer in mind.

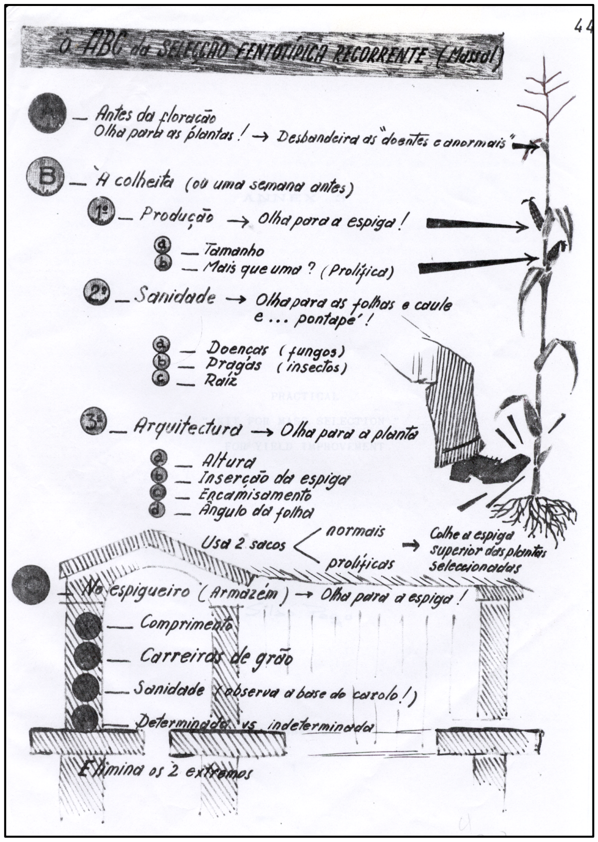

Figure 13: Kit for Mass Selection for Yield Improvement, by Pêgo

The kit describes how to select the best ears for replanting the following season. In step A (Before Flowering), the farmer is advised to listen to the plant! Then, one is to go through the field essentially removing the male flowers of sick looking plants. This removes the possibility of half the genes of this individual from being passed on, while still allowing for the farmer to keep the plant and get something from it (breeders might remove the plant altogether because they do not depend on it for food).

Step B occurs later in time, one week before harvest. Here there is a suggested gradation of concern, first to production (listen to the ear!). The farmer's attention is guided to the size of the ear and the quantity per plant (prolificness). Secondly, the farmer is asked to consider the health of the plant, (listen to the leaves and stalk, give it a good swift kick!). Problems of fungus, insects and health of the roots can be determined by a kick to the stalk and the reaction of the plant. Thirdly, in step B, is a consideration of the architecture of the plant (listen to the plant!), a careful look at the height, the position of the ear (on the stalk), how tightly enclosed by husks and the angle of the leaf. Pêgo believes that farmers know ears should be tightly encased by the husk, plants should be tall, but not too tall, and that the leaves should be angled upward to best catch the sun. Lastly, Pêgo recommends that farmers carry with them two sacks, one for prolific plants of more than one ear, and another sack for normal plants.

Step C involves recommendations for selection (of seed to plant) at the steed storehouse or espigueiro and selection will be upon the ear (listen to the ear!). Recall there are two sets of ears collected, from normal plants and from prolific plants that produce more than one ear per plant. In each set, the farmer is directed to select the best ears based on: ear length, the number of rows of kernels, the general health of the ear and indeterminate character or the tip of uncovered kernels. After selecting these ears, eliminate the extremes, shell the ears and mix the seed for next season's planting.

With this kit, Pêgo accomplishes two things. First he sets out a standard set of recommended practices that, he believes, builds on the existing practices of farmers and that will make sense to them. By doing this, Pêgo effectively translates farmer knowledge into a new knowledge that combines scientific knowledge and practice with that of the farmer. This translation implies many non-humans (plants, ears, seeds) and humans. Secondly, the kit is mobile and can be translated into any language and thereby used as an enrolment tool anywhere, it is both highly spatial (involving socio-material-spatial-embodied practices) and non-territorial at the same time. The kit is itself a co-construction of farmer agency and knowledge that translates global and local knowledges and locates this in the bodily practices of farmers, a process noted by other ANT scholars dealing with similar kits of recommended practices (Eden et al. 2000, Higgins 2006, Jons 2006, Kaljonen 2006, Morris 2004). But will the farmers do this?

Breeders almost universally assume that farmers practice a mass selection of plants for the next year at storage. That is, they assume that selection is a) an event, and b) that this event takes place at the storehouse as farmers look for good ears after which they take seeds from those ears for planting. I spent a good deal of time on this question with Meireles, but I did so over the course of an entire year, almost on a weekly basis. I visited the farm at planting time, and nearly weekly after that. When one does this, it becomes abundantly clear that farmers are continually selecting plants based on conscious criteria and unexpected circumstance through a number of means over the plant's life cycle.

The selection kit is a means to translate farmers and their embodied knowledge into a set of mobile practices and to enroll yet more farmers. The Contest for the Best Ear of Maize in the Sousa Valley is social means to conjoin the interests of both farmers and maize varieties (humans and non-humans). The following section describes *how* it is done.

The Best Ear of Maize in the Sousa Valley

There has been a contest for the best ear of maize in the Sousa Valley for the last 7 years (since 1993). This contest, or *concurso,* is hosted annually by the Farmers' Cooperative of Paredes. Farmers from anywhere in the Sousa Valley can enter, and they do not have to be members of the Cooperative. Around the first weeks of October, one goes to the Cooperative and registers the ear. The limit is two ears per farmer name (so one could feasibly enter several ears under a family member's name, which proves to be the case). Although the prize trophies and other support is provided by private seed companies and cooperatives, the contest has always had a strong participation by small farmers who mostly enter local varieties of maize (see table on maize varieties used in the Sousa Valley). The *Concurso* has become much more formal since the first years, primarily because Silas Pêgo became involved and began to link the *Concurso* with his project. He did this to test his project's varieties against the local varieties and to spread the word about his project. I argue, however, that the *Concurso* has become another interessement device, a tool of enrolment and translation (Figure 14).

Figure 14: Winner of the 1999 *Concurso,* photo by author.

The contest officials divide the competition into the following categories based on kernel type and whether it is regional (farmer's folk variety) or commercial:

The Queen---the Overall winner of the Contest (any type of maize)
White Flint (Regional)
White Dent (Regional)
Yellow Flint (Regional)
Yellow Dent (Regional)
White Flint (Commercial)
White Dent (Commercial)
Yellow Dent (Commercial)

Only in 1999 did the *Concurso* separate the commercial from the regional maize varieties. Silas Pêgo explains that this is because the regional maize always won, and this upset and alienate the commercial sponsors (who provide the trophies and other support). A statistical analysis of all the years bears this statement out (that folk varieties won most of the trophies). A trophy is awarded to the farmer based on his/her submitted ear. Exactly how the best ear(s) are determined is particularly interesting because, as one can imagine, selecting ears seems to be a large part of breeding (both farmer and scientist breeding). Winners are selected based on a final number that is generated through a formula Silas Pêgo devised. Prior to this, the *Concurso* was based only on the look of the ear, similar to the United States corn shows of the early 1900s (Kloppenburg 2004).

Pêgo has offered to make the *Concurso* more objective and based on yield than simply on the look of the ear. Breeders maintain that an ear is poor indicator of yield across space and time in a field of maize. The final award ceremony is in early November at the Cooperative in Paredes. In 1999 I attended and the overall winner of the contest (Queen) went to a female farmer who had entered a Yellow Dent regional variety called Fandango—which is in fact a name given by Silas Pêgo to an improved population. Evidently, Meireles had provided her with some seeds.

Selecting a winner

Pêgo was trained in the United States under one of the most famous specialists in quantitative genetics in maize breeding, Dr. Arnel Hallauer. This being so, Pêgo knew very well that simply looking at the ear is not a good way to determine a winner, because this trait (ear size) has little correlation with yield—something every breeder is interested in. The ear is real, however, as Pêgo points out to me, so the ear does in fact represent a genotype that is out there (SP interview, various times). However, what matters to Silas is what happens at the population level because a farmer cannot survive on a singular big, beautiful, ear. To Silas though, the ear represents a goal for the population---such an ear is the potential of the population.

To bring a little more rigor to the winner selection process, Silas has devised a formula which he says, "…is a way for me to transmit my knowledge to the farmer..." (Pêgo, interviews). The formula, then, is designed to transform a maize ear into a series of numbers which tells the scientist how good the ear is. This is then fed back to the farmer through a trophy. Because the winning ears are not always the best looking, farmers become curious and begin to think about yield (or so Pêgo hopes). After the Concurso ears are collected and numbered during October, they are brought to the laboratory of the gene bank in Braga (or elsewhere). The following measurements are then taken for each ear: ear weight, total kernel number, row number, ear length. The next step is to take a sample of kernels from the ear for further measurements. This sample consists of kernels from four rows. Kernels from two rows are sent to cold storage. Kernels from the other two rows go on to the next stage. (Only four rows are taken as a sample so the ear continues to look good for the contest, and also so that the farmer can retain seed when the ear is returned to him/her).

The sampled kernels are then counted, weighed, dried, and weighed again. Another formula is used to extrapolate the following: the total humid weight of all the ear kernels, the total dry weight of all the ear kernels and the percentage of humidity of the kernels. Based on this data, the total kernel weight at 15% humidity is determined by yet another formula. The kernel color and type (dent or flint) is also noted. Finally, what is called the valor da espiga (Ear Value) is determined by a master formula, which incorporates all the other formulas (I have put text where there are sub formulas):

VE = (0.6*the total kernel weight at 15% humidity + 0.2*ear length + 0.15*row number + 0.05*total number of kernels) / 4

Thus, the master formula deals with many characteristics of the ear and the kernels combining them with different coefficients so that just one character is not determining the winner. Pêgo says the farmer will …just look to the ear and to the length and kernel number. What Silas is trying to accomplish with the formula is a way to get farmers to select different kinds of ears, not just the long ones with many kernels. He also wanted a way to encourage the expression of fasciation trait by including some measure of the row number. This is where the regional maize will beat the hybrids, he says.

This formula is one way in which Pêgo views the ear and how he determines a good ear which gives the local farmer with traditional maize a chance in competition with the hybrids. I conducted an analysis of the Concurso formula and the winning ears and found that among the regional maize entries, the relative value of the ear is related to the (humid) weight of the ear. This is the weight the farmer can feel in his/her hand. I thought back to my work with Meireles and recalled that he always tosses the ears into the air and lets them land back on his hand when selecting for seed. Later, at the actual seed selection time he will shake the seeds in his hand to listen to the sound. A high pitched tinkling sound, much like metal coins falling on a table, indicates a good seed, good for making the broa he says.

The *Concurso* attracts all kinds of farmers from an elderly woman (in her 60s) who works as a farm laborer to a young man (in his 40s) who is a manager of a local commercial farm. Of course there is Meireles, who rents land and there are others who own small pieces of land and work a full-time job during the week. In effect, the *Concurso* is a self-selected sample of farmers from the surrounding areas. Although the contest is open to anyone in the Sousa Valley, approximately ninety percent of the entrants are within a 10 mile radius of the Cooperative of Paredes. The *Concurso* farmers are unified through their interest in maize, and particularly, their interest in winning something tangible for their efforts.

<u>Enrolment?</u>

Enrolment in an *actor-network* or an actor-world is a matter of both the network builder's skill at attracting human and non-humans into a trajectory that is different than the one they are on. This can be achieved through a variety of means, but ultimately the goals have to converge or slippage and network break-up is inevitable. In terms of the VASO actor-world, the potential for scientific colleagues to learn more about in-situ conservation and the role of plant breeding on-farm in this laudable goal is a relative easy enrolment. The colleagues have little to loose and much to gain from being a part of the VASO actor-world-in-the-making. Given the movement within agricultural science for more sustainable solutions adds to this enrolment. Cracks and crevices can appear, however, if the VASO Project proves to be ineffective, expensive or idiosyncratic. In a word, if more transcriptions do not emerge, more publications and validations from colleagues, then their enrolment is weakened. The VASO Project has lived on for twenty-plus years and has begun to appear in scientific publications. This makes the likelihood that others will join and be enrolled (as an example of globalizing networks, Pêgo mentions to me frequently that farmers in West Africa are growing *Pigarro*).

Farmers in Portugal, however, are difficult to enroll, and the VASO Project has yet to expand in any meaningful way into the farming community in the Sousa Valley. One reason for Pêgo's desire to expand his "kit" into Portuguese Africa, is that he senses the loss of a critical mass of farmers in Portugal necessary to reproduce the VASO actor-world. The selection kit and the recurrent selection methodology are both means to enroll plants and farmers and to embed plant breeding techniques into plants through prescribed bodily practices. People have actually to engage physically in the prescribed practices and grow the actual plant. The *Concurso* provides a glimpse into this glomming through a formula that encodes knowledge, practice and socio-material-spatial relations. These, however, remain only as possibilities because the VASO Project has yet to give way to the VASO actor-world that, if formed, produces a more edible landscape of social relations. In particular, we must look to the relationship between breeder, farmer, miller, baker and crop variety that grants each their identity within this landscape.

CHAPTER FOUR
THE MILLER TELLS HIS TALE

Introduction: The *Broa* Actor-network

This chapter unpacks yet another complex heterogeneous actor-network, known as the traditional maize-rye bread *broa*. *Broa* is the traditional Portuguese bread that has been, until recently, so important in the Northwest that when farmers walk through fields of maize they might still refer to it as *andar no pao*, or walking in bread (Bentley 1992). Centuries following the introduction of maize to NW Portugal soon after 1492, *broa* became a staple food and emerged as the nutritional and symbolic embodiment of rural subsistence and civilized culture. Of all the staple foods in the NW Portugal, it is impossible to over emphasize the importance of broa in the history and culture of the region.

There are many different ways to make a broa, the essential ingredient of which is maize flour (3 parts maize flour, one part rye). As with any food, there are a wide range of opinions on what makes the best broa. Most in the Sousa Valley would agree, however, that a traditional made broa, the kind people ate for centuries, is made with flour derived from local (white) maize varieties and, specifically, flour that has been produced by the ancient water mills (moínhos de água). There are verifiable reasons for this preference, local maize varieties tend to contain more moisture locked inside the kernel by a tough outer coating. This moisture becomes infused in the bread itself, allowing it to remain edible for up to a week. Flour from drier, commercial, maize varieties results in a predictably drier broa.

In addition to using the right kind of maize, a truly traditional and preferred *broa* is always made from the flour of a water mill. Again, this has to do with the drying out of flour as it is processed. Even high-moisture content local maize varieties can be dried and ruined as they pass through the much higher-speed industrial electric mills (moínho electrico). The large milling stones of industrial mills run at a constant high-speed allowing for large quantities of flour. Conversely, the much slower-spinning *millstones* of the water mill gently grind the kernels into a moist, soft, pile of flour. The air inside a small traditional water mill is infused with the smell of ground corn; a rich, oily, farm smell with hints of grass and soil. Inside the industrial mill, there is a burning popcorn smell testifying sensually to the different techniques and the kinds of flour each produces.

So, there are many different ways to put together a *broa*, but the essential point here is that each *broa* contains different processes of production that imply different forms of consumption. Each *broa* constitutes a *landscape of social relations*. Here in this chapter I attempt to trace how effectively, or not, the VASO project has enrolled the landscape of associations that are black-boxed into *broa* into the emerging VASO collective. By disaggregating *broa* into its constituents: that is, taking the ingredients and tracing them back through their socio-spatial relations, I am able to bring to light the social relationships that constitute *broa*. The VASO Project is attempting to insert itself and *Pigarro*, as the only way to bake a *broa*. To do so, however, one has to deal with the associations of which the baker is apart (and from which grant the baker identity and agency).

Retracing actor-networks in black boxes like *broa* is more than an intellectual exercise. In fact, it is only through this work that critical hidden actors can be revealed as their identity is caught up with, and mutually defined in, these associations. Here I focus on the moleiros, (grain millers), or those who transform the maize seeds into flour, and therein transform their importance in the maize collective that VASO seeks to build. I illustrate that VASO had anticipated the importance of *broa* only as s disembodied commodity, a black box, in relation to the emerging network. This notion of *broa* as mere commodity is too simplistic, not reflecting the reality of bread-as-social-relations. Thus, the VASO project overlooks the grain miller as an entity worth enrolling. This casts serious doubt on VASO's success.

In relation to the importance of the invisible miller to VASO collective, I also discuss the *padeiro*, (baker) who turns flour into *broa*, and consequently is viewed as a critical player (by insiders) in the VASO collective. However, whereas VASO correctly identifies the traditional oriented baker as a key actor, what is far more critical to understand, I suggest, is the *relationship* between the baker and other entities, particularly the miller' and the *broa*. Since VASO has failed to see (translate or enroll) the miller at all, the project has also failed to tap the important relationship that actually produces a *broa* and that links farmers to bakers. In short, all the paths constructed for maize to travel in the VASO collective from seed to bread must pass through the miller. The lesson is clear: without the miller there can be no *broa*; and without *broa* there can be no VASO. My central point here is that where the VASO visualizes a *product* (*broa*), it must now see a *relationship*.

Lastly, in the conclusion to this chapter I re-present the *broa*-actor-network as a truly embodied landscape of associations. By consuming *broa*, people of the NW Portugal, or anywhere, consume the VASO collective and all the spaces, places and relationships that it comprises. In this way, the VASO collective is a landscape that is metabolized in human bodies and thus the connection between landscapes and edibility is made. Since metabolism implies reproduction (the body is nourished and is able to produce and reproduce) the VASO actor-world is reproduced through the bodies of *broa*-eaters, and an edible landscape emerges.

The chapter is organized into four main sections. First, I present a picture of the horizontal water mill, or *moinho de água* that predominates in the Sousa Valley. I outline general typology of sample water mills found in a survey of Sousa Valley, along with a discussion of mill structures, mill mechanics and the milling landscape, or relation of structures to surrounding physical and social landscapes of production and consumption that exists in the study area of the Sousa Valley. The mill typology is a reflection of how the mill functions in the context of surrounding landscapes of association. A key observation here is that mill structures alone do not make a milling landscape. Rather, a milling landscape, one key component of the edible landscape, requires the work and livelihood of a miller to embody the milling landscape through physical work and skill and thereby connect mill structures and mill mechanics to people's stomachs.

The second section takes a closer look at the life and work of select millers in the Sousa Valley area, and grinding a landscape. Each miller occupies a unique position in the continuum of traditional-artisan to commercial-industrial. The stories of particular people and their mills reveal how millers grind a landscape of association that extends into farms, bakeries and restaurants. The milling profession, always in a unique position in the rural world, is well positioned to take advantage of the longing for traditions and cultural continuity that accompanies modernization and mechanization. Water milling is the only way to transform seeds like *Pigarro* into the kind of *broa* VASO hopes for, and it is the only way for *broa*-eaters to consume the edible landscape.

The third main section concentrates on bakers, and baking a landscape. Different bakers each reveal unique actor-networks in their own right. I distinguish here two types of *broa*, the *broa* de Avintes (*broa* from *Freguesia* of Avintes) and the more common *broa* found in the Sousa Valley. Baking is essential to the forming VASO collective in that bakers and millers co-define one another in the *broa* actor-network that must be mobilized. This is so not only in a metaphorical / theoretical sense, but in a practical one as well. Bakers pay millers for flour, and therefore play a role in the price for both flour and seeds in that the price millers pay to farmers like Meireles for seed is dependent on the price bakers pay for a sack of flour. In between the price of flour and the price of seed is the miller's profit.

Lastly, the conclusion recapitulates the *broa*-as-actor-network and the consumption of it as eating the landscape. *Broa* constitutes congealed social relations between humans and non-humans spread over a landscape of production and consumption. *Broa* is the sum total of the cumulative links between humans and non-humans as they transform the seed into flour, and eventually into bread (Figure 15).

Figure 15: Sousa Valley *broa* loaves assembled for a competition, photo by author

Silas Pêgo must find space in these relations, and VASO must translate the entities into a collective that includes them. The pre-cooked dough is a glob of social relations and implied landscapes: baking the dough fuses these relations into an edible form. Grain milling is of tremendous historical, cultural, economic and environmental significance in northwest Portugal. The miller as an important if not dubious character looms large in historical accounts not only in Portugal but also hroughout Europe. Geographical place-names using *moinho* or *moinho de agua* abound in northwest

Portugal. Places such as valley of mills, place of mills, or avenue of mills are ubiquitous. Although grain milling is critical to the food history as well as the current politics of food regional food in Portugal, there is very little research on this important process.

The Horizontal Water Mill

There are local histories of the traditional water mill in the Sousa Valley, but these are more concerned with their structure and distribution rather than how they function to tie different actors together in the overall food landscape. Indeed, there is no research that I know of that links the process of milling grains to the consumption of food and what this link means for sustainability in the Valley.

Reflecting what Hilary Tovey refers to as the curious division of labor between scholars who study food production and those who are concerned with its consumption, I too did not set out in this research to study or even consider mills and millers. Yet, it was in doing this research that millers became important, I would argue critical to both thinking about the VASO Project and identifying where the project may have some additional work to do to achieve its goals of sustainability (or what I have called the construction of an edible landscape).

My first contact with traditional water millers had little to do with my ethnographic interest in the either millers or mills. In the beginning of this research one of my concerns was to gain a better on-the-ground sense of the maize varieties present in the Sousa Valley and what the local names of these varieties are, how this represents the diversity of maize in the Valley and what people and farmers thought of their local varieties. Previous research on seed networks and seed exchange among local people in other parts of the world revealed that seeds pass through many hands and traverse much ground over time as they are exchanged between farmers and between communities. The gist of this research is that seeds move through their own social landscape through these exchanges, and that the best way to find out who is growing what is to follow the seed, so to speak. Following seed is not as easy as it sounds, and there is a lot of cross checking and back-tracking, but when finally done a network begins to emerge (presented in chapter one).

Finding mills

One of the key socio-spatial nodes of the Sousa Valley maize network is the mill. Discovering more about these mills and how they function in the VASO Project (or at least should function) required more off-farm work and more thinking about consumption, in particular the almost liminal phase of transformation from production to consumption. As many have pointed out, humans in Europe generally do not eat the maize kernel, rather it has to be transformed by culture in order to be edible. In the case of maize, one step of this transformation is milling.

A concerted survey of water mills, or *moinhos de agua*, was carried out in the Sousa Valley in the summer of 2001. Mills were located through a combination of techniques including interviews with farmers and bakers, opportunistic sampling of rivers and farms located along rivers. The topographic map of Sousa Valley revealed a plethora of milling-related place names. Following a general survey of 55 existing mill structures, a typology of functioning and non-functioning (abandoned) mills was developed to organize data analysis and future data collection on use of the mills. This typology was important to build my understanding of all types of mills found in the Valley, which made interviews with mill personnel more informative. These points were further elaborated in conjunction with more focused surveys that included interviews with a total of 10 full-time millers, or moleiros, and a number of other peripheral persons associated with the mill (workers, family members). Interviews focused on grain seed types and processing techniques, perceptions of social and agricultural change in the Sousa Valley, mill ownership and family history, and the clientele of the mill (discussed below in millers section).

In the Sousa Valley, and surrounding areas surveyed, by far the most commonly occurring mill in the landscape is the horizontal water mill also called the Norse Greek or clack mill due to the noise of an appendage that drags along the runner stone and shakes kernels loose from the hopper. These mills are believed to be among the oldest and simplest mechanical mills ever found, and they are distributed throughout the world from Nepal to Norway. Horizontal-type water mills in the Sousa Valley are typically small one-room stone buildings with a pitched tile roof (Figure 16).

Figure 16: A restored water mill, Sousa Valley, photo by author

The mills are always situated immediately adjacent to, or in close proximity to, weirs constructed to hold back enough water to operate the mill. Unless the mill itself juts out over an existing large stream or river, long stone millraces are built, maintained and cleaned regularly to direct water flow to the mill's water wheel located beneath the structure. As structures, mills are solidly constructed and secure with only one entrance and a single small window both of which can be tightly closed and locked to keep out moisture, rodents and (human) thieves. Worn footpaths and narrow dirt or stone roads (sometimes with deep wheel ruts for ox-carts) connect small mills with each other and with surrounding agricultural fields. Most of the mills in fact are located immediately adjacent to grain fields, making the trip from field to mill a short of one as possible.

Water mills are usually solitary structures in the farming landscape located along streams running through fields of maize. In the summer, these isolated mills are nestled deep in fields of tall maize plants and are barely visible. However, there are urban water mills, those located in or near densely populated neighborhoods or lugars, that can double as the miller's main residence (the upper floors) or the mill can be located a few meters from a separate residence. Regardless of their location, mills are always hubs of activity at the center of a network of footpaths, roads, weirs, millraces, streams and rivers. There is a certain social radius around each mill that makes it possible to locate them by simply asking local people, Where could I find the miller? (The practice of local water milling was still prevalent enough at the time of this research that one can get an answer to such a question.) Since mills are located along streams they are usually situated in low-lying and difficult areas to access easily. One may have to traverse steep, slippery, rocky, footpaths down to the millhouse(s). In times past, millers would use animal traction, horses either weighted down with bags or pulling loaded carts. Today, the small-sized flat-bed truck servers the purpose well.

Water mill mechanics

The horizontal water mill functions by the power of a focused stream of water delivered to a rotating horizontally aligned water wheel designed to capture the water with radiating paddles with cupped ends. There are many variations of these water wheels in Portugal, called *rodizios*, ranging from wood to metal. A single water wheel is fastened to sturdy spindle made of wood or metal that is in turn connected to a strait shaft that projects up through the floor of the mill house and is connected to the running stone or mó, the rotating member of a pair of milling stones. When asked about the quantity of mills a miller operates, the miller responds in numbers of *mós* (or the number of runner stones).

The *mó* sets on the stationary foot stone, or *pé*, which is nestled in a wooden cradle. The running stone is affixed to the rotating spindle by a forged eyelet piece that inserts into an eyelet notch on the underside of the running stone. Radial grooves that act like teeth are carved into the underside of runner stones. The grooves allow tufts of flour to be spewed out from between the millstones. Running stones bear the most wear and tear of milling, and they require constant repair, or dressing, of the grooves. Millers related that they would dress millstones if an expert stone carver could not be found. Millstone supply is something of a trade secret among millers, with most millers saying that quality stones were at one time plentiful from local quarries but are less available now in the NW. One miller stated that his stones come from a supplier in Italy.

The entire weight of the water wheel, spindle and runner stone, rests upon a small stone pivot piece embedded in the tip of the spindle that at the water wheel radial arm under water. The radial arm is connected to a small pedal on the millhouse floor. Millers can raise and lower the runner stone to change the consistency of ground flour by slightly tapping on the pedal. Millers all delighted in showing me how easy this process is, considering the heavy weight of runner stone and the whole spindle – wheel mechanism.

Generally, two types of product are produced by the water mills, flour for bread, *farinha*, and rough-ground grist, or *farelo*, used for animal feed (chicken, hog, bovine).

Maize grain to maize flour

The process of moving from seed to flour is complicated and involves multiple social actors (human and non) as well as landscapes of farming. Ideally, flour for bread is produced exclusively from the flint type of white maize, such as *Pigarro*, and rye. Yellow-dent maize is always used exclusively for animal feed grist, and is often being used now for bread flour as well. Mixing yellow and white-flint maize with inferior white-dent seeds together can stretch the supply of the much scarcer and preferred white-flint maize supply for bread flour. This mixing of seeds is controversial and topic of complaints from *broa*-eaters and bakers.

A small water mill can run continuously through the day and night if the mill has a continuous water supply. Millers may choose to lock up the mill house at night and let the stones grind away at a full hopper until early the next morning. A small mill consisting of one roda (the term for both foot and runner stone) is capable of producing 200 kg in a full day. Demand for flour begins to peak in the winter months (Coelho, miller, 2001). The most popular product out of mills is the yellow grist for animal feed (Pica no chao). Grist is sought out even at the individual level if a particular farmer is known to have his/her own electric mill (as does Meireles). These individual mills can become a side business for maize farmers, and neighbors will buy grist as their own supply gets low.

Full-time millers differ in the degree of their commercialization and extent of their client networks. Whereas all millers interviewed produce both *farinha* and *farelo* (flour and grist), traditional water-millers might specialize in either of the two, and may switch if the seasonal demand changes. Commercial-industrial millers tend to specialize in electric-mill grist production, and they may use any water mills for bread flour. Water mills, as one miller pointed out, have the advantage of not using expensive electricity.

Mill houses are extraordinary sensory places, something all the millers interviewed commented upon. As the stones grind, the small structure becomes filled with maize dust that slowly covers everything around and exuding a rich, savory, dry odor of maize. Millers frequently become covered with the dust that settles in the hair and eyebrows and clings to any article of clothing. The millers' face looks as if it has been rolled in flour. Spider webs covered with the dust hang from the ceiling like thin white garlands spanning the open ceiling joists. A small exposed light bulb dangling from a chord, or an open window, is all the light that is available in most mill houses.

The sounds of millhouses are equally interesting. The rushing water underneath the mill's wood floorboards strike a mesmerizing chord with the slow, steady, scraping sound of the stones and the wooden toggle that bounces to a clackety-clackety rhythm on the surface of the runner (upper) stone. The faint, cling, cling of individual seeds falling into the runner eye can be heard as well on their way to being pulverized. The floors of mills are constantly swept clean giving them a smooth, polished appearance. It is natural reaction to want to take off one's shoes to avoid contaminating piles of flour slowly accumulating beneath the stones. Chiera bom! (smells good) millers will exclaim about the wafting dust of maize flour.

The miller's tool-kit is strikingly simple. In addition to having to be part-time mechanics expert, carpenter, stone cutter and river water expert, the miller needs few implements. There might be rudimentary repair tools, chisels, wooden hammers and saws carefully stored in the little mill-house buildings. The most important pieces of equipment are sifters, scales and bag sealers. In NW Portugal, the most important unit of measure is the kilogram (kg), and the miller's economic life is measured out in 50 kg bags of flour at a time. After being ground to the desired particle size, sifted and cleaned, the flour is bagged up into 50 kg paper sacks with the miller's logo or other type of identifier (usually the particle size) and the heavy bags are hoisted onto a nearby cart.

Millers themselves are complex entities that occupy a commanding position in the local, preexisting, actor-networks of production and consumption relationships in the Sousa Valley. Essentially, millers act as a kind of supply/demand bottleneck for seed flows throughout the valley. Generally, farmers will take their seeds to the miller for cash, flour or a combination of the two. A few millers still practiced the maquia or barter in flour. Millers then sell the flour to individuals, bakeries, stores, or anyone wishing to buy their ground product. The profit for millers is obtained from difference in the price of flour the price the miller pays for seeds. The miller has to consider his/her time, the upkeep of the mill (stones, water wheels, spindles, cleaning mill races and sluices), and the price that bakers and others will pay for the flour. There is little wiggle room as the price per kilogram differs only by a few escudos (the Portuguese penny). Hence, the miller has achieved a reputation, as in Chaucer, of being shifty and underhanded (the miller is said to have a heavy thumb on the scale). The price millers set for seeds has a tremendous impact on what farmers will grow.

During the time of my research (1999-2002), millers were paying the same price for all seeds yellow or white, traditional flint, or hybrid dents. Every miller had grown his/her own seed supply as well, and some have stopped the practice whereas others have expanded. Whether self produced, or purchased from farmers or other sources, millers were effectively not including a measure for quality, in the sense of the VASO project, in their pricing.

Likewise, bakers interviewed for this research were not differentiating between flour produced from cheaper imported hybrid seeds or local farmers' varieties. All the millers and bakers interviewed emphatically professed preferring the old *broa* made from traditional maize and rye varieties. However, each gave different answers for why they are effectively undercutting quality in the supply chain by paying the same, low, price for all maize seeds and maize flour. There is less and less supply for the local varieties because there are less and less farmers. The farmers' varieties are tough and hard to grind. Bakers will not pay us more for the local maize flour. Farmers complain that their yield of traditional varieties, and hence their intake at the miller, is too low, and that local varieties of maize take too long to mature.

The milling landscape is the cumulative set of social relations of production (seeds) and consumption (flour) and the physical properties (river diversions, millhouses, sluices, millraces) emanating from the milling *practice* (Powell 2002:86). In a real sense, the miller is a conduit for the realization of a *broa*-landscape, the character of which tilts in favor of what prices the miller is able to set for seeds and flour. The VASO project has considered farmers' complaints and baker's desires for better flour (they might agree to pay more for flour if they can charge more for their bread). To the peril of the emerging

VASO collective, however, the miller and the milling landscapes of association have thus far escaped notice. For a VASO collective to take shape, the millers have to be enrolled.

Millers and Their Tales

A total of five active millers were interviewed after a general survey of operating mills in the region. These five millers were selected in part because they were willing to share the many visits to their mills required and the time for interviews. Each miller was selected as representative of the general types of mills to be found in the Valley. Within the general categories of functioning and non-functioning or abandoned grain mills in the Sousa Valley, a continuum of functioning mills was constructed that ranges from the traditional-artisan to commercial-industrial depending on the extent of time devoted to milling and the extent of clientele networks. In truth, there is no pure traditional artisan-miller as the categories of traditional and commercial are not always mutually exclusive even with the same person. One industrial mill surveyed, for example, uses a series of water mills connected by millraces along with large electric powered mills to produce all types of flour. Among the functional water mills there are three recognizable types: artisanal professional, industrial water and electric powered, and informal – tourist mills.

Artisanal professional millers

All of the millers in this category are professional full-time millers, and have been for their adult lives. The millers in this group come from a long line of millers in the family, usually (not always) passed down through males, *pai, avó, e bisavós* (father, grandfather, and great grandfather). Millers with sons all claimed to be teaching their sons the milling trade. Women play a vital role in the milling business, and wives and daughters assisted in most of the mill activities I observed. Millers commented that there are moleiras and that this did not seem strange or particularly odd. Typical clients for these millers are lavradores (farmer-owners), and padarias (bakeries). Lojas or small all-purpose shops were also customers for the farelo. One miller in this group ran his own restaurant and bakery in a compound that incorporated the mill. All of the millers in this group owned their mills and adjacent fields. The practice of barter, or maquia, (trading flour for seeds) is still practiced among millers in this group.

Sr. Coelho and family:

Senhor João Coelho was the first practicing miller I encountered serendipitously in the summer of 2001 after a full year of fieldwork on farms and studying farming practices. During a drive into the nearby countryside just outside the city of Paredes I noticed several maize fields growing along the banks of the Sousa River. My interest was in learning more about the maize in the fields, and interviewing another farmer. In addition to being a farmer, Sr. Coelho turned out to be a full-time miller, and this prompted me to think much more about the milling profession. I met Senhora Coelho at the gates of their small farm and I enquired about their maize and asked if I could talk with her. Mrs. Coelho invited me to talk with her husband, and she motioned to open the gates and follow her down a rocky footpath toward the gently flowing Sousa River.

Passing by a flatbed truck and an old oxcart we came upon a series of small stone buildings that appeared to be little more than piles of rocks with a roof. We stepped over narrow canals of rushing water that disappeared beneath the structures. Together, Sra. Coelho and I entered the dark stone buildings where Sr. Coelho, covered in maize dust, was transferring mounds of white flour into a mechanical sifter. There was a lot of noise: rushing water, clicking and clacking of the sifter, grinding stones whirring. I had never seen a scene like this and nothing I had read or seen previously prepared me for it. Immediately this added a new dimension to my research and I had the sinking feeling that after a year's work I missed something very critical. After this chance encounter, I could no longer exclude consumption from my understanding of sustainability and the VASO project.

Sr. Coelho works closely with his wife, both in their 50's, and his son and daughter-in-law running the mill. Watching the Coelhos work is like watching a carefully orchestrated duo that is perfectly timed. Without a word spoken, each completes the many steps necessary to transform maize seeds into flour. First, the sluices must be opened so that water can pass over the penas or cup-shaped blades of the water wheel. Sr. Coelho works eight mós, (millstones) four of which are lined up side by side in a large barn-type structure along the Sousa River. The other four mós are located in the little stone buildings, a set of grinding stones to each building.

Coelho lets his mills run all through the night, and he collects the milled flour early in the morning before making his deliveries to his clients. Coelho deals mostly with bakeries and he specializes in bread flour and produces farelo on the side for himself and local people. The Coelhos rent land and the smaller mills as their business has expanded over the years in this location. There are plans to take over several other abandoned nearby mills. This milling enterprise thus includes a complex of buildings perched on a small cliff of stone cut through by the powerful Sousa River. Mr. Coelho warns of the danger of flooding in being located so close to such a river. This sentiment, a concern for catastrophic flooding, was echoed in all the millers' comments. Some of the smaller mills are designed to withstand the periodic floods.

The Coelhos grow their own maize seed supply and they import white maize kernels and rye from France stored in large bags stacked in a storeroom. Overlooking the mills and the water below Coelho's son and daughter-in-law were constructing a new house. The daughter-in-law knew the basics of operating the mills and she developed an automated sifting mechanism that uses the water power to move the sifter back and forth. One of the sons intends to take over the business when Mr. Coelho decides to retire.

It is hard to imagine the hard working, enterprising Coelho ever retiring. He is in continual movement as we talk, and I follow him through his tasks. He stops and notes in a raspy voice (likely from breathing maize dust), a farinha e mais fina com o mó de água (flour is of finer quality with water mills). He smiles at this comment and seems to savor the taste of imaginary bread made with his flour.

As Mr. Coelho hoists 50 kg sacks of flour onto his shoulder and carries them uphill to the waiting truck, Mrs. Coelho continues sifting, filling and weighing the bags. When the piles of soft flour on the millhouse floor are gone, Coelho drives the truck up to the house where his wife, having already closed the mill behind her, is waiting up the hill with the bag sealer and their professional seal displaying the Coelho name and the bag's contents: flour for bread making. The Coelho family is an example of a hybrid between cultural tradition and contemporary enterprise that consumes the family and combines artisan technology with commercial output. The Coelhos are contributing to the persistence of a milling landscape that is easy to overlook if one is not careful.

The Coelho family represents a specialized intense family actor-networks only touched upon here. For this research, the family milling operation illustrates teamwork, connection to landscape, small enterprise, cultural survival and continuity of an ancient profession in the Sousa Valley.

Once I had decided to explore millers and their role in agriculture in the Sousa Valley, it seemed as though water mills and millers started to emerge everywhere I had previously been, but did not notice. One such person is Sr. Pacheco, miller of the San José community in the frequesia of Castelões de Cepeda located near the city of Paredes. As with Sr. Coelho, Pacheco's mill was located alongside the Sousa River. This millhouse stands out as unique being located in a suburban neighborhood and being the only mill surveyed that also doubles as the miller's residence. Pacheco, in his early 70s, is now retired from milling due to heart surgery from the previous year. The spry, quick-witted, Pacheco wears a constant smile and has an unmistakable glimmer in his eyes. He insists that we discuss his milling operation over glasses of his own *vinho verde* (*espedal* variety) and his smoked *presunto* and *salpicão* (a kind of port-wine marinated smoked pork sausage).

"I cannot do this anymore…I have five daughters, one is a seamstress, and they will not continue, younger people do want to do this job" (Sr. Pacheco). Mr. Pacheco talked to me about the quality of life as a miller, he enjoyed getting to know his clients and he remained their miller for decades. Later, we met bakers in town that verified this. Pacheco explained the function of the mill, and how he had to do a lot of work to keep it running, including cleaning the millraces cleaned, fixing the wooden water wheel, and keeping the spindle strait (energy is lost if the spindle is not straight). As to be expected, Pacheco expressed a love of history and how millers fit into this history, particularly gastronomic.

Typical of millers in the Valley, Pacheco's spouse helped in every way in the running of the mill in the past, Pacheco grew his own maize in nearby fields (the mill is surrounded by residences that were once maize fields) and he is related to many of the surrounding people. Today, Pacheco has converted his maize storehouse to a wine making and storage facility where bottles of *vinho verde* are kept cold. Pacheco still maintains grape trellises and harvests his own grapes for personal use. There is no doubt that Pacheco realizes the importance of eating, and that his occupation figured prominently in that importance.

The Pacheco interviews and visits were important as he illustrates a late stage miller in contrast to the younger Coelho operation mentioned above. These two millers, who live very close to one another but professed not to know each other, provide an interesting window into what happens in the late and middle stages of milling occupation, and how the family life-cycle, inheritance, ownership and business operates. In the case of Coelho, he is expanding operations by diverting more water and restoring more mills involving one son and his resident spouse in the operation of the business, and increasing his capital investments.

Pacheco, having only daughters, and daughters not interested in milling for a living, has transferred his business to another nearby miller Sr. Moreira (described below). Ownership of the mill, however, will transfer to the eldest daughter, but only in structural form and not functional form. Pacheco gave the impression of being a shrewd business person, similar to all the professional millers, and he relished in relating tales of how much maize flour he would produce and the money he would make from it: the bag (pointing to maize seeds) gives 20 (*escudos*), this bag (pointing to a sack of flour) brings 50!

All Pacheco's clients, bakeries, *lojas*, *padarias*, and individuals, will be transferred to Sr. Moreira, down the Sousa River in a neighboring community. In a sense, Pacheco's four *rodas*, (four sets of grinding stones), sit idle in his house, but the *practice* of milling will continue. I invited Pacheco to join me in a visit / interview with his protégé, Sr. Moreira (I had learned from experience with farmers that bringing a locally known farmer along for initial contact is the best way to interview farmers).

Another miller, Mr. Moreira's milling operation, also on the Sousa River, is located midway between Coelho and Pacheco. The mill, a small stone structure adjacent to the Sousa River, consists of three *rodas* (three sets of milling stones) and a small storage area. Three sets of milling stones is common among millers because it allows maize-*farinha*, maize-*farelo*, and rye-*farinha* to be milled simultaneously and without having to adjust the stones constantly. More than with any of the other mills, the coexistence of modernity and the ancient practice of milling stood in stark relief at this location. The drone of speeding automobiles of the newly constructed A4 highway can be heard, and seen, just across the river from the mill. To approach the mill one has to carefully descend a steep driveway that dips sharply down to the river just behind the modern suburban residence of the miller and his family.

Mr. Moreira and his spouse were in their mid 40s during the time of my research. Again, the spousal teamwork mirrored the Coelho family as both husband and wife seamlessly carried out their chores in the mill (sweeping, transferring 50kg bags of flour and maize kernels, sifting, weighing, and loading into the truck or storehouse.) The extent to which couples carried out their demanding physical work, almost without words, mirrors exactly what transpires on most farms in the Valley: the labor is divided because it is too much for any one person to accomplish alone at a profitable level.

Mr. Moreira has been a miller his entire working life, as was his father. Moreira's grandfather had purchased the mill property, but was not a miller. As with Pacheco, Moreira had only daughters, neither of which would become a miller (it is important to remember that millers all expressed that a woman could, indeed, become a miller, but that the cultural preference was for males). One of Moreira's daughters owned a nearby café in the city of Penafiel (cafes are not generally customers of millers).

Moreira's business consisted of fifteen bakeries located in the Sousa Valley. His for rodas produced an average of nine hundred kg of flour per day (packaged into 50kg sacks with his name and logo). As with all the millers, Moreira relished in telling the history of the river and the craft of milling, explaining the details of how yellow and white maize yield different products and how maize and rye are sold in different particle sizes (135 size sifter for rye and 175 for maize flour). I learned from Moreira that stones for milling were becoming increasing rare and expensive and that local suppliers are disappearing. The two millers, Pacheco and Moreira, took the opportunity of our interview and visit to chat about customers and politics in the Valley. Topics at the top of their complaint list were the responsibility for cleaning the river (trash accumulates in the water wheel) and the Parish's plans for decreasing the river water flow (dams). Other millers would reiterate the water-flow problem.

Sr. Alves is known in the Sousa Valley as The *Moleiro,* which is the name of his combined restaurant, mill, bakery and *espaco de lazer*, (place to pass time). Certainly the most enterprising of the the millers interviewed, Sr. Alves combined just about every actor-network in one place: with his family he grew and purchased maize for milling, he ran a successful restaurant, bakery and wine cellar. The restaurant specializes in *broa*, *presunto*, and *salpicao*.

Sr. Alves had been a miller for all of his adult working life, and he derives from a long line of millers. Would his two sons, who now run the 30-year old restaurant, take over the mill I asked. The watermill is what brings the customers, he responded. Apparently, an annual ritual of fishing by the mill with friends, and supplying them with a meal, evolved into the restaurant where now people come from as far as Porto (an hour drive) on weekends to sit by the river, drink wine, and eat fresh *broa* (maize bread) with their sumptuous meal. Aware that milling and watermills are something unique, the restaurant and surrounding area is filled with milling artifacts like used mill stones for seats, photographs of the mill, and milling jokes. The miller is keen to point out high water marks from floods in years past (the year of fieldwork, 2000, was a year of severe flooding in the Valley).

In addition to baked *broa*, wine and other food, Alves specializes still in flour and animal feed which remain his mainstay, selling 300 – 400 kg of flour per day. Dressed in special miller clogs designed to easily slip on and off, and that keep his feet warm, the miller gave me a tour of the mill and some insight into the trade. Interviews with Alves, the Miller revealed the importance of millers in the local networks of seeds and landscapes of association through which the maize travels and transforms into *broa*.

Alves explained that he now pays the same price for all seeds, regardless of color or eventual use. Asked about local maize varieties known to be best to make *broa*, Alves explained, "There no more farmers around, so there is less of the milhos regionais (regional maize)." The farmers who are left are old, and they can't afford to grow the regional maize because the production is so low and they (regional maize) require so much work. The new seeds produce more, he explained, and they require less work.

Alves procures seeds from his own fields, from fields he rents to farmers, and from seeds he buys from neighbors, seed salesmen. Lojas, the small stores, and local caseiros (tenant farmers) buy the farelo (grist) for fattening their pigs. With the caseiros, Alves still practices the maquia, or grinding the farmer's maize into grist and keeping a share for the mill. For cash-poor farmers this is an equitable method, but Alves notes that farmers always feel cheated (he laughs).

There is a growing market in smoked pork meat locally and in the nearby cities. Farmers like Meireles can make more money of a good smoked pig than just about any other farm product. A good reputation of delicious pork can translate into high profits for farmers equipped to smoke the large animals over months. Everyone in Portugal who would seek out such a whole-smoked pig knows that pigs fattened with good maize feed are the most delicious.

Another market for the yellow grist is for chicken feed. In small bags of 5kg, the chicken feed is sold to local lojas, or country stores. Many households in the Sousa Valley maintain chickens as a source for fresh eggs and for soups. Farmers and local people prefer freshly slaughtered chickens fattened with maize-feed. I have seen white and yellow maize used as chicken feed. Finally, the roughly ground grist is also used as a supplement to cattle feed. Highly nutritious for the cattle, it is believed that maize-feed transfers good taste and eating qualities to the meat.

I asked Mr. Alves to explain the advantages of a water mill in producing grain, as opposed to an electric mill. He explained that with the electric mills, one can produce higher quantities, year around. And, he continued, every miller now has an electric mill to augment production in the busy times and to grind grain in the summer months when the rivers are low. However, the electric mills cost, of course! The water is free, no?!

A key quality distinction, according to Alves (and other millers) is that electric mills run faster making the resulting flour dry. "*Com o electrico, a farinha esquece…com as moinhos (de agua) a farinha nao tao seco…mais saborosa, nao é*?" (With the electric mills, the flour is dried, whereas with the watermill the flour has much more flavor). Mr. Alves, along with all the other full-time millers interviewed, explained how a miller also needs carpentry skills to work on the rodizio or water wheel. Alves also voiced concern over disappearing sources for millstones.

I learned several lessons from Mr. Alves. First, he, like other millers, has incorporated his family and his residence into the business of milling. This melding of family labor and cultural practice allows for apprenticeship and continuity in the profession. Also, The Miller fuses gastronomy, landscape, traditional farming and practices and economic sustainability. Sr. Alves made clear to me that millers occupy a critical node in the local, preexisting, networks and landscapes of association.

For bread, everyone agrees that the local farmers varieties are the best (he particularly mentioned the HB varieties, old hybrids from Portugal's maize breeding days decades ago). However, by paying the same price for farmers' varieties and the imported seeds, the miller is undercutting the incentive to grow local varieties. He does this also by mixing seeds of the same color but of different maize varieties. There seem to be no distinction made at the mill regarding quality of flour based on seeds. Quality was seen to differ in the method of milling: the fast electric mill that dries out the flour, thereby making the resulting dough less moist and faster to stale; or, the slow, steady, watermill grinding that produces higher quality flour.

The viability of small-scale traditional farmers and the landscapes of association they produce are located in the small space of the price differential between what the miller will pay for seeds, and what he will sell as flour. Alves reinforced that networks of association merge and blend together at the mill, and that in the act of eating one reproduces these networks: farmers produce seeds, seeds are transformed into flour for the *broa* and flour for the animals that are later consumed. Fewer farmers growing local varieties, and lower prices at the mill, means less of these varieties make their way into edible products that imply landscapes of farming, milling, baking and eating. The Moleiro restaurant serves much more than food; it offers the opportunity to consume an edible landscape.

Industrial water and electric powered mills

The millers previously discussed can be differentiated from industrial scale milling operations that produce thousands of kilograms of flour in a day. Two of these mills were visited for interviews and observations. One operation incorporates watermills and local farmers, and the other has stopped water mill use and is exclusively electrified.

The Rocha milling factory is located on the Ferreira River in *Penhas Altas*, *Freguesia* of Lordelo in the Paredes Concelho. *Penhas Altas* is Portuguese for high cliffs, a place-name that aptly describes the setting for the Rocha Mills. A series of water mill houses parallel the descending river that falls sharply down into a steep, stony crevasse. The water mills are powered by a series of stone millraces (water channels) that capture the river just before it takes a plunge into a dramatic waterfall. Redirected, the water flows rapidly down hill underneath the millhouses to eventually rejoin the river below. It is an ancient landscape complete with Roman bridges of stone and worn paths. Millraces traverse the steep hillsides feeding many abandoned stone millhouses that lack roofs and are caving in on themselves. The river rushes rapidly through this little valley and all the paths are wet and slippery. The hillsides are green with fig trees and small terraced plots with the requisite cabbage plants and, something different for the Sousa Valley, sheep. There are abandoned houses and vagrants in the area, and locals claim it is dangerous to walk the narrow, steep paths, at night.

The Rocha Milling factory maintains 18 *rodas* (sets millstones) dispersed in 8 millhouses. The largest millhouse contains 4 *rodas* and the other 7 each contain two *rodas*. The Roca Mill also maintains three large, industrial size, electric mills and sifters in a large warehouse where stacks of imported maize seeds sit ready for milling. The Rocha family owns and operates the business and it employs several four part-time workers to clean the mills and bag the flour.

The Rocha mills have divided up the milling roughly into two separate processes: the water mills produce white bread flour and rye flour, the electric mill processes the yellow maize farelo. Several visits to the mill operation verified this. Although the Rochas would buy maize from farmers occasionally, the main supply for their mill is imported maize from the Americas. Local grain, both rye and maize, are also purchased from sources far to the North in the Minho.

In addition to purchasing large quantities of imported seed, these mills are distinguished from previously mentioned mills in the wide network of clients that include bakeries and small lojas 40-plus kilometers away. The operation of the mills requires much higher capital investment in hired labor, machinery, transportation and communication than the traditional-professional millers discussed previously. The Rocha mills also require upkeep and repair, something which the owners feel the Concelho should assist if it is interested in rural tourism and helping local businesses. Because mills are subject to periodic inundation, repair costs can be devastating to small mill operations. Another key point brought out by the Rocha milling operation is the impact of dams upstream that reduce water flow to the mills. This concern, as well as the responsibility of the government to help keep rivers clean of debris, was echoed in several other millers interviewed.

One industrial mill, *Rocha e Sousa, Ltd*, outside the Sousa Valley was visited in order to gain perspective on what a completely electrified industrialized mill operation would look like and what issues might arise in terms of networks, nodes and landscapes of association.

The Rocha e Silva mill operation is fully mechanized and industrial. The millstones used are larger than a small automobile, tall silos store seed and flour the output of which can reach 1,000 tons per day. Both bread flour and animal feed is produced and bagged at the mill. This mill is operated by a family that formerly operated a large watermill nearby. The watermills gave way to the electrified mills in the 1970s. The Rocha e Silva mills purchase seed from the world market and their clients include large industrial baking companies that require a steady, large, supply of flour such as the chains of cafes and restaurants that offer baked goods. The nearly insatiable demand for baked goods in the northwest region provides a brisk market for industrial and artisan professional millers alike. As buyers of seed, large mills like Rocha e Silva can influence the price millers can get for grain.

When asked about using local varieties of maize, the kind of milhos regionais, being experimented with in the VASO project, the Rocha e Silva millers provided an interesting response. The regional maize makes a better *broa*, they agreed. However, regional maize is *muito duro* (or very tough, durable) and is difficult to grind and gives much less flour, *da menos dos híbridos*. Consequently, the local maize requires more work and repair of the stones and equipment for all for less final product. In addition, the millers pointed out, bakeries do not pay more for the local maize flour. Why, then, should we (millers) pay more for local maize? This is a question VASO has yet to answer.

Informal and tourist mills

Amid the full-time professional millers and the industrial mills is a network of informal millers who restore and operate watermills for personal reasons, have old abandoned mills on their property, maintain a mill primarily for their own use, and/or have converted mills into a recreational use. Most farmers today have their own electric mill that is used for household purposes and limited sale to neighbors and friends. The arrival of electricity to many areas in the 1970s certainly provided an impetus for decentralizing the milling profession (Meireles passim).

The best example of an informal miller is Sr. Jaime, who has painstakingly restored his water mill just down the river Ferreira from the Rocah mills described above. Sr. Jaime was a young man in his 30s at the time of fieldwork, and he was a full-time factory worker. Jaime’s father had been a miller before turning to factory work, a fact that motivated Jaime to restore the mill. On weekends Jaime would grind the maize and rye flour and bake a loaf or two of *broa* which he would sell or give away to friends and family.

Jaime explained in great detail the workings of the mill, the types of stones used, and how to operate the mill. Through Jaime, I was able to learn basic mill vocabulary and operation techniques that I could then ask other millers. There is a difference in stones, for example, between electric and water mills. Watermills should use the pedra azul or blue stone, whereas electric mills use pedra cinzenta or grey stone. Coupled with the speed of runner stone (faster in electric, slower in watermills) the type of stone used has an impact on the quality of flour and bread produced from the mill.

Most of the maize one sees growing in the Sousa Valley during the summer is not destined for the mill at all. Rather, the vast majority of maize is used for silage production, or as green feed for cattle. Silage production has grown steadily since the 1980s now occupies most of the acreage dedicated to maize in the Sousa Valley. A landscape of grain and milling has given way to a landscape of silage. This is one reason millers either purchase seed from a*broa*d or grow their own.

In addition to the silage landscape, rural areas in the Sousa Valley are increasingly being viewed as places of *lazer* or casual recreation and rural tourism, or *turismo no espacao rural*. The many rivers and streams provide cool places to relax outdoors even in the summer months. Small parks and recreation areas are springing up all over the Valley. These parks usually incorporate a rural theme that corresponds to the history and culture of the area. Watermills figure prominently in this rural tourism and local governments (Freguesias) are beginning to respond by capturing rural development money for the restoration of demonstration mills. These demonstration mills are like small museums that dot the countryside producing a different type of milling landscape, a disembodied milling landscape (Powell 2002).

The tourist milling landscape clearly competes with the functioning milling landscape by historicizing a contemporary practice (water milling) and by diverting development funds from functioning mills to static mills that produce only recreation. None of the millers interviewed receives funds from any level of government for milling (the farmers may receive funding for farming, or not farming, maize however). This illustrates that mills do not belong to any one network per se, but multiple ones, and can therefore be enrolled simultaneously in multiple competing collectives.

Baking a *Broa*

The end result of flour milling is grist for animals and flour destined for the traditional maize bread, or *broa* detailed above. Historically, at least since the early 1500s, *broa* was a mainstay in households of NW Portugal. The bread was so important that the landscape reflected its composition: alternating fields of rye in the winter and maize in the summer. All rural households, say farmers, baked their own *broa*. Farmers in Valley will still refer to fields of maize as fields of pao, or bread.

Baking a *broa* is a relatively simple process on a commercial scale at least. It is more intensive and time consuming when done on one’s own. Maize flour and rye flour are mixed (in proportions that vary according to the baker, but generally more maize than rye by at least 2-3 parts), warm water is added, some salt, and active dry yeast. Individuals may add olive oil, milk, or other ingredients to taste. The mixture is thoroughly mixed, either by hand or by machine, and allowed to sit for a specified time (half hour usually). Upon rising the dough is transferred into deep bowls that give the *broa* its form. In bakeries, the bowl full of dough is turned over spilling the contents out onto a long baker’s paddle and is transferred to the oven for baking. The baker’s paddle will usually have a piece of paper or cabbage leaf on the paddle to receive the dough. This allows the dough to slide off the paddle and prevents the dough from sticking to the oven shelf and burning during baking. When done, the *broa* assumes its characteristic form with a hard, cracked, golden outer crust. The process for individual baking at home is different in the mixing and kneading, but the end result is a similar looking loaf.

As mentioned previously, the loaves are dense and heavy and, when made with the right kind of maize variety, can retain moisture and freshness for a week. The simple recipe, the heartiness of the loaves, and longevity of the *broa* shelf life no doubt contribute to its popularity in the rural areas now and in the past.

In the distant past, *broa* was the basis of household consumption throughout rural NW Portugal. Every ethnographer and social scientist that has worked in the region comments on the importance of the bread (Bentley 1992; Black 1992; Pina-Cabral 1986; Ribeiro 1998). Over time, however, the *broa* has become subsumed by the previously more expensive refined white bread (called wheat bread in Portugal) purchased in stores. Pina-Cabral notes in Minho during the 1980s that to buy white bread in stores signified higher social status by virtue of being able to pay for the white bread (Pina Cabral 1986). *Broa* became labeled as food of the poor and associated with subsistence farming. The rush to white bread has, evidently, opened a niche for *broa* to appear once again anew as specialty bread. A good *broa* is difficult to locate, and far more expensive than store-bought white bread. Sensing their loss of something valuable, many Portuguese seek out the *broa* and there are fairs and baking contests devoted to the bread. The bread is a true boutique item of nostalgia and remembrances.

However, the social resurgence of *broa* as boutique food has problems, partly because it is still an actor-network of subsistence farming social relations of production and consumption. Authentic *broa* implies landscapes of social relations that are disappearing: there are fewer farmers, fewer farms, and less grain. The VASO project is attempting to transfer these disappearing relations into contemporary landscapes of associations that are reproduced in the certified *broa*. Essentially, the *broa is* the VASO Project in edible form.

The story related to me at the time of my research, reiterated in various forms by nearly every interviewee, is that people used to make *broa* at home every week. Evidently, a loaf of *broa* could last a week and still retain flavor and moisture. Silas Pêgo claims that this quality was due to the nature of the seed grain of the old maize varieties he is working with, namely varieties like *Pigarro*. Farmers invariably indicated that their local maize varieties produce better flour for the *broa* (I return to the dilemma related to this issue below).

Increasing, *broa* has become something of boutique specialty item, as well as remaining a staple food in the more rural areas. *Broa* can be purchased from local stores, cafés, farmers' cooperatives, individual bakers and restaurants (particularly restaurant tipicos or restaurants specializing in traditional food). The bread is sold at the many periodic ferias, or fairs, that occur weekly in cities around the Sousa Valley.

Each year, in the summer, there are a series of annual *Concursos* or competitions for a variety of farm products offered in the Sousa Valley. The *Concurso de broa* is held annually in conjunction with the AGRIVAL festival in the city of Penafiel. Under a sweltering tent, the loaves are carefully arranged on a table each with a number and sliced open to expose the dough consistency. Opinions on the proper consistency vary widely. The bakers represented are mostly informal household bakers, usually women ranging in age from young to old. The atmosphere in the tent is tense, eased somewhat by the presence of bottles of *vinho verde*, the regional effervescent wine and drinks of choice, as the judges carefully take a bite of each loaf and confers. Once the decision is made, the gathered crowd awaits the announcement of the winners. This year (2001) a young woman in her 30s wins, indicating the continuing tradition of baking *broa*. She uses both local and commercial white maize flour, but prefers water-milled flour to industrially processed flour (or even flour from a small electric mill).

A separate type of *broa* found in the *Freguesia* of Avintes near Porto has become such a popular item that it has its own festival, the *Festa da Broa de Avintes*. Comprising three days of music, dance and various shows, bakers from Avintes open their booths and offer up their product: the dark, dense, *broa* de Avintes. Here the *broa* achieves a specialty bread boutique appearance as bakers bag loaves in decorative bags with nostalgic images of days past. At the festival large tents are set up where people can eat *broa* with grilled chicken, smoked pork sausages, the traditional *caldo verde* or soup of greens and other local specialties. Local *vinho verde* is the favorite beverage with *broa*. On stage, local dance groups *folcloricos* perform traditional dances, like the Fandango after which the maize variety is named (Chapter 2). Silas Pêgo has hopes of enrolling the *broa* de Avintes bakers into the VASO collective.

***Broa* de Avintes**

The Neto bakery specializes in *broa* de Avintes. In a small bakery down a steep, narrow, street the Netos have been baking *broa* for five generations. The latest Neto generation supplies the nearby city of Porto and others desiring the unique bread. Silas Pêgo claims to be able to buy the bread in Holland! The exact recipe is a trade secret, but the bread involves the same ground white-maize flour, farinha, as the other *broa*s, and it is equally long-lasting. The bread loaf is a small, dense, small bread loaf formed by a deep rectangular form (recall the other *broa* of Sousa Valley is formed with a deep bowl).

With slight variation in cooking time and last-minute embellishments just before entering the oven, the process and recipe is similar to baking Sousa Valley-type *broa*. What makes the *broa* de Avintes unique is the extreme density and small loaf size. The loaf is so dense that it is difficult to slice. Expensive restaurants will offer *broa* de Avintes on the table, but it is generally sold as baked loaves to bakeries that sell directly to the public.

The *Broa Actor-network*

Dr. Silas Pêgo and colleagues realized the importance of the traditional maize bread early in the VASO Project's conception (Pêgo 1984 Projecto VASO n.p. doc). As mentioned earlier, *broa* is widespread in the northwest region and it has been a staple food for centuries in the region following the maize revolution there (Ribeiro 1998). Since the beginning of the VASO project, and the beginning of the actor-world of the same name, *broa* has figured prominently as a rationale for increasing the yield of farmers' maize varieties. In the most recent phase of VASO, *broa* has become the most central ray of hope for the project's fate is linked to the *broa* de Avintes. The VASO Project has engaged with what I call the broa *actor-network.* That is, no just a loaf of bread composed of salt, olive oil, maize flour, and yeast. Rather, an authentic *broa* that links plant breeding with food and sustainability is more properly thought of as a actor-network of interacting humans and non-humans within specific places that collectively compose a *broa* as conceived in VASO.

In the beginning of VASO (the 1980s) the production of maize flour from farmer's varieties was only sketched briefly in project documents, leaving the details of flour and bread to one's imagination (e.g. farmers produce their own bread, somehow from the maize and that the process itself is unimportant).   Today the story is much different, and the fate of farmers' varieties and farm diversity (sustainability) is linked to the success of the maize bread. The VASO Project breeding program now explicitly incorporates flour quality and quantity, and links this to the production of *broa* for sale in restaurants, markets, and bakeries. In so doing, VASO is taking advantage of other, coexisting networks and landscapes of association, centered on regional food product identity in the NW Portugal and throughout rural Europe. This regional food identity is being coupled with product marketing and scientific plant and animal breeding such that high quality, locally produced products like cheeses, wines, milk, melons and meat can be guaranteed in the authenticity of their high quality and local production. In Portugal there is concerted effort to valorize in the market place special products through a *selo de guarantia* (seals of guarantee) of the kind being used to market demarcated wines (DOC wines).

The impetus for the guarantee seal is similar to organic food guarantees. The seal, validated through independent inspections and standards, guarantees consumers that the product is what it claims to be, and that a higher price is deserved. This process has worked exceedingly well for Port wine and local *vinho verdes* (green wines) creating a vibrant market for these products (two centuries old in the case of Port wine). Many, like Silas Pêgo and others, hope the seal can be applied to regions in dire need of economic support, such as the mountainous regions in Minho. Silas Pêgo, for example, has even attempted to link his breeding efforts in VASO to organic farming in the mountainous Basto region nearby (Pêgo 2002). Much of the new-labeled food is more expensive for consumers owing to the low production and higher quality. More importantly, promoters of the food point to the sustainability issue of the food's production process. The seal, they contend, certifies the whole production process from farm to table: effectively certifying a constellation of actor-networks and landscapes of association. Pêgo hopes to enroll another actor-network, IDARN, an independent food-certifying agency in Portugal, into the VASO collective. The hope is that a guaranty seal can be placed on the *broa* produced from *Pigarro* flour.

To summarize, by the time of my fieldwork Silas Pêgo had begun to link the sustainability of small scale farming, indeed its survival in places like the Sousa Valley and the mountains of Minho, to the viability of the *broa* as a certified product. This, Silas Pêgo believes, is the only way to save the small farmer, small farms and the maize diversity and knowledge practices that go with this all. Put simply, higher prices from certified bread will, somehow, filter back to the farmer.

After more extensive fieldwork among millers, I realized that the plan to have certified *broa* to save the small farmer and farm-level maize biodiversity embeds some fatal flaws. One of these flaws is that within the confines of conventional plant breeding theory one completely overlooks millers, significant actor-networks hidden among the other actor-networks being enrolled in the VASO collective. To uncover the important relationship between farmers, millers and bakers (of *broa*), one must move research from a focus on the seed-as-unit-of-production to the seed as a condensation of social relationships of consumption as well.   Silas Pêgo had not conceptualized millers in the VASO collective, nor did I think of them initially (Powell 1999). Conceptualizing the VASO project as a world in the making, however, helped to focus research effort off-farm on the wider actor-networks involved and their landscapes of associations. In this way, an actor-network theory approach helps to shed light on hidden entities and networks such as the millers and the milling landscape that is embedded in the edible landscape of northwest Portugal.

Bruno Latour has famously claimed that ethnographers of science study how scientists pack the world into words. By this he means that in the course of their work, scientists regularly go about reducing the complexity of the socio-material world around them into transcriptions, or the charts, maps, graphs and numerical data that translate complex entities into mutable mobiles. Once they accomplish this reduction, through a series of translations of form, scientists can reshuffle and reassemble—on the surface of a desk, inside a computer or in a laboratory experiment--the reduced, transcribed, social world into a desired form and then expand this form out again into society as a new reality. Some entities acquiesce to this newly configured socio-material world more readily than others thereby introducing the possibility of disorder and network breakdown. Thus, new social worlds built through this process require constant work to maintain and to reproduce.

This is essentially the process described by Latour in the Pasteurization of France, wherein Louis Pasteur makes reductions and simplifications, performs experiments to realign entities into a new actor-network and expands this out to form a new Pasteurized world that is maintained and reproduced through the pasteurization process and through the consumption of pasteurized products (milk, cheese and inoculations). The same could be said for Edison and his rearrangement of socio-material elements and networks into the incandescent light bulb and the subsequent en-lightened world that emerged around this entity (lit spaces, offices, homes, etc.). If scientists are successful at performing translations, reductions and re-amplifications, the result is a thing that encapsulates the world and allows for its movement and reproduction with relative ease (the light bulb, pasteurized milk, and so on). These things form congealed socio-material (and I would add spatial) relations that glom together to form black boxes. Remove or change one element and the thing breaks down (for example if no one drinks or continues to learn how to pasteurize milk or make or use incandescent light bulbs).

In this chapter I have outlined how the process of packing the world into things like light bulbs plays out in a loaf of traditional northwest Portuguese bread called *broa*. I have sketched out range of diverse kinds of actors from millers to bakers, knowledges and practices of milling and baking that congeal in a loaf of *broa*. The milling and baking landscapes referred to here consists of the spatial associations between millers, farmers, bakers and *broa*-eaters. These landscapes are made edible through contests, fairs and the long held tradition of eating *broa*. For a good *broa* to emerge, farmers have to use right fertilizer (made from cows who eat maize), millers have to grind grain properly, to do so they need a water mill and good seeds (they must buy good seeds and not mix them with poor seeds in the flour), and bakers have to finish the product.

The point to stress here is that a *broa* consists of social relations of a material and spatial kind that must come together in a seamless, smooth running network of associations in order to render the landscape edible. Whether he acknowledges it or not, Pêgo has set himself this task.

CHAPTER FIVE
CONCLUSION

Assessing VASO: success, failure, or something in between?

One of the main goals in this research is to do more than merely describe what is happening through VASO, but to arrive at a point, or more accurately a point of view, from which it is possible to evaluate the VASO Project in terms of its relative successes, failures at not breeding plants but rather as breeding (or putting together) an actor-world that rests upon the successful production and consumption of *Pigarro*. This when the politics of science, in the sense of convincing, coercing and compromising of getting other humans and non-humans to accept a particular discourse, practice or knowledge claim, is revealed. This is to claim that in evaluating the VASO Project, one cannot look to some universal truth, rationality or abstract content of science purportedly floating free from the politics and exigency of human history, society, and locality. Nor should one search for the sullying effects of the social context to explain where, how and why a particular scientific practice went astray. There is no "a-ha" moment when failure or success in science can be attributed to getting it right or not. A more realistic assessment of scientific practice (note not objective) builds on what is actually practiced: that is, what scientists actually do in all the steps before a world is constructed, and actors are formed with roles assigned. What does a realistic accounting of VASO entail?

The circulatory system, or vascularization, of plant breeding science

Latour (1999) offers a realistic way to account for a science through a theoretical language and model or conceptual grid (Barnes 2003:5) for understanding the intimate politics and exchanges of materials, things, bodies and ideas that link science and society together. This model invokes the metaphor of a circulatory system of facts, claims, statements, propositions and other forms of gathering allies—both human and non—into the fold of an emerging actor-world. The model of consists of interlocking loops of circulation and a central knot or node that Latour contrasts to the notion of a pure, socially disconnected heart. The heart depends upon the entire system as the system relies upon the heart—they are co-constructed in a rich vascular system in the same way a science is connected to its social world. Both science and society are intertwined at every step, and it is only when they are disconnected or unraveling that a science is in trouble. Latour writes:

> By following the ways in which facts circulate, we will be able to reconstruct, blood vessel after blood vessel, the whole circulatory system of science. The notion of a science isolated from the rest of the society will become as meaningless as the idea of a system of ateries disconnected from the system of veins. Even the notion of a conceptual heart of science will take on a completely different meaning once we begin to examine the rich vascularization that makes scientific disciplines alive (Latour 1999:80).

Consequently, there are five types of activities that science studies needs to describe first if it seeks to begin to understand in any sort of realistic way what a given scientific discipline is up to: instruments, colleagues, allies, public, and finally, what I call links and knots so as to avoid the historical baggage that comes with the phrase conceptual content (Latour 1999:99) The tighter these loops are connected and the denser the networks among them, the stronger a science becomes. The essence of science is not whether its content (findings, data, hypotheses, theories and so) are influenced by society, but rather how tightly connections with society have been made. The scholar of science thus should not assume that a science has connections with society, but should establish where, when and how, or if, such connections have been made. A stronger, that is a more powerful and more pervasive a science, according to Latour is more, not less, socially connected. Thus, Latour maps the five different interconnected "loops" through which scientific facts or reference circulates with greater or less efficiency resulting in a stronger or weaker science.

Loop one is labeled "mobilization of the world" and refers to all the means by which nonhumans are progressively loaded into discourse, (1999: 99) the instruments, expeditions, surveys and the sites of research. For conventional plant breeding this entails the ways in which the potentially complex world of plants is simplified into numerical expressions, diagrams and drawings, mutable mobiles in Latour's language, that can be transported anywhere. This is making nature presentable and controllable, the adage if it can be measured, it can be controlled applies here. Plant breeding has achieved remarkable techniques in this field, most notably in terms of quantitative genetics. With quantitative genetics, plant breeding can render the plant into a genotype and a phenotype making possible a wide range of calculations and predictions about the plant's behavior with X amount of water, X amount of fertilizer and X amount of sun (all inputs). This distills the social relations of production and consumption out of the plant, and reduces it to the language of biology, botany and genetics.

Reduced as such into genes and populations, plants are subjected to a wide range of observations and measurements. Plants and plant parts are labeled, bagged, dissected, in-bred, and crossbred with one another. The result is that plant breeders can only comprehend the plants, in an aggregate sense, in terms of statistical curves. Likewise, the environment is simplified into a set of variables that have an impact on the growth and development of the plant and plant populations.

Through the use of numerical representations, breeders can speak on behalf of plants across vast spans of space and time. Breeders in Mexico can plant crops in Africa, Asia, or anywhere that has been likewise simplified and put on paper. Spatial transference is made possible through reduction. The African, Asian or Mexican farmer is mute, as are the plants, as breeders move them around on paper and make assumptions about their knowledge (the humans) and their behavior (the non-human plants).

The second loop Latour (1999) refers to as "autonomization," or finding colleagues. This entails the journals, meetings, and institutions or the professionalization of the science. It is not enough for breeders, or any scientist, to collective data and to circulate inscriptions. The breeder also has to collect colleagues that can validate the data and the ideas being proposed. Without colleagues data is just numbers and papers, and the circulation of scientific facts among the loops is cut short. Latour writes, "the increase in the credibility of experiments, expeditions and surveys presupposes a colleague capable of both criticizing and using them…an isolated specialist is a contradiction in terms" (1999:102).

Thus, a full account of what a science is doing at any given time, is to describe the means by which colleagues are assembled and convinced (or not). The point here is that collecting data and collecting colleagues requires different skills, and breeding is more than collecting data.

As breeders need to collect colleagues they need also need to gather alliances, the fourth loop in Latour's model. Conventional breeding has been immensely successful in this regard; the placement of a discipline in a context, which is measured by the *institutionalization* of the science: the international breeding centers (CGIARs), the networks of research farms and experimental plots all over the world for ADM (the supermarket to the world and the nature of what's to come), Cargil, Dekalb, etc.

The third and fourth loops of circulation in the blood flow of a science refer to the alliances, and public representation. These are the moves science makes into the financial, political and military spheres (alliances) and into the general public (Latour 1999:104):

> Groups that previously wouldn't give each other the time of day may be enrolled in the scientists' controversies…Immense groups, rich and well endowed , must be mobilized for scientific work to develop on any scale, for expeditions to multiply and go further afield, for institutions to grow, for professions to develop, for professional chairs to open up.

Once again, the talent of a (powerful) scientist must extend beyond simply collecting data and writing reports (as insider tales suggest), One may be very good at writing convincing technical papers and terrible at persuading ministries that they cannot go on without science. Latour's point here is that science requires a great deal of work outside the laboratory, the work of connecting people and things together, and that these alliances do not pervert the flow of scientific information but are what makes this blood flow much faster and with a much higher pulse rate. Importantly, Latour continues (1999:104):

> …these alliances can take innumerable forms, but this enormous labor of persuasion and liaison is never self-evident: there is no natural connection between a military man and a chemical molecule, between an industrialist and an electron; they do not encounter each other by following some natural inclination. This inclination, this clinamen has to be created, the social and material world has to be worked on to make these alliances appear, in retrospect, inevitable.

This is the history of how new non-humans have become entangled in the existence of millions of new humans (Latour 1999).

In this respect, convincing allies that they cannot do without science, plant breeding has a certain advantage in that it deals with necessity for survival, food. This quality, the feeding the world motto, collects all kinds of human allies by virtue of a human need to eat. The public uptake and support of plant breeding (the fourth loop) is not so automatic, however, as witnessed in the widespread and heated debate over the

Frankenstein-ish genetically modified organisms (GMOs) in the food chain. Public trust of plant breeding requires the scientists to recalibrate, conduct trials and studies to show that their food is safe to eat and will not contaminate other food plants. The science of food safety meets the science of plant breeding and genetics to convince and win support of the public.

The fifth, and last, loop described by Latour is the "knot," or the content of science, the nexus of all the other loops and linchpin holding it all together. This is qualitatively different than proposing the content of a science as unadulterated, purified (from society) by sets of abstract hypotheses, theories, and calculations. Rather, the content of science is certainly theorems and calculations, but also the work of enrolling others, attracting allies, conducting trials, and convincing the public. A purified, disconnected, science is one without power to speak a discourse loaded with a chain of translated nonhumans and humans. Trevor Barnes, who has used the loops map of science to chart the rise and fall of Regional Science in American Geography, interprets the fifth loop, where the other four come together and are bound as knots and links not as the grand finale, at last the real thing: regional science. Rather, Barnes writes (2003:12):

> It (the fifth loop) remains utterly dependent on the other four loops, and attendant circulations. Blockages or impediments among any of the circuits can produce debilitating, and even terminal consequences….the most important indicator of health at the centre [sic] is the strength of the circulations around it. The greater the strength of circulation, the stronger is the fifth loop, and the studier is the science done, and the greater the potential for geographical extension.

It is then possible to compare and evaluate the different styles of plant breeding from the point of view of what plant breeders do, or have done, to thicken the vascularizaiton and flow of facts in the different worlds of: conventional plant breeding, alternative styles and, specifically the VASO Project.

VASO's Blood Flow

There is no doubt that VASO is kept alive and engaged in world-building through the singular efforts of Dr. Pêgo. Through his travels to and from farms and research stations, distant offices and local mayor's councils Pêgo performs the VASO actor-world on a daily basis. The previous chapters describe how translations of objects, practices and processes bring a complex world of farmers, farms, research stations, politicians, millers and bakers into a network / world in the making. By far one of the most difficult translations to make for VASO, or for plant breeding in general, is that of the farmer. The socio-political reality of northwest Portugal has certainly confounded Pêgo's attempts to stabilize an entity identified within the project as the small scale Portuguese farmer. Yet, this is the intended client of the VASO Project, and the various alternative styles of plant breeding in general. The small-scale Portuguese farmer, specifically, is the linchpin of VASO's success and it is the famer's decision to grow or not to grow a particular variety that forms the basis for sustainability in the region (according to VASO). The world that must be mobilized consists of complex entities to be reduced and redefined in the context of the VASO Project's objectives and goals for sustainability. Specifically these entities include the northwest Portuguese farmer and the local crop varieties, and the spaces of the Sousa Valley Region and the local farm. We can reach a more realistic level of description.

The traditional Portuguese farmer

We can locate the beginning of the entity "Portuguese traditional farmer" as defined within the VASO in the early farm surveys made in 1984 by Pêgo's social scientist colleagues (Fragata 1992). There have been people growing crops in northwest Portugal for centuries prior to VASO, of course, but the surveys nevertheless constitute a critical step in the definition of a new type of farmer defined in *relationship* to other entities such as traditional crop varieties and processes, most importantly national, cultural and even regional autonomy and the persistence of a traditional way of life in the Valley and northwest in general. Later, in subsequent surveys and reports, what Latour would call inscriptions, the small-scale northwest Portuguese famer entity would be defined in relation to both traditional practices and also, by virtue of these practices, the maintenance of traditional varieties of plants and animals as well as communal forests and water (irrigation) systems. Lumped together the small scale Portuguese farmer is composite of human and non-human entities (human + traditional farm implements + animals + crop varieties + practices + knowledge).

Thus, the farmer is itself a hybrid entity that is defined and transcribed into a historical discourse of having persisted for centuries living off minimal natural resources and having produced a living and a landscape by doing so. In the context of new sustainability discourses in which things like traditional crops and animals and less environmentally taxing practices are seen as desirable, the farmer becomes both a source for critiquing what is currently wrong with plant breeding and agriculture, and also an embodied link between sustainability and the new approach of plant breeding being offered up by VASO.

In one publication (Pêgo and Antunes 1997:306), Pêgo describes (and defines) the farmer to which the type of collaborative plant breeding offered by VASO and the kinds of problems and solutions such a farmer presents for plant breeding and agricultural development. After defining the problem of dramatic reduction in the farming population, about a 15% reduction in ten years from 1986-1996, and the general movement of these farmers from the interior to the coastal regions that results in putting pressure on existing housing, health and education infrastructure there, Pêgo identifies the four functions that the traditional farm and farmer (together an agricultural system, a kind of primitive actor network) provide to Portugal:

The former farmer who migrated from the hill slopes to the coastal border, used to run a four-fold agricultural system, which included, in fact, such different activities as: 1) Food production, mostly for self consumption, part for selling, 2) Genetic resources conservation, due to his polycropping self-sufficient agricultural system, he was the real curator of a large diversity of plant and animal genetic resources, 3) Environmental sustainability, he was the best manager of soil, water resources, taking care of their quality and control, and the administrator of the plant and animal equilibrium within a sustainability concept. 4) Forest protection, besides cleaning and administering the forest, hew also was the best fireman (by virtue of cleaning forests that now are overgrown with combustible material).

Pêgo and Antunes (1997:306) add, however, in spite of these four activities with a direct impact on the society in general, "this farmer was only paid for the first activity (food production), exactly the one, that by itself, could not be competitive in normal market conditions." This conceptualization, or construction, of the farmer entity was reiterated to me many times in informal talks, interviews and speeches of Pêgo's I recorded. The northwest Portuguese farmer is thus reduced (translated) into a series of attributes and roles in association with other humans and nonhumans and networks: a producer of food for self and market, a genetic resources conservator, a manager of natural resources and forest manager. In terms of the actual breeding program, however, the farmer identity is further reduced into a grower of crops and all the knowledge and practices that activity entails. The farmer is thus a nexus of knowledge and practice with a historical identity located in a more sustainable past that has been perturbed by modernist farming philosophy or paradigm the following of which is not practical or desirable within Portugal from the perspective of the VASO actor-world.

One of the problems with such a farmer identity (again, an identity that is the product of associations), is that it while it refers to many types of people involved in growing (and eating) food, it doesn't refer to any one specifically. What matters most in terms of forming actor networks and more complex actor-worlds, is the immutability and mobility of such identities. In this sense, the northwest Portuguese farmer can be summarized into charts, graphs and research papers and compared to similar farmers across the globe in other parts of Portugal, Europe, Africa, Asia and so on. In fact, Pêgo's highest ambition is that the VASO becomes a kind model for export as he puts it, for diffusion and implementation throughout the Portuguese-speaking world, primarily Africa where there are small farmers.

The notion that there is a kind of identifiable farmer out there undergirds all of the plant breeding literature both conventional and alternative like the PPB in VASO. Moreover, the way in which such a farmer is identified and enrolled is in very limited term (Latour would probably say flat). While this allows easy manipulation in grants and reports, it is undermined by bulk of young people in rural Portugal, the sons and daughters of full-time famers, that are opting out of rural / farming lifestyles. One has to scour the countryside to find such a farmer as identified by the VASO Project, and if one finally does find such a farmer that person will more than likely be well over 60 years old (field data) and retired. I did find one young farmer, a forty-year old man and his spouse, but they did not cultivate any of the traditional varieties of the region, a key component of the traditional farmer identity. VASO has been thus far successful in translating and mobilizing a traditional northwest Portuguese farmer, but it is dubious how far this mobilization can continue given the dramatic decline in any kind of identity resembling such a translated entity in the last twenty years. Furthermore, the farmer in VASO discourses (documents, articles, grants, surveys) appears to be more of an abstract composite rather than referring to any specific person or group of persons, as I have explained in previous chapters. People (humans) labeled farmer do many more things than farm over the course of their lives, in addition to farming in a production sense, farmers also eat (their own crops), make wine and often engage in other businesses (milling grain, driving trucks or delivering mail for example). It is unclear how successful the translated heterogeneous identity, traditional-maize-variety-growing-farmer can be continue to hold together given the emerging socioeconomic networks pulling both human and nonhumans in other directions.

Best ear of maize formula and recommended practices

By far one of the most successful mobilization devices for the VASO Project has been the formula devised to judge the Best Ear of Maize in the Sousa Valley described in Chapter 3. The formula represents a simple and effective graphical means to tie in all the actors and institutions involved in the world that VASO is forming. Importantly, the formula is not possible without technical machinery of ear drying and other tools of measurement and storage such as scales and freezers. First, there are the farmers, the maize ears and local farmers' cooperative in the city of Paredes (*Cooperativa Agricola do Concelho de Paredes*, C.R.L.) that has hosted the contest each year since 1995. A call goes out in public papers and notices a month before the contest, which is usually held in late October or early November. The rules are simple: one ear from each entrant into each of the categories: yellow dent and flint, white dent and flint (thus a possible four entries per person). The submission form notes the ear number, the date of submission, the name of the farmer, the farm location, the name of the variety and its cycle (FAO number assigned to varieties that estimate the completed life cycle from planting to harvest of a crop in a given region).

The entry forms themselves serve as a mobilization tool in that Silas Pêgo is able to obtain the names, addresses and types of varieties a farmer might be growing within the Sousa Valley. With the forms in hand, Pêgo holds a cross section of the Valley's farmers. I discovered, however, that names on forms do not necessarily match the farms or even the varieties entered as farmers will frequently swap and allow a friend, neighbor or spouse to borrow an ear for the contest and the possibility of winning a trophy. For the purposes of the formula, however, the ear number is the most important inscription. The number allows a veneer of impartiality by removing personal names and farms.

Once numbered, the ears are transported to storage in the Braga genebank (BPGV). Thus, the ears at this stage form a socio-spatial link between farmers, the Cooperative, the Genebank and VASO (through Pêgo). Linking even more humans and nonhumans, the ears are subjected to more measurement and enumeration in the laboratory at the genebank. Once translated into a series of numbers, the best ear of each category can then be computed.

As any breeder after the early 1900s will explain, a nice looking ear of maize is a very poor guide to how the variety itself will perform (yield) in a particular region or field. Maize farmers in the United States held similar maize ear shows that remained for a long time the way for farmers to judge their maize selections against one another (Fitzgerald 1993; Kloppenberg 1988). The problem with such a visual-based competition is that it is impossible to determine the underlying genetic variability represented by the ear: it could have simply been a freak outlier in a field of otherwise low-yielding maize population. Eventually, the maize ear shows of the United States were replaced with yield trials, thereby ushering in a new industry-based criteria to selecting varieties (Kloppenberg 1988).

The statistical significance of individual ears aside, Pêgo and colleagues believe the contest is an important tool of valorizing and honoring local farmers and (as I would say) enrolling them in the network of VASO, "they are, after all, real ears, showing us that is possible to achieve such large ears!" (Pêgo, author's field notes). Although farmers are not given the formula, an analysis of the data over a ten-year period shows that entries tend toward the heavy, long, ears. The important point to stress here is that the formula combines and juxtaposes many different human and nonhuman actors otherwise spread out and scattered over social, geographical and institutional space within the VASO actor-world. The formula does not produce a winning ear so much as it binds networks together and quietly enrolls and mobilizes diverse actors to great effect. The large trophies handed out encapsulate the enrolment. From the group of winners, Pêgo selects a few that look interesting in terms of varieties submitted and travels to their farms to interview them. During these personal visits, Pêgo photographs the farmer, his/her trophies and their farms thereby collecting a visual record of the *Concurso*. Although he has yet to combine these records from visits into a single document, study, or publication there is potential for yet more mobilization in the archives of VASO.

The body and in particular, bodily practices, can be effective mobilization tools. In their research on restoring a river Eden et al. (2000) demonstrate how a set of practices and procedures can serve to enroll numerous actors and agencies with a sufficient flexibility built in to allow different interpretations without completely rejecting the recommended practice. Here the notion is to translate knowledge into a uniform practice that simultaneously solves a problem and enrolls an actor or sets of actors. Here, again, the VASO has developed a potentially effective tool in its selection kit (see Chapter 3). The selection kit (ingeniously named) is focused on selection of the phenotype and based loosely on an ideotype concept (Donald 1968). The ideotype, is an ideal type of maize plant that has specific characteristics, a plant architecture (number of ears, leaf angle, height, placement of ears, etc.). Since it is not feasible for farmers to take detailed measurements of plants to make their selections, Pêgo has devised a series of steps to help in quickly identifying ideal types in the field. Again, the ideal types and steps are a composite of farmer surveys and breeder's knowledge, condensed into bodily practices that can be quickly explained and demonstrated and presumably memorized by the body. Although the selection kit could ostensibly help any farmer, it is designed with the smallholder in mind and particularly the cultivator of traditional varieties in the 'traditional" manner (e.g. walking through the field making selections rather than driving a harvester over the entire field).

The farm as a center of calculation

Finally, the first loop, as Latour reminds, deals with expeditions and surveys, with instruments and equipment, but also with the sites in which all the objects of the world thus mobilized are assembled and contained (Latour 1999:101). Centers of calculation, sometimes called centers of translation, are not just passive backgrounds but rather interactive spaces where humans and non-humans are combined and translated into networks and actor-worlds like that of VASO. Perhaps the most interesting socio-spatial rearrangement of plant breeding science and its fitting of the global to the local is the emergence of the farm as a site of crop research and development. As many inside plant breeding, and indeed within the VASO Project contend, actual farms play a minimal role in conventional plant breeding. In contrast to the common assertion in the literature that research stations model farms, in fact farms are merely the extensions of agricultural research stations. In other words, it is the farm that has been constructed as a hybrid space with the networks of conventional plant breeding, a close ally and deeply embedded partner with agri-business and multi national seed companies. If we take the research station as a center of calculation per Latour, then the farm becomes a space that reflects its translation in the industrial seed and agriculture business actor-worlds.

Projects like VASO ostensibly seek to reverse this situation; to move the center of calculation from research stations to farms. Plant breeders treat this move in purely biological terms with only passing attention to the potential social impacts. However, when examined closely from a socio-spatial perspective, the move is radical in that it attempts to restructure the socio-spatial structure of conventional plant breeding worlds—it forces plant breeding stations into a fundamentally different socio-spatial dyad with farms. This has serious implications for plant breeding, as demonstrated by VASO.

First, is the time frame of plant breeding. In order to collect the necessary data on plants to make plant breeding decisions from year to year (Chapters 2 and 3), breeders need to have several years access to the same fields and they need virtual control over these fields in terms of the specific timing of events. Any unexpected changes can alter a breeding plan several years in the making and thus virtually ruin or set back that program. The Francisco Meireles farm illustrates how these two problems present themselves (access over time and sudden changes).

In the past, only a small fraction of the farmland in the Sousa Valley is actually owned by the farmer. Most farmers have been tenants of one kind or another. Access to farmland, and to the necessary inputs like water, is an exceedingly complex affair in northwest Portugal in general. Many land agreements are verbal or implied between renter and actual legal owner, and water rights are equally complex and depend largely upon membership in a group, or *consorte* (interviews with Meireles). Francisco Meireles is an example of how complex and shifting these rights to land and water can be. Meireles explains in that he has chosen a particular piece of property mainly for the grape vines which are old and produce very good *vinho verde*. Secondly, the farm has a good mixture of different qualities of soil and excellent water supply from the local *consorte* to which the land owner (now in his 90s) has membership rights. Meireles is a hybrid of renter and sharecropper providing cash rent and a share of his maize and wine grape harvest. The relationship between owner and renter / sharecropper is fluid and can change as the farmer ages and his/her needs change with respect to the family life cycle. As the reputation of the farmer grows and he/she is found to be a good farm operator and manager the relationship with landlords can also change in favor of the farmer, as is the case with Meireles.

Thus, when a plant breeder wishes to work on-farm over the course of several years, sometimes a decade, the breeder has to be certain of future access to the farm. In the case of Meireles, there has been stability to provide a place for research, but this has not always been the case with every farmer. As farmers die, or stop farming altogether, this stability can be suddenly lost. Moreover, working with a breeder also obligates the farmer to some future uncertainty (will the breeder suddenly leave or abandon a project?). For this reason, Pêgo pays his farmers in cash each season, but again, this can complicate the relationship between farmer and landlord (does the landlord get cash rent as well?). For the last twenty years Pêgo has been lucky with Meireles, a fact that frequently arises. Certainly, although I did not research this thoroughly, property rights and access to key inputs like water shape decisions and actions on farms in ways that confound the smooth network flows of plant breeding. The local in this instance is composed of shifting socioeconomic networks that pull on existing and future arrangements between breeder and farmer. Alternative plant breeding styles and VASO have yet to successfully reduce these variables to a manageable component of plant breeding.

Another serious problem in transforming a farm into a center of calculation and translation has to do with the timing of measurements and the farmer's needs. During the course of fieldwork an entire field of maize that Pêgo was hoping to perform a series of isolations and measurements on was completely de-tasseled, a traditional farming practice in Portugal where farmers remove the top of the maize plant after flowering or when all the pollen has been shed from the male flower. Portuguese farmers use this part of the plant for feeding cattle and to hasten the ear development. Sudden removal of the tassels like this can ruin a season of measurements or remove the option for making additional data collection. Absolute control over the plant is never achievable on-farm, yet the conventions of plant breeding—the need for numeral data—remains a dilemma of incomplete farmer enrolment that Pêgo and others must absorb into their translations and mobilizations.

In sum, part of the success or failure of VASO depends on the stability of entities like the traditional Northwest Portuguese farmer, the kinds of crop varieties these farmers are said to grow and the types of farms in the Sousa Valley. The difficulty of establishing the farm as a center of translation underscores the ambivalence of farmers in many cases to play along or their desire to join other, competing, networks such as wage labor, factory work or retirement. Access and rights to land and water constitute complex social networks in which farms are always embedded and which shift constantly as property values change and both farmers and landowners age. When VASO began in 1984, for example, land was less available and difficult to rent. At the time of my fieldwork, land was plentiful and cheap, owing in part to Portugal's full integration in the European Union and shift to the Euro. This opened up jobs and money making opportunities that vastly out compensate farming. Farmland in the Valley is rapidly becoming a mode of capital accumulation through real estate markets, home building, and golf courses.

Autonomy: establishing participatory plant breeding as a viable technique

To convince someone Latour writes, scientists needs data but also someone to convince (Latour 1999:103):

> A pedologist may be great at digging trenches and keeping worms in vats in the middle of the forest but utterly useless when it comes to writing papers and talking to colleagues. And yet one has to do both. Circulating reference does not stop with the data. It has to flow further and convince other colleagues as well.

Autonomy is measured by the institutions and organizations that exist to validate the research, or the invisible college of learned societies, small cliques, and research clusters.

Here, conventional plant breeding has an advantage over alternative styles being well represented in, and by, prestigious Universities, programs, science texts, conferences of professional societies and so on. The methods and results of conventional plant breeding are relatively easy to access and judge—the circulation of this loop is strong and unimpeded.

For projects like VASO, however, there is no clear silent college and the approach of on-farm or collaborative plant breeding has not yet become a fundamental and accepted way of doing things. There is much internal disagreement even among the practitioners about what this plant breeding is, how to do it and what it hopes or even can actually deliver. For this reason, perhaps, much of the breeder's effort is focused on developing this silent college at the same time as developing the plant breeding program itself, a process of co-construction. Again the VASO, and Pêgo, provide an example.

When I began work with VASO I had expected to spend a majority of my time on either a farm or a research station. At first I was dismayed at how little time I seemed to be spending in either places, and how much time I had spent following Silas Pêgo to a meeting, a lecture to students at university, or to conferences. Not until after many months of fieldwork did I realize that this ostensibly "social" activity also is plant breeding—that Pêgo was working on developing his own external source of professional validation. Pêgo was literally socially breeding the crop at the same time as breeding *Pigarro*. This activity is where the circulation of reports and published papers, devices to gather the acceptance of colleagues, becomes important.

Pêgo began this silent college building process early on, during his Ph.D. research at Illinois. He asked his professors how the commercial maize breeding program could relate to the small farmer of Portugal that Pêgo recalled from his youth on his fathers farm and as a working breeder in Portugal during the 1970s with NUMI (Chapter 2). Pêgo explains, "when I asked my professors this question, some became upset with me, they asked me why I wanted to come to Illinois then?" Pêgo eventually won his professors over and directed his studies for the Ph.D. in plant breeding toward understanding the genetics of a trait (fasciation) of interest to the Portuguese small farmer he claimed (Pêgo 1984). Pêgo has always felt professionaly like he has a foot in both camps, the conventional and alternative approaches to plant breeding, and he has pursued success in both. After completing his studies in Illinois, Pêgo's professors allowed him to stay on a few extra months to further study the question of developing a plant breeding program for small farmers in Portugal. He obtained a scholarship to travel to CIMMYT in Mexico, a Rockefeller Foundation research center for maize where early experiments in on-farm breeding were being developed.

Global interest in on-farm breeding has increased substantially since 1985 when VASO was founded. This has made the job of constructing autonomy less difficult for Pêgo over the years. Most recently, Pêgo has trained younger colleagues and they have published in numerous journals. These recent publications provide some evidence that VASO has become increasingly linked to society and thus has become more secure in its translations and world-building.

Today a MacDonald's fast-food restaurant sits on the very spot where in the 1970s Dr. Silas Pêgo once worked as a maize breeder in Portugal's now defunct Center for Maize Breeding, or *Núcleo de Melhoramento de Milho* (NUMI).NUMI functionally was a part of the *Estacao Agraria de Braga* (Agricultural Station of Braga) in the

Northern city of Braga.NUMI, yet another catchy acronym applied by Dr. Pêgo to his craft in the late 1970s was the place where Pêgo (not yet then a Ph.D.) became caught up in maize breeding, and where his professional identity as a maize breeder truly began. Through extreme hard work, political wrangling, and a miniscule budget, the NUMI staff was able to produce some of Portugal's most successful hybrid maize varieties that are still preferred by farmers in the region today. The presence of MacDonald's, on the site of a former plant-breeding station, is a both cruel twist of fate for Dr. Pêgo, and a signal for the direction of landscape change in northwest Portugal. The restaurant implies a radically different sense a socio-material configured landscape. The VASO project is Silas Pêgo's attempt to halt the tide of this change and to push for a more locally grounded and scientifically networked edible landscape.

<u>The Edible Landscape of the VASO Actor-world</u>

Breeding sustainability

Indeed, sustainability in European agricultural policy brings to the fore the relative edibility of landscapes, the balance between preserving centuries of unique farming systems and the desire to modernize food production and consumption according to more economically efficient standards. In this context the smallholder, who has long been a critical social and material feature of rural European landscapes, plays an ambiguous role in terms of policy. Smallholders do not produce the quantity of food products required by international agricultural trade policy, yet they are also seen as critical to traditional landscape and natural resources management in rural regions. This ambiguous identity has resulted in the bureaucratic response of lopsided subsidies, lakes of milk, fallowed land where there was once food production and the increasing consolidation or conversion of small-scale farmland into larger enterprises or industrial sites.

Whether explicitly stated or not, the extent to which such hybrid landscapes retain their edibility into the future is a key problem underlying sustainability discourses throughout Europe. These sustainability discourses come at the same time that countrysides across Europe are made increasing less edible through modernist-inspired rational planning, the abandonment of family farming as a way of life and the transformation of rural regions as sites for suburban sprawl, recreation and new forms of rural-based industrial production and pollution. Public-sphere discourses and national policies attempt to address the problem of diminishing landscape edibility in the framework of sustainability that call for new alignments of food, farming and landscape to be achieved by specific agri-development schemes and policies. These (increasingly market-driven) policies attempt to preserve traditional rural cultures and their associated farming landscapes along with other types of rural socio-natures such as plant and animal varieties and various forms of protected nature (lakes, estuaries, rivers, forests). In this context, agricultural science, located at the interstices of farming and production-consumption relations has emerged as a key mediator of sustainability goals in the countryside.

Among all the agricultural sciences, plant breeding—the science and practice of improving crops—is perhaps one of the most important forces in edible landscape formation and change. Indeed, it is the plant breeder's *raison de être* to produce crop varieties that are cultivated on farms that fill the agricultural landscapes of the world and that are processed and consumed, or metabolized, in the individual and social body. Thus, in a very real sense plant breeding is a nexus of production and consumption processes and, particularly, of food-farming-landscape connections. What, then, is the role of plant breeding science in forming edible landscapes like northwest Portugal? How does plant breeding relate (that is, come into being with) edible landscapes? What does plant breeding look like when viewed from the perspective of food and, particularly the socio-spatial organization of food production and consumption?

Plant breeding, food, and landscape

Plant breeding is linked directly with food by virtue of producing edible products, the plant varieties that are either directly or indirectly consumed by humans. Yet, despite this connection with eating, there is surprisingly little research that makes this explicit and that further explores the connections between plant science and food. The plant breeding science literature itself is overwhelmingly dominated by a concern with the genetics and ecology of plants with little or no concern with plants as food. The word food is scarcely mentioned at all in the plant breeding literature of any kind, alternative or conventional. Rather, the literature is replete with discussions, models, graphs and charts of production-related processes, the most important being crop yield as I have discussed. On the rare occasion that food or consumption is mentioned, it is cast in opaque language such as end-uses for crops. However, it is clear that crops themselves have a total life span as entities that move through complex chains of commodification and transformation that link production and consumption actors and processes.

Crops are used as food, whether as farm-family food, feed for farm animals or as a product that is prepared and processed to be sold and eventually consumed. By not considering crops as food and plant breeding as a form of consumption, the literature ignores the tangle of social relations contained in food that comprises scientists, farms, farmers, markets, traders, processors and, eventually, consumers. However, food is always implied in plant breeding and eating food nearly always implies plant breeding, at least in the contemporary world (exceptions would be those who live by hunting and gathering of non-domesticated food sources). So, in addition to producing different kinds of crop varieties through different means of collaboration with farmers and resituating plant breeding on-farm, *breeding sustainability* has to account for food and consumption related actors and processes.

If the alternative plant breeding styles are to make a connection with sustainability, there must be a more nuanced approach to understanding crops as food and plant breeding as contributing to edibility. How, for example, does plant breeding imply eating? Conversely, how does eating imply plant breeding? Or how does plant breeding constitute consumption and not just production. Within agricultural development, sustainability must at some point include consumption as well as production. It is not enough to produce new crop varieties without an understanding of the food that is derived from these varieties.

Whereas the desire for sustainability through plant breeding implies the inclusion of wider network of social actors (mainly farmers) and processes (mainly ecological) that are inevitably brought into play with any type of plant breeding, there has been little analysis thus far on the *social component* of alternative plant breeding.

Thus, although the alternative plant breeding styles pose significant challenges to business-as-usual plant breeding paradigms and practices in the name of encouraging a more sustainable agriculture worldwide, there are several key areas that could be expanded upon to shed more light on the kinds of challenges that lie ahead for this type of hybridized scientific practice. Namely, these challenges have to do with understanding plant breeding as a social process that includes an alternative geography, or spatial strategy (Naylor 2005), and that explicitly considers eating and consumption as part of the calculus in how plant breeding can connect with sustainability within the social space(s) of a development project like VASO.

There is ample room to open up and explore the many philosophical and pragmatic problems raised by alternative styles of plant breeding beyond the narrow technological and behavioral-ecological frames that predominate in the literature. This opens up a critical need to take account of the many diverse actors and processes involved in plant breeding, farming and the producing and consuming of food. Social actors and processes may intersect, or touch-down, briefly on the farm and the plant breeding research station, but social actors also travel through other places, spaces and interactions such as scientific conferences, farmers' organizations, parties, coffee shops and boardrooms. There are important discussions in bars, scribbles on napkins and arguments put forth over dinner tables that, in addition to soils, temperatures and plants, condition what is done in any given project like VASO. Ethnography is uniquely suited to follow the actors wherever they go in their pursuit of breeding sustainability.

I began this research with an interest in the strange world of plant breeding (now called biotechnology). With every new development in plant breeding science, it seems controversy follows: The Green Revolution, Golden Rice and so on. The entities coming out of these controversies are hybrid socionatures in the way that I and other social theorists have begun to apply the term. What the study of VASO offers, at least I hope, is that we as food consumers are already part of a network and actor-world of plant breeding to begin with. That is, we are already producing and reproducing a type of plant breeding world by virtue of our consumption of its products, either directly or indirectly. To question new varieties like golden rice and other GMOs, we have to realize that we are beginning analysis with already formed characters arranged in an already aligned socio-spatial configuration: we have been networked as a particular entity and expected to act in a particular, predictable, way. When GMO protestors shout Franken food, drive tractors into fast-food restaurants and throw GM tomatoes at politicians, they are challenging their own complacency in co-constructing such a world in which there are GMOS in the first place by attempting to break out of this network, to change their pre-designed identity and agency.

I have attempted to do something of the same here, to order a world of socio-material things by using words and social theory. My goal is not to destroy an actor-world-in-the-making, but rather to describe how it is being constructed and to assess ways to improve this construction toward a more inclusive and successful end. I am interested in helping projects like VASO, and for carving out a space for social science of science in doing so. It is possible, I argue, to follow the construction of one crop variety, here *Pigarro*, and to unpack how science itself becomes intertwined with it. To plant breeders, the process is relatively straight forward: investigate, develop and produce crop varieties of use to farmers. Sustainability, as a goal or set of goals for plant breeding, adds new dimensions to this basic problem: what kinds of crops for what kinds of farmers? Crop varieties at their essence are visceral geographies: as eaters of them in one form or another, our bodies are inscribed in the geography of the crop variety's construction. We are socially and materially co-constructed with crop varieties. Plant breeders breed sustainability at the same time as the physical plants.

Following the food

Following the path something takes through the web of social relations proves to be a revealing exercise. Following a commodity, thing, or actor, as it moves through society forces one to enter the world that swirls around things. So inextricable are things from human life, that it is impossible to realistically remove them analysis. I decided to discover everything I could about maize varieties in the area of the VASO project. My method was to treat the seed as an actor as I followed the seed through chains of translations and through social spaces. Charting the world of the maize seed in the Sousa Valley pushed me to consider consumption as always being present, not just at the end of a chain.

In her research on organic farming in Ireland, Hillary Tovey (1997) makes the keen observation that social scientists of agriculture and rural society seem to be divided into a curious division of labor. This division, Tovey suggests, artificially separates scholars of production and scholars of consumption. Rarely are both considered together, simultaneously, in the same research. Further, Tovey argues, this division makes no sense in light of what farmers (organic at least) think they are doing: producing something people eat.

In light of Tovey's research, most of what I had read regarding small-scale farming, farmer knowledge, and collaborative plant breeding seemed glaringly lacking with respect to food. In almost every study I can cite from this large body of research, there is scarcely any mention at all about what people eat, and what they think about this food, e.g. is it healthy or tasty? All the farmers I interviewed can properly be said to border on obsession with food. Taste, healthfulness and self-worth (as well as money) were all involved in growing food plants like maize.

<u>Edibility and the Edible Landscape</u>

Following the moments of the actor-world being formed through VASO revealed a wide range of human and non-human actors involved in plant breeding for sustainability. These are actors that would have otherwise escaped analysis if I had focused on production and productive related resources separate from consumption. Indeed, much of the literature on farming, sustainability, and plant breeding cited above has very little about food, taste or eating in general. In this research I have asked: *How does breeding imply eating, and how does eating imply breeding?*

ANT works very well as a framework to analyze scientific projects like VASO in an objective symmetrical language, separate from the vocabulary of the scientists and other actors themselves (e.g. breeding terminology, farming terminology). However, ANT fails to situate the analysis in time and space; we are left wondering what the geography of networks would look like, and what the impacts of networks on the landscape might look like (Murdoch 1995).

The term landscape is useful for grounding the physical and social dimensions of actor networks such as those in VASO. Landscape reminds one that networks, actor-worlds and network builders themselves, have real spatial strategies and impacts. The concept of landscape has proved useful for cultural geography in mapping the impacts of tourism on local places where, for example, local people are seen to prepare the landscape for consumption by outsiders (Oaks 1999). Linking landscape with consumption has profound implications for the type of research I present here.

My main objective in this dissertation is to interpret the VASO project in a way that includes all the actors involved, and in a way that avoids looking for good science versus bad science. I read the VASO project, and by extension any agricultural development project, as a process of refashioning existing networks in the image of the project. In this way, the world is packed into a project. To illustrate this point, I focus on the transformations *Pigarro* undergoes from seed to bread. *Pigarro* is the name given to an actor-world, not a type of white maize found in the Sousa Valley.

To make these points I suggest the theoretical concept the edible landscape that serves to ground the networks of association concept. I prefer the term landscape because it focuses attention on the spatial connections between actors as well as the physicality of their presence in the world. One cannot escape social or physical landscapes as active agents in consumption. Anthropologists have long pointed out that people the world over spend a great deal of effort either preparing to eat, talking about eating, or actually eating, and yet this act of consumption is rarely a part of broadly defined sustainability scholarship.

In reading the VASO project as outlined above, I suggest that edibility is much better term than is sustainability when describing the pressing problems of agriculture-based society. Edibility sharpens the focus in agricultural development so that we can ask: How does the project affect eating? When linked with landscape, we can ask: How does the project increase, or decrease, the edibility of a landscape? How are people, things, and institutions lined up to increase global edibility? Thus, edibility subsumes all other issues, because all research to date suggests that people must eat, and people like to eat things that taste good. Yet, taste is subjective (to a certain extent) and therein is the need for anthropological (ethnographic) analysis.

The world-building process occurring with the VASO project is represented in the theoretical model of the edible landscape of Northwest Portugal, a spatial arrangement of social connections and complex negotiations between the natural and cultural, the technological and the social. Specifically, within zones of production and consumption are embedded socially organized spaces of interaction between entities focused on the transformation of plants into food. An edible landscape is the overlapping zones of food production and consumption that bracket the more specialized spaces of social interaction that organize the flow of materials and actors involved in producing, processing, selling and eating food. The socially-defined boundaries of these zones and spaces are dynamic and their precise location at any one given time is less important than the socio-material flows and exchanges that link them together. This landscape provides a means to evaluate the VASO Project in terms of multiple actors and processes rather than in terms of technical failures such as yield. The success of VASO depends on the persistence of the VASO actor-world and the coordination of actors into a more focused and durable edible landscape. All of this is encapsulated in a single kernel of white maize called *Pigarro*, the continued reproduction of which is doubtful without the persistence and meshing of maize, bread, and milling actor-networks.

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VITA

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