FROM FOOD SECURITY TO FARM TO FORMICIDAE: BELO HORIZONTE, BRAZIL'S *SECRETARIA MUNICIPAL DE ABASTECIMENTO* AND BIODIVERSITY IN THE FRAGMENTED ATLANTIC RAINFOREST

by

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“Development is human. It is either everyone’s or it does not exist.”

“Não sou otimista babaca, mas otimista ativo.”

—Herbert José “Betinho” de Souza

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To my grandparents, Dorothy (Freeman) Chappell, Willie Chappell, Clara Lucille (Williams) Brown, and Benjamin Franklin Brown, Sr., and to Luthcia Raggs. To their spirits of excellence, devotion to family and community, and education I will always be indebted.

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ABSTRACT

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Chair: John H. Vandermeer

Widespread food insecurity and rapid biodiversity loss are two of the most serious problems facing the world today. My work in this area focuses on two important questions: how can we address hunger in a world that produces enough food, but where poverty denies so many access to it? And, how can we accomplish this while conserving the environment upon which all organisms depend? In order to examine these questions, I conducted a case study of the connections between food security and conservation in the context of a large city (Belo Horizonte, 2.5 million residents) and its local food system, situated in the "mega-biodiverse" Atlantic Rainforest of southeastern Brazil. Belo Horizonte's government made access to food a right of citizenship in 1993, creating a Secretariat of Supply (SMAB) to guarantee this right. SMAB has overseen dramatic reductions in infant malnutrition and mortality since its creation in 1993. SMAB's programs also connects it to local, small family farmers, implicating the role local food may play in landscape biodiversity conservation. The objective of this work is to understand how SMAB formed, how it has achieved its present successes, and whether or not its

connection with local farmers has generated differences in biodiversity in the agroecological landscape. Using ants as an indicator of biodiversity, my results suggest that SMAB has had a positive influence on the conservation of biodiversity both on the studied farm fields and within adjoining fragments of native rainforest. It appears that SMAB produces these effects by enhancing economic security for the partnering farmers (such security has been previously shown to affect the sustainability of farmer practices), and via the partner farmers' regular contacts with agricultural extensionists as part of their participation in SMAB. My results may be the first comprehensive evaluation of a political ecological system starting from food policy and tracing its effects through to biodiversity. Only through such an integrated, holistic understanding of the articulation of human food systems and natural habitats can we conserve crucial and irreplaceable biodiversity, and provide human rights like food security in the "Developing World", or indeed, in any of the world.

CHAPTER 1

INTRODUCTION

The present work, taken as a whole, focuses on two important and timely questions: how can we address hunger in a world which produces enough food, but where poverty denies so many access to it? And, how can we feed everyone while conserving the environment upon which all organisms, including us, depend? The paradigm suggested to address these questions simultaneously has often been that of "sustainable development," defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED) 1987). This paradigm is perhaps nowhere as severely tested as in the problems surrounding malnutrition and hunger, where given the scope of human resource use, choices to address malnutrition necessarily involve choices affecting the rapid loss of irreplaceable biological diversity. Biodiversity within the ubiquitous agricultural areas surrounding native habitat fragments (such areas are also known as "the matrix" within which such fragments are found) is now known to be much higher than previously recognized (see i.e., Harvey and Haber 1999, Moguel and Toledo 1999, Armbrecht and Perfecto 2003, Montagnini 2006, Perfecto and Vandermeer 2008). The impacts of agricultural practices in the matrix on biodiversity at the local and landscape levels continue to be discovered and elaborated, with significant effects even seen in fragments close to large and intact native habitats (Stouffer et al. 2006, Tscharntke et al. 2007, Vandermeer et al. 2008). The impacts natural habitats in turn may have on agriculture continue to be studied as well, especially the positive effects studied in the field of ecosystem services (Daily 1997, Ricketts 2001, Philpott and Armbrecht 2004, Harvey et al. 2007, Fielder et al. 2008, Veddeler et al. 2008). An approach, therefore, that examines the effects of the matrix and its properties in relation to native fragments is necessary. To my knowledge, the present work is the first to directly integrate an understanding of the conservation dynamics of fragmented landscapes with food security and changes in local food policy institutions.

This thesis is divided into three main parts in addition to the Introduction and Conclusion chapters. Chapter 2 explores the relationships between food production, agricultural method, and biodiversity, outlining the general scope of the problems of food security and rapid biodiversity

loss before reviewing the extant literature to determine if providing universal food security and simultaneously conserving biodiversity can be reconciled in a world of limited resources and difficult choices. In this manner, Chapter 2 explores sustainable development from the perspective of development as the evolution (as opposed to growth) of the economic system in order to provide universal attainment of basic human rights – specifically food security, in this case – while maintaining or even advancing sustainability in terms of conservation of native biodiversity. Other human rights, such as self-determination, access to suitable education, fulfilling and gainful employment, adequate housing and safe working conditions are all part of sustainable development as well when developed in ways designed for environmental benignity and stability (the rights listed here are those advanced by the United Nations in both its Declaration of Human Rights in 1948 and its Covenant on Economic, Social and Cultural Rights in 1976).

There are over 800 million people in the world estimated to be suffering from malnutrition, and a total of approximately 2 billion people suffer from dietary imbalances or micronutrient deficiencies, what some researchers have called "hidden hunger" (Gardner and Halweil 2000, Bruinsma 2003). Meanwhile, biodiversity is being lost at an estimated rate of one thousand times the "background" extinction rate, with some estimating the rate of loss as greater than that by an order of magnitude (Hanski et al. 1995, Pimm et al. 1995). With the human population projected to continue growing for a number of decades yet, up to a projected peak of 9-10 billion people in the year 2100, old Malthusian worries of the size of the human population outstripping the earth's capacity to produce food seem to loom large, and to call for drastic measures (Lutz et al. 2001, O'Neill 2005). Increased conventional intensification with the modern package of synthetic pesticides and fertilizers, along with genetically modified crops and livestock are advocated even by some academic ecologists and mainstream environmentalists, in order to save what natural habitats we have left and conserve the diversity they represent (Balmford et al. 2005, Fischer et al. 2008). The exercise of "land-sparing" in this way by producing more food on less land with "whatever means necessary" would be obviated if what has been called "wildlife-friendly agriculture" can produce sufficient food for the human population without necessarily using more land or resources. Chapter 2 reviews the literature in this area, examining the possibility that alternative agriculture (the set of practices and philosophies in common between methods called, among other terms, wildlife-friendly, organic, and agroecological agriculture) can provide enough food for the human population without using more land than conventional methods, while better conserving endangered biodiversity. An important part of examining the potential of alternative agriculture also lies in understanding

today's food systems and agriculture with respect to a key, un-Malthusian fact: more than enough food is already produced today to provide everyone with sufficient food on an energetic basis. This means, among other things, that alternative agriculture does not need to produce more than conventional agriculture per se, but rather produce enough for everyone in today's and tomorrow's global population, a smaller order (Badgley et al. 2007). It also means that the intensification approach may overlook key factors in food accessibility and distribution, and the key role played by poverty in creating and maintaining hunger.

After introducing the issues, Chapter 2 specifically looks at the state of world food production, comparing the alternative and conventional modes of agriculture. I then review the state of global biodiversity, defining what is meant by "biodiversity," and elaborating how biodiversity and agricultural production are related. With over 40% of the world's land surface (excluding Antarctica) in use as agricultural land, agriculture's effects on biodiversity are not to be underestimated, with farming practices such as pesticide use and the planned assortment of crops and livestock directly affecting local biodiversity, along with "downstream" effects from agriculture such as fertilizer and pesticide run-off, which can have negative effects on biodiversity far removed from any particular agricultural source (Steingraber 1997, Devine and Furlong 2007, Food and Agriculture Organization of the United Nations (FAO) 2007).
Given such an intimate relationship between agriculture and biodiversity, I then review how alternative agriculture may differ in its interactions with "natural" landscapes compared to conventional agriculture at broad and general scales. Chapter 2 concludes with a brief look at how such analyses apply at smaller local and regional scales, along with a brief consideration of the history of agriculture and patterns of energy use within it, capped by a look at the way forward for those concerned with ecology and the development of human rights.
Following from this, Chapter 3 looks at these questions of conservation and food security from the point of view of a case study of the Municipal Secretariat of Food Supply (*Secretaria Municipal de Abastecimento*, or *SMAB*) of Belo Horizonte, the capital of Minas Gerais state in southeastern Brazil (see Figure 1.1). Belo Horizonte, one of Brazil's largest cities with its population of 2.5 million people, is situated in the "mega-biodiverse" and highly deforested Atlantic Rainforest of southeastern Brazil. Belo Horizonte's government made access to food a right of citizenship, and created SMAB in 1993 to guarantee this right. SMAB's programs have had an unprecedented level of success in enhancing food security – that is, access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle. For example, infant mortality and infant malnutrition have been decreased by more than 50% since the Secretariat's start. The city's programs also connect it with local, small

family farmers situated in the Atlantic Rainforest, implicating the important role local food may play in biodiversity conservation and tying this case study back to the central theme of this work, the development of the human right to food security in a way that allows or even aids the conservation of biodiversity. The uniqueness and relative recentness of SMAB's programs provided a singular opportunity for a case study of a food system and its effects on an agroecological matrix.

After a review of sustainable development, human rights and food security in the beginning of Chapter 3, I continue with a review of my research questions with regards to SMAB, asking what conditions allowed or supported SMAB'S creation and political sustainability, what institutional characteristics support SMAB's successes and effectiveness, especially in working with civil society, and how such characteristics of SMAB may encourage or inhibit conservation in the local landscape. This is followed by a very brief review of the history of food security policy in Brazil, post-World War I, to put SMAB's programs and innovations in context. Looking at the local and national conditions when SMAB was formed in 1993, a number of things stick out immediately: the very real problems of hunger and access to food, the decades of experiments with food policies and programs (primarily at the national level), and the political mood of 1993, heavily influenced by a highly mobilized public pushing an agenda addressing food security and inequality and buoying Brazil's Workers' Party (PT) to greater prominence and positions of power, it can appear to one that the time was ripe for Belo Horizonte's PT Mayor, Patrus Ananias, to take action. I specifically examine what factors allowed him to take action and take advantage of this "window" where societal problems, policy approaches, public sentiment and political circumstances had all come together. The overall framework I use in my examination is that of John Kingdon (2003) and Michael Cohen, James March, and Johan Olsen (1972) – Kingdon's 2003 work (originally written in 1984) built on the Cohen-March-Olsen model of the policy process, the "Garbage Can Model of Institutional Choice." At its core, the Kingdon/Cohen-Mark-Olsen model maintains the proposition that organizational choices at times reflect an "organized anarchy," where the actual problems in society, policy solutions developed by researchers and technocrats, and political winds of electoral politics and the mood and priorities of the public all develop independently of each other, to a large degree. In this framework, solutions to extant and possible future problems are not implemented when they are developed for a variety of reasons, and thus end up stored in "containers" or "garbage cans", to be sorted through on later occasions when solutions to a persistent, growing, or new problem are demanded. The reasons policies are not implemented as they are developed is perhaps summarizable as the fact that the decision makers necessary to implement policies are dispersed

throughout a system, unable to devote their full attention to all problems at once, typically share an incomplete understanding of the problems with the public and the policy developers themselves, and have their own priorities that may not align with those of policy developers. Thus, as problems, policies, and politics evolve independently, those who can take advantage of opportunities where all of these "streams" come together are called "policy entrepreneurs" – such as Mayor Ananias was in 1993, when the problems, policies, and politics of food security all joined, and he appointed an economist who focused on nutrition, Maria Regina Nabuco, to head SMAB. Nabuco also ended up being a policy entrepreneur; this process of the three "streams" flowing along and aligning in 1993 is the concentration of most of the body of Chapter 3, as part of the development of explanations of how SMAB works, why it works, and how it came to be. Following the discussion of SMAB itself, I look at how SMAB practices have affected farmers in the Atlantic Rainforest region through partnerships between SMAB and the farmers that bring them directly to the city to sell their produce. Having to keep 20% of their property in rainforest by law, the farmers can have a major effect on the remnants of the Atlantic Rainforest. They may thus possibly support significant regional diversity by raising the quality of the matrix – their farm lands – allowing populations of diverse organisms to persist via movement throughout the larger landscape of matrix and fragments. Interviews with members of SMAB and local farmers inside and outside of the SMAB programs themselves, along with documentary review, supplied the information necessary for this chapter, information that then informed a direct examination of the levels of biodiversity on the farms and their forest fragments of the Atlantic Rainforest.

Examining the social linkages between SMAB and local farmers in terms of what Peter Evans (1996) has called "state-society synergy" allowed me to directly articulate SMAB's successful food policies with the agroecological matrix of the Atlantic Rainforest around Belo Horizonte. Having made the connection on the social side, Chapter 4 examines the potential effects on the ecological side: biodiversity of ant species on farms and their associated forest fragments, on farms that work with SMAB and those that do not (Figure 1.2). Studying these sets of farms allowed me to begin to answer the question of whether or not SMAB supports the conservation/sustainability aspect of "sustainable development" as well. If working with SMAB is able to influence farmers into making their properties into a better "matrix", then in this way, "SMAB" vs. "Non-SMAB" farms may stand in as rough proxies for what has been referred to as "syndromes of production" (after Vandermeer 1997, and Andow and Hidaka 1989). That is, sets of practices that may act together to optimize productivity – and may additionally support higher or lower levels of biodiversity – where different optimums may be reached using different sets. Thus, the pre-existing sets of "SMAB" and "Non-SMAB" farms of similar sizes and

backgrounds, in same region, formed a sort of "natural experiment" or case study to examine whether providing greater local food security may have also led to differences in biodiversity within the local agroecological matrix. Figure 1.2 presents this as a possible "indirect effect" of SMAB, where a positive force for food security may also have an indirect positive effect on biodiversity.

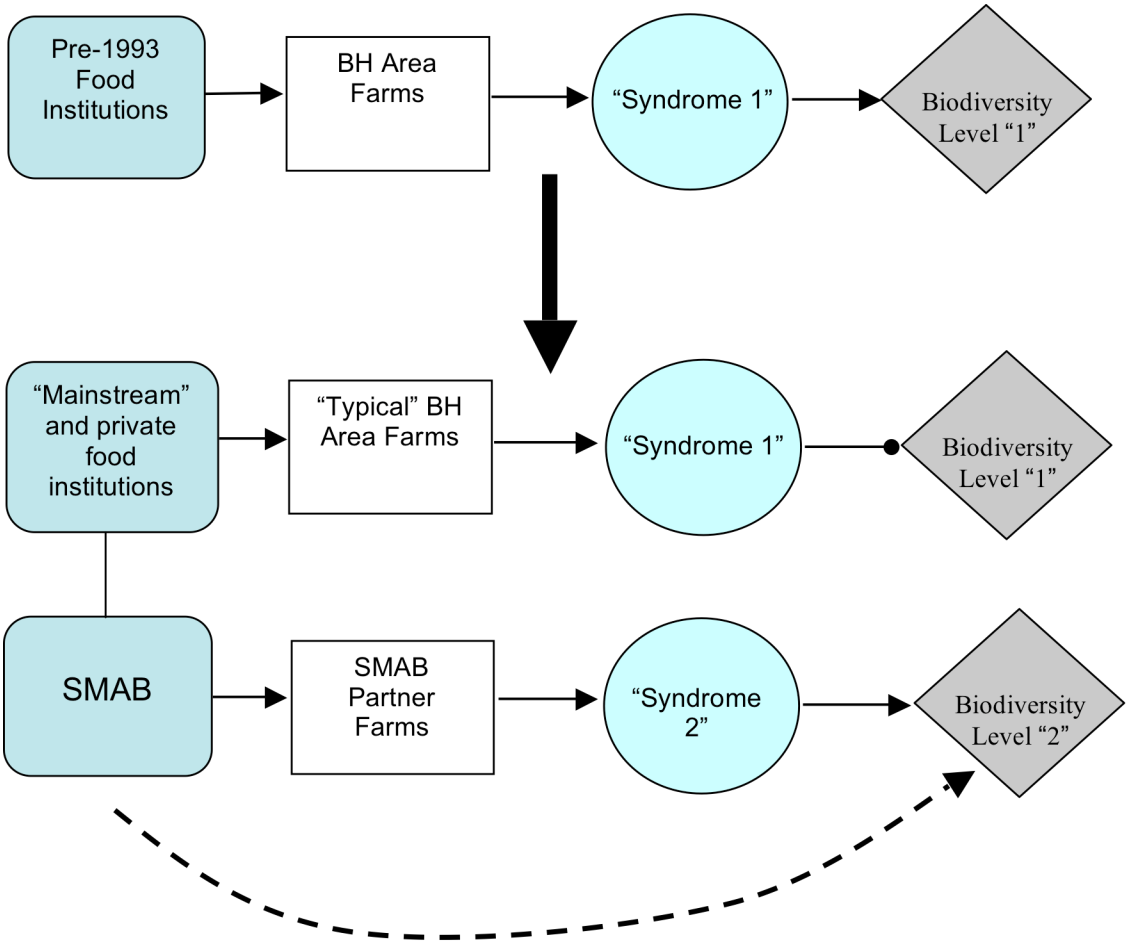
In Chapter 4, I extensively review how agriculture and biodiversity interact with one another, and why one might expect SMAB to affect biodiversity in the Atlantic Rainforest. Ants stand in as bioindicators for other types of biodiversity and sustainability in general; in Chapter 4 I explain the advantages as well as the pitfalls of this approach and the insufficiency of ants to stand in for all other taxa. Given such caveats caveats, in Chapter 4 I continue my analysis using seven sites owned by six farmers to compare ant biodiversity on SMAB and non-SMAB farms. I compare a number of measures of alpha diversity – species richness – and use linear mixed effects regression models to determine the relationship between a number of important characteristics of the farm matrices – participation in SMAB, but also the size and number of rainforest fragments in the area, their shape, distances, and other factors that would affect species richness. I also do straight statistical comparisons of diversity measures in SMAB and non-SMAB farms using resampling, adding measures of beta diversity – differences in species identities between two sites – to the examination of diversity within all of the SMAB farms and all of the non-SMAB farms, and how beta diversity may differ between SMAB farm fields and forest and non-SMAB farm fields and forests. Chapter 4 is followed immediately by my Conclusion chapter, which synthesizes the results of this dissertation and discusses their implications.

The purpose of my dissertation is to understand political ecological systems like that of the food systems of Belo Horizonte, and bring an ecologist's rigor to understanding their functioning. Along with inspiring examples in Cuba and other projects already known and unknown to academic literature, models such as that of Belo Horizonte and others hold hope of workable solutions to the problems of hunger and malnutrition without aiding and abetting the destruction of the earth's ecosystems and our panoply of fellow organisms. There is the exciting possibility that a new Green Revolution, a Food Security Revolution, will start to fulfill promises of human rights and development often repeated since the UN declaration of 1948 and covenant of 1976. Ecologists, environmentalists, food and nutrition researchers and advocates must continue to cooperate and remain open to crossing classic disciplinary boundaries. Only through such integrative work and continuing examinations of the articulation of human policies with their underlying ecological systems, in particular food policies and agroecological systems, can

we conserve crucial and irreplaceable biodiversity. Only through such an endeavor can we strive to provide human rights like universal food security, anywhere and everywhere, from the Global South to the Global North, as part of truly sustainable development.

Figure 1.1. Belo Horizonte, Brazil. Fieldwork took place within Belo Horizonte itself and in the rural "greenbelt" areas immediately surrounding it, all within what was historically the Atlantic Rainforest. The approximate historical extent of the Atlantic Rainforest Region is outlined by the dashed line. As can be seen here, it encompassed most of Brazil's major cities, including Belo Horizonte but also São Paulo and Rio de Janeiro. Map is © Microsoft Corporation, 2005, reproduced here under Fair Use.

Figure 1.2. The "political ecosystem" of Belo Horizonte. Solid lines indicate direct effects of one system on another; the dashed line represents an indirect effect mediated by the intervening elements. After 1993, food institutions in Belo Horizonte changed to include SMAB; whether or not this influenced biodiversity such that "Biodiversity Level 2" > "Biodiversity Level 1" (and thus "Syndrome [of production] 2" would represent a more "biodiversity-friendly" set of practices) will be tested in Chapter 4.



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CHAPTER 2

FOOD SECURITY AND BIODIVERSITY: CAN WE HAVE BOTH? A POLITICAL ECOLOGICAL ANALYSIS

ABSTRACT

This paper examines two hypotheses relating universal food security and the preservation of global biodiversity: 1) that they can be accomplished through complementary means, or 2) that they are mutually exclusive. Widespread food insecurity and rapid biodiversity loss are among two of the most serious problems facing the world today. There are serious questions as to whether adequate food can be provided for the growing human population, which is predicted to peak at approximately 9-10 billion in 2100. There are similarly grave concerns regarding biodiversity loss, which is estimated to be progressing at a rate thousands of times the background extinction rate. Remedying the problems of food security and biodiversity loss is complicated by the fact that humans are already using a vast amount of the world's resources, and it is questionable as to whether we can increase our use without further compromising biodiversity. An extensive literature review was conducted in order to evaluate the two hypotheses. It was found that the current agricultural system provides sufficient food on a worldwide basis, but in doing so methodically undermines agroecosystems' capacity to preserve biodiversity. However, the evidence tentatively supports the hypothesis that food security and biodiversity preservation can be supported simultaneously using appropriate alternative agricultural practices.

KEY WORDS

Agroecology, alternative agriculture, biodiversity conservation, food security, organic agriculture, political ecology

BACKGROUND

Among the challenges facing the world today, the urgency of providing food security to the growing human population and slowing the rapid loss of irreplaceable biological diversity loom large.[1] A sense of urgency is warranted in both cases: estimates of the current rate of losses of biodiversity range from several hundred times the background (i.e., "natural") rate (Pimm et al.

1995) to between 1,000 and 10,000 times the background rate (Hanski et al. 1995, but see Ibáñez et al. 2006), and approximately 925 million people are malnourished today (Food and Agriculture Organization of the United Nations (FAO) 2008). In spite of a number of international efforts, including those of the countries party to the 2002 Convention on Biological Diversity and the attendees of the 2002 World Food Summit, neither problem seems on the verge of resolution. The loss of biodiversity is likely still accelerating (Gaston and Fuller 2007, Secretariat of the Convention on Biological Diversity (SCBD) 2002), with 1-10% of the world's species projected to be lost in the next quarter century, a rate comparable to the extinction event most famous for the demise of the dinosaurs at the end of the Cretaceous period (Hanski et al. 1995, Lawton and May 1995). The commitment made at the World Food Summit to reduce the number of malnourished people by half by the year 2015, to approximately 425 million people, has been made "much more challenging" in the words of the FAO: recent (since 2006) spikes in food prices and growing diversion of agricultural products to biofuels have effectively wiped out previous gains in decreasing malnutrition worldwide (FAO 2006, 2008, UNMP 2005). Nor did the Summit's commitment to halving malnourishment necessarily address the more than 2 billion people thought to be suffering from undernourishment in the form of dietary imbalances or specific deficiencies (UN Millennium Project (UNMP) 2005, World Health Organization (WHO) 1996). In reality, many of the countries that participated in the World Food Summit have seen and may continue to see an increase in malnutrition (FAO 2006, Rosegrant et al. 2001).

The problems of biodiversity loss and food insecurity are global in scope and cannot be viewed independently: in a world with limited resources the methods used to address one necessarily involve choices affecting the other. Human beings fix more atmospheric nitrogen than all natural sources combined (Vitousek et al. 1997), may consume as much as half of the planet's net terrestrial food supply in terms of photosynthetic production (Haberl et al. 2007, Rojstaczer et al. 2001) and are using approximately 40% of the earth's land surface for agriculture (FAO 2007), of which an estimated 16 to 40% is already lightly to severely degraded (Bruinsma 2003). Humans use more than half of all accessible surface water and significant amounts of the world's soil and groundwater are being appropriated as well, despite the fact that both agricultural soil and so-called fossil water from groundwater aquifers are essentially non-renewable resources (Ehrlich et al. 1993, Hillel 1991, Reisner 1986, Vitousek et al. 1997). Desertification, the extreme degradation of land resulting in the dramatic loss of biological and economic productivity, may affect as many as 250 million people and over 3 billion hectares of land, although this may be an overestimate – quantification is difficult and imprecise (Bruinsma 2003). Desertification's causes include overcultivation, overgrazing, deforestation, and poor

irrigation practices (Hillel 1991, United Nations Convention to Combat Desertification (UNCCD) 2004). It is clear that, as Vitousek et al. (1997) state: "[N]o ecosystem on Earth's surface is free of pervasive human influence." Our co-optation and use of such significant amounts of the world's resources necessarily carries profound consequences for the world's ecosystems and their ability to support biodiversity.

Malthus' simple dictum that a growing population will inevitably exceed its environment's limited capacity to produce food, despite ignoring a number of important complexities, contains an undeniable truth: an ever-increasing population will inevitably overtax its resource base in a finite world (Arrow et al. 1995, Malthus 1798, Vandermeer 1996). As Malthus' many intellectual inheritors have pointed out, starvation is just one of the consequences of a large and ever-growing population for both human society and the world environment. Although predictions of a population peak at or under 10 billion people by the year 2100 have been shown to be relatively robust (Lutz et al. 2001, O'Neill 2005), it has been proposed that the world cannot sustainably support more than 2 or 3 billion people, meaning that we will continue to dramatically erode the earth's biodiversity and ability to support life (Daly 1996, Pimentel et al. 1999, Smail 2003, Wackernagel and Rees 1996). Many researchers have concluded that the only or best way to meet these challenges is to produce more food with less land (i.e., agricultural intensification) (i.e., Balmford et al. 2005, Budiansky 2002, Ehrlich et al. 1993, Fresco 2003, Pinstrup-Andersen 2003, Trewavas 2002). Intensification will be necessary, according to their analyses, in order to alleviate the burden we put on the rest of the world's ecosystems, and to avoid further expansion into areas important for biodiversity conservation – although it is recognized to varying extents that this would only be a stop-gap measure, with many proposing population control and reduction as the most important long-term solution. Although such analyses may also mention complicating factors and other possible approaches, researchers with alternative analyses often place much greater emphasis on the roles played by poverty, gender inequity, racism, and lack of political will in creating hunger and preventing access to food. Proponents of such analyses generally advocate holistic, integrative, regenerative approaches to sustainability over agricultural intensification per se, and propose that political change, equity, decentralization, land reform, and/or democratization are what are required to provide universal food security and preserve biodiversity – maintaining that intensification and population reduction themselves are problematic and wholly inadequate or incomplete solutions (see i.e., American Dietetic Association (ADA) 2003, Dahlberg 1993, Drèze and Sen 1989, Lappé et al. 1998, Sen 1994). A number of these issues are often brought together under the concept of "food sovereignty", the ability of a region or people to define their own agricultural, food, and land

policies that are ecologically, socially, economically, and culturally appropriate (International Steering Committee of the Forum for Food Sovereignty (ISC-FFS) 2003). However, under any scenario or suggested solution, in order to evaluate our choices we must first understand how food security and biodiversity are related to each other.

HYPOTHESES: FOOD SECURITY AND BIODIVERSITY

Granted that the null hypothesis of the relationship between food security and biodiversity (i.e., they are independent of one another) is not supported based on the information reviewed in the Background, two alternative hypotheses of their relationship naturally arise:

1) The goals of food security for the present and future population and preservation of earth's endangered biodiversity are inevitably contradictory, or
2) The two goals are complementary.

These hypotheses intentionally avoid a number of important complexities in order to address the simplest possible questions of feasibility, questions equally vital as those regarding implementation and societal change. It is also important to note that this work deals mostly with agricultural production, as distinct from food systems. A food system entails not just the production of food, but the commercialization, consumption, disposal, politics, and institutions of food – all areas that will need to be (re)designed sustainably at local, regional, and global scales in order for agricultural production itself to be truly sustainable (Dahlberg 1993). Thus, confirmation of our hypotheses in this work will in reality indicate conditions and/or methods necessary, but not sufficient, to food security and conservation within a context of agricultural production. Given these caveats, we will examine these hypotheses and evaluate them in a review covering the relevant fields of economics, agriculture, social policy, political ecology, and environmental/ecological economics. Pre-existing, related literature reviews were used when possible, to analyze current knowledge and understandings while noting both the predominant and dissenting views. Where these were not available in the extant literature, an attempt to qualitatively evaluate, summarize and present a representative selection of the larger number of articles reviewed was made, similarly noting differing viewpoints. In these cases, we acknowledge that positive or negative results from specific cases themselves may not be generalizable. However, it is possible even in such cases that lessons learned from them can then be used to help extrapolate technical feasibility. Generally speaking, the aim of this paper is to

evaluate minimum theoretical and technical feasibility, rather than a specific roadmap to the future in terms of agriculture and biodiversity.

In terms of the structure of the paper, our analysis starts with **State of the Biosphere: Global Food Security**, an overview of the current state of global food security, along with a review of two different broadly defined approaches to agriculture ("alternative" vs. "conventional") and the implications for food production from each approach. The following section, **State of the Biosphere: Global Biodiversity** conducts a brief examination of the different types and definitions of biodiversity, the estimates of total global biodiversity, and how agricultural land use is related to biodiversity loss. The third section, **Alternative Production**, follows up on this by attempting to address the questions of whether alternative agriculture can provide enough food for the world population, and whether it can generally be said to better sustain biodiversity than conventional agriculture. A fourth section, **State of the State: Regional Food Security and Biodiversity**, examines how our findings at the global scale hold up at a regional-level analysis, and briefly presents several case studies to illustrate. **Other Considerations** reviews several topics not covered in the paper proper. Lastly, **Conclusions** reviews and expands on the synthesis of the literature presented and whether, based on this, one of the above hypotheses can be tentatively confirmed.

STATE OF THE BIOSPHERE: GLOBAL MEASURES OF FOOD SECURITY

While global food security (i.e., suitable and sufficient food for the entire human population) is insufficient to guarantee regional food security (i.e., on a per-nation basis), it is nonetheless an important prerequisite – the inability to generate sufficient food on a worldwide basis necessarily means that some or all regions of the world suffer from food insecurity. Therefore, our analysis will start with global food security before continuing on to the more complex issue of regional food security.

Current food production systems encompass the spectrum from high-input, highly technified industrial practices to traditional, indigenous agricultural systems that have been developed over thousands of years (Altieri 1990, Bruinsma 2003, Netting 1993, Rosset 1999). At the high-input-technified-industrial end, what are typically termed "conventional practices" include a dramatic reduction of biodiversity to allow specialization in fewer high-input crops (Buttel 1990, Evenson and Gollin 2003, Matson et al. 1997, Vandermeer and Perfecto 1997). Fundamentally, conventional agriculture encourages and rests on ideas of increasing centralization/consolidation, arguments of economic efficiency, functional separation, and control over nature such that it is, in many ways, just another commodity. The inputs in conventional

intensive agriculture are synthetic fertilizers and pesticides, usually produced with heavy use of fossil fuels (creating problems both in terms of the non-renewability of fossil fuels and their negative effects on the environment, especially global climate change), applied in order to subsidize the continual extraction of soil nutrients in the first case, and to reduce yield loss from competition and herbivory in the second (Buttel 1990, Tinker 1997). Along with a high degree of mechanization (traction, harvesting, etc., again involving heavy fossil fuel use) and irrigation in most cases, these practices characterize the endpoint of much of modern agriculture (Dahlberg 1993, Giller et al. 1997, Izac and Sanchez 2001), although the actual degree of adoption of each practice varies enormously. At the other end of the agricultural spectrum is the broad category of alternative agriculture, which ranges from traditional indigenous practices to the US organic system codified in 2002. More than a dozen terms have been used for these closely related methods, including low-input, sustainable, ecological, agroecological, biological, and organic agriculture (Pinstrup-Andersen 2003), Integrated Pest Management (IPM), Integrated Plant Nutrient Systems (IPNS), and No-Till/Conservation Agriculture (NT/CA) (Bruinsma 2003, Lockeretz 1989, Merrill 1983, Vandermeer 1995).[2] In general, alternative approaches look to create or maintain a more holistic system, involving and integrating with natural ecological processes as much as possible, using high levels of recycling, and recognizing the fundamental interconnections between agriculture, human culture, and larger social issues in the rest of the food system, outside of the farms themselves (Dahlberg 1993). Indeed, the National Research Council (1989), rather than characterizing alternative agriculture as a certain methodology, defined it as a range of management and technological options used to reduce costs, protect health and the environment, and enhance biological interactions and natural processes. Lockeretz (1991) and Bruinsma (2003) similarly considered the many different alternative practices as complementary methods targeted at improving sustainability. The methodological differences between alternative and conventional agriculture include: lowering or eliminating pesticide use, elimination of mechanization where practical (thus lowering reliance on non-renewable petroleum fuels), and lowering or eliminating inorganic fertilizer use. The reduced external and inorganic inputs are replaced by various natural ecosystem processes, including: lengthened fallow periods and green manuring, crop rotations, intercropping, greater diversity in animal and crop species, and natural predators as pest control. As with conventional agriculture some, all, or none of these practices may be adopted, but taken exclusively, alternative practices will represent the opposite end of the production system spectrum.

The use of conventional agriculture has grown rapidly since the 1950s and today dominates the world system in terms of land area (Evenson and Gollin 2003), while organic

agriculture today accounts for approximately 0.7% (30 million ha) of agricultural land in the world (Willer and Yussefi 2007, based directly on data from 123 countries — meaning it is almost certainly an underestimation).[3] The additional 62 million hectares of registered areas with "organic wild collection" could also be considered to be under alternative agricultural management; they occupy a total area equal in size to 1.1% of global agricultural land (Willer and Yussefi 2007). The use of inputs on the ~98-99% of land where alternative practices are not used has grown to such an extent that the former Assistant Director General for the FAO's Agriculture Department estimated that fertilizer application accounts for 43% of the nutrients that global crop production extracts each year (Fresco 2003). Assuming further intensification, Fresco estimated that fertilizer application might account for up to 84% of nutrients extracted in the future. So can this current and future regime of intensive agriculture provide enough food to feed the world?

As was mentioned in the Background section, many researchers have long assumed or concluded that population growth is a primary cause of past, present and future world food insecurity, and correspondingly advocate increasing intensification of agriculture as a (usually short-term) solution. However, to re-state the earlier point, many contend that the problem is not as simple as Malthusian principles would have it, and that population size, food availability, and food security have a rather more complex relationship. This is apparent when one considers the world's 850 million malnourished persons, several billion people with the "hidden hunger" of less severe deficiencies, and that nearly 80% of all malnourished children in the "Developing" World live in countries that report food surpluses, all while the per capita food availability for the world is close to 2,800 calories per day (Bruinsma 2003, Gardner and Halweil 2000).[4] In fact, despite population growth since 1961, per capita food availability for the world increased by 24% in the same period, (Bruinsma 2003, FAO 2007). Further, projections indicate that between 2,860 and 3,015 calories per capita per day will be available in the "Developing" World (and ~3,480 calories in the so-called Industrialized Countries) in 2020, with 3,070 calories per capita per day available in the "Developing" World (and 3,540 calories in the Industrialized Countries) in 2050, when human population size is projected to reach 8.9 billion (Alexandratos et al. 2006, Rosegrant et al. 2001). The recommended daily intake of calories is approximately 2,200 (Center for Nutrition Policy and Promotion (CNPP) 2000, FAO/WHO/UNU 1985).

It is widely thought that given the projected human population of 9-10 billion people, the expansion of agricultural land will be necessary in addition to intensification in order to provide enough food to feed the world in the future. To avoid or at least mitigate such expansion's encroachment into biodiversity-rich areas, the use of genetically modified (GM) crops is often suggested in order to push intensification as far as it can go (Balmford et al. 2005, Fresco 2003,

Trewavas 2002). However, a number of factors point to caution in regards to GM crops' potential to aid global food security. For example, even though yield gains can be expected in certain circumstances (see i.e. Lipton 2007, Saito and Miyata 2005, Zilberman et al. 2007), conventionally bred non-GM alternatives may allow similar benefits in some crops (Goodman 2002, Uphoff 2007). Indeed, GM crops may require equal or greater development time while costing 25 to 50 times as much as conventionally bred varieties with comparable performance; GM research may also draw scientists and resources away from effective alternative methods (Goodman 2002). Additionally, despite the promised yield gains and other benefits for poor and small farmers (see i.e., Herring 2007), GM crops have presently mainly benefited large farms and multinational companies, and have only infrequently been applied to problems most pertinent to poor and marginal farmers (García González 2007, Monastra and Rossi 2003, Uphoff 2007, Verhoog 2007). The possibility of health risks to humans and animals still remains, though studies in this area have been both contradictory and controversial (see i.e., Ewen and Pusztai 1999, Filipecki and Malepszy 2006, Malatesta et al. 2005, Schubert and Freese 2004, Semal 2006, Séralini et al. 2007, Wilson et al. 2004, but see, Brake et al. 2004, Doull et al. 2007, Larkin and Harrigan 2007, and Sanden et al. 2006). In regards to environmental effects, it has been concluded by some researchers that many of the relevant fears have not been realized to date (Sanvido et al. 2007). However, this does not negate nor establish the overall likelihood of the relevant known and unknown ecological risks posed by genetic modification – many successful and destructive invasive species have remained at low abundance for decades before explosively increasing (Lewis and Kareiva 1993, Letourneau et al., unpublished data, Saito and Miyata 2005, Shirai 2007, Tomov and Bernal 2003). These ongoing debates provide compelling reasons to fully embrace the "precautionary principle" in regards to GM crops, especially in light of the fact that this "upgrade" to conventional agriculture will not necessarily change other crucial food security requirements such as local access or global distribution, and may in fact aggravate the very situation such crops are meant to address (Yapa 1993, but see Stone 2007, Stone et al. 2002).[5]

The expansion of agricultural land seems very likely to encroach further into tropical forests and other biodiverse areas, where access and distribution problems can loom largest (Angelsen and Kaimowitz 2001, Angelsen 1999, de Sherbinin et al. 2007, Sloan 2007). A projected increase in agricultural land of 25-28% would produce as much as 3,050 calories per person per day for a population of 9 billion (Bruinsma 2003). However, if distribution and local access are addressed, the amount of extra agricultural area needed will be diminished – a likely necessity in any case, as it is estimated that upwards of 75%-90% of the land suitable for

agriculture is already in use (Sloan 2007, Young 1999). Meanwhile, the argument that intensifying agricultural land use (usually with conventional means) to produce more food on less land will "save" extra land for biodiversity (see i.e., Balmford et al. 2005, Tilman et al. 2002) may not be valid in its own right – beyond the fact that it ignores the effects of agricultural matrices on adjacent natural habitats (see Dorrough et al. 2007, Perfecto and Vandermeer 2008, Vandermeer and Perfecto 2007, and discussion in the next section). In two classic studies, one evaluating a set of 19 empirical and theoretical cases (Angelsen and Kaimowitz 2001) and another reviewing 146 analytical, regression-based, and simulation-based models (Angelsen and Kaimowitz 1999), the two researchers determined that intensification – increasing yields per unit labor or unit capital – is strongly correlated to greater deforestation. The basic explanatory mechanism is rooted in elementary economics (and illustrates the dangers of an analysis that does not look beyond a strictly technical production context). An increase in labor and/or capital efficiency encourages in-migration of new agriculturalists and encourages individual farmers to increase forest clearing, due to the fundamental economic pressure to take advantage of successful high-yielding practices. In contrast, intensification that increased yields per unit area, but with greater labor demands, was found to generally avoid spurring such in-migration and expansion. Therefore, if the discussion is about "saving land" for biodiversity, maximizing productivity per unit land area would be preferable to labor efficiency, and maximizing land productivity with increased labor would therefore presumptively do more to obviate the need for agricultural land expansion (not to mention the potential to alleviate rural unemployment and urban in-migration from the countryside in many areas of the "Developing" World (Badgley et al. 2007).[6]

Strictly with respect to food security, it is not even clear that more land is necessary to produce sufficient yields to adequately feed the world (making the "saving land for nature" argument superfluous). Indeed, a recent study by Badgley et al. (2007) implies that intensification in "Developing" Countries using alternative or conventional methods may be able to increase production on the current land base sufficient to provide enough food on a caloric basis for a world population of even 10 billion people.[7] As alternative agricultural methods tend to be labor-intensive, they potentially negate the economic pressures for expansion elaborated by Angelsen and Kaimowitz. If it is therefore possible for alternative agriculture to provide sufficient yields, maintain a higher level of biodiversity, and avoid creating economic incentives for expansion, it would indicate that the best solution to both food security and biodiversity problems would be widespread conversion to alternative practices.

Such comprehensive and relatively robust results suggest that global food security is already possible today, and plausible for the future, even with a larger population. The necessary implication is then that, on a caloric basis, the problem of food insecurity is a matter not of total availability but indeed one of local access, political power, and equity. The fact that sufficient food supply is often available even in areas suffering from famines or persistent malnourishment belies the idea that today's billions of food insecure people are a result of insufficient production, leading the FAO, among many others, to argue that poverty is the major cause of malnutrition, as well as a result of it (ADA 2003, Drèze and Sen 1989, FAO 2006, FAO 2002, Patnaik 1991). The problem of food security is not one of global supply then, but of a need for equitable global distribution and local accessibility, which implies that further conventional agricultural intensification is unneeded in the short, and possibly long terms.[8] Additionally, with severe on-farm decreases in biological diversity occurring as a result of modern agriculture's focus on monocultures, simplification, and specialization, conventional intensification may not only be unneeded for food security, but also directly antithetical to biodiversity.

STATE OF THE BIOSPHERE: GLOBAL BIODIVERSITY

Biodiversity, like food security, is a regional as well as global property, and it can be divided into a number of interdependent levels. Such levels include genetic diversity, species and subspecies diversity, diversity of functional traits, diversity between populations or communities of species, ecosystems or habitat diversity, diversity among large landscape zones, and global diversity (Bisby 1995, Hooper et al. 2005, Swift et al. 2004). For the purpose of this review, biodiversity can be assessed globally to the extent that the rate of global loss represents a composite of the rates of regional loss – taking into account that extinction of unique or indigenous biodiversity represents its global loss by definition. At the core of all biodiversity concepts is the recognition that there are measurable, (semi-)regular, and classifiable variations between organisms and ecosystems at a variety of scales, and that when the ultimate source of such variation is wiped out, a unique form of being or place may be forever lost.[9]

Agriculture, occupying approximately 40% of the world's land surface (excluding Antarctica), represents perhaps the biggest challenge to biodiversity, in the form of environmental effects of intensification as well as agricultural land's potential future expansion (Bruinsma 2003, FAO 2007). In comparison in terms of land use alone, the global network of protected wildlife areas is estimated to cover 12% of the global land area. Less than half of these areas are specifically set aside to protect biodiversity rather than for recreation or other mixed use (Brooks et al. 2004). Similarly, Rodrigues et al. (2004) estimated that 12% of the 11,633 species of birds,

mammals, amphibians, and reptiles they studied live completely outside of any protected area. Ferrier et al. (2004) estimated that 43% of all terrestrial plants and invertebrates live in these "gap areas," and a number of studies have found that the persistence of numerous organisms living within protected areas or native habitat fragments depends to a greater or lesser extent on habitat outside of such areas – that is, the matrix of the surrounding landscape (Daily et al. 2001, Perfecto and Vandermeer 2008, Ricketts 2001, Stouffer et al. 2006, Tscharntke et al. 2007, Vandermeer et al. 2008, Vandermeer and Perfecto 2007, Vandermeer and Carvajal 2001). Such matrix areas very often are in use for agriculture, as may be expected from its commonness as a land use. The need to integrate the matrix/"gap areas" in general and agriculture in particular into the conservation of biodiversity is thus quite clear.

While today's accelerating decreases in biodiversity cannot be laid solely at the feet of intensive agriculture, intensification does directly and indirectly account for a number of (arguably the most significant) threats to biodiversity (Bruinsma 2003, Tscharntke et al. 2005). (Intensification and its effects will be discussed in detail in the next section.) At the most extreme, overintensification and/or mismanagement of an agricultural area can destroy the capability of its ecosystem to support diverse lifeforms, creating and expanding literal and biological deserts (Hillel 1991, Sivakumar 2007, UNCCD 2004). And as was discussed in the previous section, economic pressures from certain forms of intensification, as well as urbanization and diet change, can increase rates of deforestation and its usual concomitant loss of biodiversity (Angelsen and Kaimowitz 2001, Buttel 1990, Schroth et al. 2004, Sloan 2007).[10]

Given the scope and complexities involved, exact estimates of biodiversity loss are difficult at best, making estimation of the species lost solely due to agriculture or population expansion nearly impossible. Today, there are an estimated 13 million species in the world (though estimates range from 3 million to 111 million). As outlined in the background, the current rate of species loss is thousands of times higher than the rate estimated for most of evolutionary history, with the rate of loss only increasing (Gaston and Fuller 2007, Lawton and May 1995, SCBD 2002). Habitat loss is the most significant cause of the accelerating rate of extinctions (Hanski et al. 1995). Given that agriculture occupies (and has impacts on) a large and growing amount of land, the connections shown between agricultural management, habitat loss and biodiversity make it clear that management of human food systems will significantly affect the progression of the biodiversity crisis.

ALTERNATIVE PRODUCTION

The current global availability of 2,800 calories per capita per day can be taken as an apparent success of conventional agriculture (FAO 2007, but see Note 8). That is, today's intensive agriculture can and does provide sufficient food for global food security in terms of raw calories. Furthermore, the likely negative correlation between intensive agriculture and biodiversity has been reviewed. Is, however, an alternative system possible that mitigates this inverse relationship? That is,

1) Can alternative production methods provide a comparable level of (global) food security?
2) Can alternative production methods sustain a higher level of biodiversity?

Food security from alternative agriculture

Many doubt then that alternative agriculture can comparably meet the needs of the world's growing population (Avery 2007, Emsley 2001, Fresco 2003). These researchers and others have maintained that only intensive agriculture is capable of producing the high yields necessary to feed the world, and that alternative agriculture is economically infeasible, requires higher management skill, and even that organic agriculture degrades the soil. Occasionally, alternative agriculture is so completely dismissed that it does not even bear direct mention (i.e., in Evenson and Gollin 2003).

However, there is a significant and growing amount of literature specifically addressing the critiques above. Many scientists have obtained results contrary to the idea that alternative agriculture cannot provide enough food for the world. A review by Rosset (1999) provides an analysis suggesting that alternative methods used on small and family farms have great potential for productivity. He portrays an alternative route to ample production by smaller, less chemically and mechanically intensive and more ecologically friendly farms. Published data shows that small farms almost always produce far higher output levels per unit area than larger farms, this phenomenon has been called the "inverse relationship between farm size and output" (Assunção and Braido 2007, Barrett 1996, Cornia 1985, Feder 1985, and a review by Heltberg 1998).[11] Among the reasons cited for this relationship are: 1) multiple cropping; 2) more efficient use of irrigation; 3) relatively higher labor quality and better supervision (likely due to the use of family labor with a greater stake in farm success rather than alienated outside workers), and 4) non-purchased inputs as opposed to the agrochemicals of large-scale intensive agriculture (Kirner and Kratochvil 2006, Lappé et al. 1998, Netting 1993, Oduol and Tsuji 2005, but see Benjamin 1995,

Bhalla and Roy 1988, Lamb 2003). Further, a recent study by Badgley et al. (2007) found that alternative methods could produce enough food on a global per capita basis to sustain the current human population, and potentially an even larger population, without increasing the agricultural land base. The study concluded that a hypothetical worldwide alternative agricultural system could produce between 95% and 157% of the calories produced presently, without land expansion and with no net increased resource use from the present predominately conventional system (see Note 8 for more details of this study). This is in addition to the body of empirical and theoretical literature connecting alternative agriculture's utilization of higher crop diversity to higher stability in yield – that is, less variation in yield year-to-year (see i.e., Di Falco and Perrings 2003).

Rosset's 1999 work suggests that in "Developing" Countries, the small family farm is central to long-term management and agricultural sustainability. Such systems may use methods based on thousands of years of experience (Altieri et al. 1987, Netting 1993, Struever 1971, Ucko and Dimbleby 1969). Prolonged tenure on the same land means that the small farmer risks collapse of her farm in the long-term due to ecological degradation when wagering short-term gain against sustainability. Awareness of this long-term risk and, importantly, secure land tenure, can lead to higher and more stable production from family farms in comparison to larger farms in the same region, in part due to practices to minimize and reduce degradation (D'Souza and Ikerd 1996, Rosset 1999, Templeton and Scherr 1999).[12] Labor-intensive practices may be used to enhance soil conservation and fertility, allowing harvesting with minimal reliance on industrial inputs (Netting 1993).

The FAO (Bruinsma 2003) found that the use of integrated plant nutrient systems (IPNS) can provide for 10 to 30 percent greater efficiency in fertilizer use, and therefore the ability to apply less fertilizer for the same benefit level. The FAO also found that no-till/conservation agriculture (NT/CA) avoided the problems of degradation and unsustainability seen in conventional soil tillage, reduced the need for herbicides and raised yields by 20 to 50 percent over conventional methods. Additionally, Bruinsma (2003) found that the introduction of plant protection based on integrated pest management (IPM) was able to help avoid overdependence on pesticides while generating good to dramatic improvements in production and a simultaneous reduction of costs in some cases. Similar results for IPNS, NT/CA and IPM have been found by Pretty et al., (2003, surveying 89 projects), Pretty et al., (2006, surveying an additional 218 projects), and Uphoff (2007), among others.

While such examples provide some evidence that alternatives to intensive agriculture exist that may be viable in terms of necessary yield and sustainability, the economic viability of

alternative practices remains to be addressed. As Madden (1987) points out, an agricultural system requiring financial suicide on the part of the farmer cannot be said to be sustainable. However, there are indications that the economic performance of alternative farming systems can be comparable to, if not better than, that of conventional farming systems. This is supported by work at national levels as well as within-farm levels (Greene and Kremen 2003, 2002, Madden 1987, Offermann and Nieberg 1999, Pacini et al. 2003, Padel and Lampkin 1994, Smolik et al. 1995). The findings of Smolik (1995) support the conclusions of Rosset (1999) by suggesting that the widespread adoption of organic farming in their study system would tend to counter the trend of increasing farm size: conventional farming was calculated to require a greater area for the same level of profitability as a smaller organic farm in most cases. Additionally, supporting the viability of alternative agriculture in terms of the level of difficulty in its management is the work of Pacini et al. (2003), Lockeretz (1995), and the comprehensive survey of sustainable farms by Pretty and Hine (2001). The conclusions from these studies imply that the management requirements of sustainable agriculture, if at all higher than in conventional agriculture, can be overcome with local and international educational initiatives – though the political, logistical and economic obstacles to such initiatives may be significant in some cases (Pretty 2008).

On the other hand, Bruinsma (2003) points out that organic agriculture carries the financial burden of finding a different set of appropriate inputs (i.e., non-GM seeds, green manure), and that an increase in the supply of organic foods would lead to a decline in the premium prices assumed to maintain profitability. However, in addition to the work cited above, a number of studies point out the extremely high direct and indirect costs of conventional agriculture (including decreased energy efficiency and environmental damage from pesticide and fertilizer run-off and the burning of fossil fuels), and that organic or alternative agriculture can be comparably profitable, in some cases even when subsidies are not subtracted from the profitability of conventional farming (Faeth and Crosson 1994, NRC 1989, Stockdale et al. 2001, Tilman et al. 2002). Profits from alternative agriculture may also be less variable, providing farmers with greater predictability and flexibility (Di Falco and Perrings 2003, Pimentel et al. 2005).

In sum, there is evidence to support the proposition that alternative agricultural methods can provide enough food, on the global scale, to provide a comparable level of food security as can conventional agriculture. Further, there is even a real possibility that alternative agriculture can provide food security more efficiently and with higher profits for small farmers.

Production method and biodiversity

Thus far, the information reviewed implies that (conventional) agricultural intensification is unnecessary for global food security, as alternative agriculture may have the potential to generate as much or more food. When one additionally considers agriculture's effects on biodiversity, and the effects biodiversity may have on system stability, sustainability, adaptability, and resistance to invasion by exotic organisms (Hooper et al. 2005), it becomes clear that further evaluation of the mechanisms of biodiversity's interactions in agriculture is necessary. This section will review such mechanisms and how they are typically affected by alternative and conventional practices, keeping in mind that agriculture is an important, but far from the only, aspect of human food systems affecting biodiversity and sustainability.

Broadly, a recently meta-analysis found that alternative agriculture increases biodiversity in most cases, with an average of 30% higher species richness and 50% greater organismal abundance, though this varied among the studied taxa and spatial scale (Bengtsson et al. 2005). For this reason and others, agricultural ecologists commonly find it useful to distinguish between planned and associated biodiversity in agroecosystems (Perfecto et al. 1997, Swift et al. 1996, Vandermeer et al. 1998). Planned biodiversity is determined by the combination of the biological components chosen by an agroecosystem's manager (i.e., crops/crop varieties and livestock) and those eliminated (i.e., weeds and herbivores). In addition to this biodiversity planned by the manager, there can be a great number of species and species varieties distributed throughout an agroecosystem as a result of interactions with the species and land management practices chosen by him or her. The amount of inputs, the degree of mechanization and the size and type of crops or livestock determine the structural complexity and possible linkages available to other organisms, in effect determining the number of niches available (Armbrecht and Perfecto 2003, Lavelle and Pashanasi 1989, Matson et al. 1997, Moguel and Toledo 1999). In turn, the planned and associated biodiversity along with the land management practices complexly influence various ecosystem functions, including resource capture by the crops, pest and disease resistance, stability in response to environmental perturbation, and reproduction (Kibblewhite et al. 2008, Tscharntke et al. 2007, Tscharntke et al. 2005, Vandermeer et al. 1998). Specifically, a positive association between planned and associated biodiversity has been, according to Vandermeer et al. (2002), established "beyond credible doubt" for vertebrates, arthropods, and non-crop plants, based on their review of over 30 studies on biodiversity and ecosystem functioning. Associated microbiological biodiversity showed either a positive or insignificant association with planned biodiversity in the papers reviewed, with positive, negative, or insignificant associations shown as well elsewhere (i.e., see review by Hooper et al. 2000, Kibblewhite et al. 2008).

Recent works further support the findings of Vandermeer et al. (2002) for the biodiversity of "higher" (that is, macroscopic) organisms. Some examples from the extant literature include: vertically complex edge habitats – planned structural biodiversity – have been found to support a rich diversity of bird species (Hughes et al. 2002); Luck and Daily (2003) suggested that increasing planned biodiversity in the Costa Rican countryside would support diverse avifauna that could, in turn, contribute substantially to the dispersal of rain forest plants and thereby encourage even further associated biodiversity; higher species richness of ants was found in a polycultural coffee plot versus a monocultural one (Armbrecht and Perfecto 2003), and Beecher (2002) and Petit and Petit (2003) similarly found that organic cornfields and shade coffee plantations, respectively, had higher avian species richness and were more important to conserving biodiversity than conventional systems. These studies are what the authors consider a representative sample of the overall literature in this area, which largely confirms the findings of Vandermeer et al. Thus we conclude that it can reasonably be expected that macroscopic associated biodiversity will increase with planned biodiversity in a large majority of cases.

Further exploring differences in planned, and therefore, associated, biodiversity, it is useful to compare what pertinent, if broadly drawn, differences there might be between alternative and conventional agriculture. While there is not a direct line of practices and procedures to connect them on the spectrum between their extremes, a generalized outline can be made (Swift et al. 1996, Swift and Anderson 1995). What follows is, again, based on what we consider representative samples of a very large and complex literature.

Two general goals are part of modern agriculture: more frequent use of the same area of land (i.e., decrease or elimination of fallow periods) and increased specialization of productive species (loss of plant biodiversity, usually in the pursuit of higher yields and ease of mechanization). The extended fallow periods in traditional agriculture are abandoned in order to use the same area of land every year or for continuous production. Such loss of extended fallow periods perhaps has its most notable effect in agroforestry systems. In such systems, the shift from extensive, shifting cultivation to shortened fallows or continuous cultivation and the use of chemical fertilizers can threaten the ability to conserve native forest and the associated biodiversity of wild plants, terrestrial and understory insectivorous forest birds, and organisms that live only or primarily in the secondary growth of long-term fallow (de Jong 1997, Finegan and Nasi 2004, Jessup 1981, Somarriba et al. 2004, Whitmore 1984).

Outside of agroforestry, modern agriculture's more frequent use of the same area of land means annual cropping and frequent, short, and/or bare fallows, which have been found to be disruptive to soil micro- and meso-organismal communities, especially as compared to perennial

crops (Campbell et al. 1999, Campbell et al. 1991, Chander et al. 1997, Neher and Campbell 1994, Zentner et al. 2004).[13] The key factor in mitigating such disruptions and in maintaining soil health and biodiversity appears to be a steady feed of below-ground carbon substrate, i.e., as provided by continuous vegetative cover and rooting systems, whether this is provided by perennial crops, leguminous green manure, or non-leguminous cover crops – although synthetic (inorganic) fertilizers can also mitigate soil degradation and concomitant biodiversity loss to some extent in intensive conventional systems, even independent of the fallow regime (Kibblewhite et al. 2008, Pimentel et al. 2005). However, inorganic fertilizer application (and over-application) can instead itself degrade soil quality in some instances (Biederbeck et al. 1996, Demkina and Anan'eva 1998, Ukrainetz et al. 1996), though this is likely not a direct toxic effect but rather the result of associated practices and complex, ill-understood interactive effects on soil carbon cycles (Kibblewhite et al. 2008).

Other differences in normative practices between conventional and alternative agriculture also affect soil health and biota. Increases in mechanization (tillage and compaction from machinery) have near-universally negative effects on populations of soil communities, from microbes to carabid beetles, and the effects of pesticides broadly mirror those of mechanization – although in both cases species or functional group population sizes are sometimes affected much more than biodiversity itself, which may raise chances of local extinctions but is not necessarily detrimental to ecosystem functioning in the short-term. Such negative effects on population sizes and/or diversity in turn **can** have negative effects on yield, though much more research is needed in all areas studying soil health, intensification, and agricultural practices (Foissner 1997, Fox et al. 2007, Kibblewhite et al. 2008, Neher 1999, Pimentel et al. 2005, Tscharntke et al. 2005, Vannette and Hunter, in review).[14]

Returning aboveground, biodiversity in the agroecosystem can be decreased further when traditional, diverse, locally adapted crop varieties with resistance to native diseases and pests are abandoned and intercropping is halted in favor of high-yield monocultures. Such extreme specialization can be encouraged or even dictated by adoption and intensification of mechanization (Altieri 1990, Buttel 1990, Ramakrishnan 1992, Salick and Merrick 1990, Vandermeer 1989). For example, as opposed to the seven domesticated species and several thousand land races of potatoes that Zimmerer (1998) found in traditional Andean agriculture alone, Soule et al. (1990) found that between 10 and 20 different crops provide about 85 percent of the world's calories. The narrow range of crop species planted in modernized conventional systems additionally represents a loss of structural diversity as it replaces multi-strata vegetation and complex crop patterns (Fageria 1992, Vanderplank 1984, in Swift and Anderson 1995,

Vandermeer 1989). This loss of crop diversity, along with lower or non-existent levels of non-grain biomass and the increasing size of planted monocultures increases isolation from native habitat fragments and contributes to losses in planned and associated biodiversity, especially in invertebrate consumers, predators, and pests (Altieri and Liebman 1986, Klein et al. 2006, Tscharntke et al. 2007, Tscharntke et al. 2005). The genetically uniform, higher-yielding hybrid crop varieties of conventional agriculture are additionally often less resistant to pathogens and pests, especially given the highly dense and structurally simple concentration of food or host plants – meaning that they may fall prey to new or adapted parasites.[15] When conventional varieties are monocultured, the pests attracted by such a buffet of their food items then tend to dominate the agroecosystem at further expense of biodiversity, while the planned and associated biodiversity of polycultural plots often includes useful pest predators, which reduce pest damage in many cases, thereby increasing yield (Andow 1991, Gurr et al. 2003, Kromp 1999, Loya-Ramirez et al. 2003, Root 1973).[16] Indeed, in contrast to the large reductions in biodiversity that are normatively seen in monocultural and conventional agroecosystems, a significant amount of work notes the benefits to biodiversity of indigenous planned polycultures (Altieri 2000, Altieri et al. 1987, Finegan and Nasi 2004, Leakey 1999, Moguel and Toledo 1999, Oldfield and Alcorn 1987, Somarriba et al. 2004, Toledo 1990), and even certain forms of swidden agriculture (de Jong 1997, Fox et al. 2000, Schmidt-Vogt 1998).[17] In turn, local-scale agricultural diversity is both supported by and contributes to biodiversity at the landscape-level, as part of a more broadly diverse mosaic of agriculture and natural habitat fragments (Tscharntke et al. 2005). And lastly, as compared to less-diverse systems, diverse agricultural systems offer the possibilities of redundancies and resilience in the form diverse ecological responses and functions that can be a form of "insurance" for temporal and spatial sustainability; this is especially important when considering changing yearly or long-term environmental variation (i.e., global climate change), disaster and extreme weather events events like hurricanes, droughts or floods, and landscape- or regional-level conservation (Hooper et al. 2005, Holt-Giménez 2002, Kibblewhite et al. 2008, Lin et al. 2008, Tscharntke et al. 2005).

Without such "insurance" and resilience, systems that are intensified and simplified end up with their yield (and profit) much more dependent on an "optimized" environment, defined by high-input, irrigated, fertile zones free from disease, rather than local or changing conditions in any given agricultural area (Ceccarelli 1995, in Rhoades and Nazarea 1999, Tilman et al. 2002, Witcombe et al. 1996). To keep an optimized environment, wide-spectrum pesticide applications are used to control pests, but they can also wipe out useful pest predators that may come as stragglers or newcomers (Swift and Anderson 1995). Pests meanwhile persist through resistant

individuals and their progeny, leading to continually diminishing effect of pesticide applications (i.e., the "Pesticide Treadmill") (Pimentel et al. 1991, Russell 1993, van den Bosch 1978, Vandermeer 1996). Through bioaccumulation, overapplication, and runoff, these pesticides can additionally flow into the ecosystem outside of the farm and, along with fertilizer runoff, damage environmental and human health and cause secondary reductions in biodiversity in the surrounding environment, i.e. eutrophication and the infamous "Dead Zones," (Devine and Furlong 2007, Pimentel et al. 1992, Steingraber 1997, Tilman et al. 2002, Tonitto et al. 2007).[18]

The diversity of alternative agricultural practices seems to represent a distinctly different tact than conventional agriculture. Although the current agricultural regime provides a sufficient global (caloric) supply of food, with approximately 97% of agricultural land under conventional management and 3% under alternative methods, there are often serious reductions in biodiversity as a result. Following from the previous results, global food security is theoretically possible even if the current regime adopts alternative agriculture in whole or in part. Given that and the review presented in this section, the decision to use alternative agriculture may allow us to feed the world while preserving a higher level of planned and associated biodiversity at local, regional, and global levels.

STATE OF THE STATE: REGIONAL FOOD SECURITY AND BIODIVERSITY

The analysis thus far has taken a broad view of both food security and biodiversity. Having presented evidence that sufficient food (on a caloric basis) is being produced for the global human population, and that sufficient food could theoretically be produced as well under an alternative production regime supporting biodiversity, questions of regional food security arise. Global food security is a necessary result of regional food security, without the reverse being true: the fact that some regions of the world have sufficient food does not mean that all regions have food security. Global and regional biodiversity have a somewhat more complex relationship. There is not necessarily a given amount of biodiversity each region "should" have (as opposed to relatively absolute caloric and nutritional intake requirements for human well-being), with the (highly contentious) possibility that relatively high and/or low levels of biodiversity may lead to ecosystem characteristics undesirable from a human point of view (DeAngelis 1975, Frank and Mcnaughton 1991, Hairston et al. 1968, Hooper et al. 2005, MacArthur 1955, May 1972, Pimm 1979).[19] The consequence of this lack of absolute standards is that global biodiversity can be constructed as biodiversity maintained under an average or weighted extinction rate, leading to an approach to conservation that proposes that human impacts on biodiversity loss should be minimized to the extent possible, the limit being the background

extinction rate of any given ecosystem or region. Different ecosystems have different background extinction rates, so that even in an "optimally biodiverse" world, some regions could have higher "acceptable" rates of extinction than others. This is a completely different result than is acceptable for food security, where the normative goal is for each person in every place to have access to somewhere in the range of 2,200 to 2,800 calories per day. New local habitat can even, in principle, be created as old habitat is destroyed, or matrix quality retained such that endemic biodiversity reduction or species loss in general is minimized at the farm or even landscape level (Hanski 1999, Hanski and Gilpin 1997, Perfecto and Vandermeer 2002, 2008, Vandermeer and Carvajal 2001). Thus the idea of "making up" regional biodiversity so that it all averages out is a contrast to the goals of food security, which at the limit would have the egalitarianism of universal and equal access to sufficient and satisfying food (though not necessarily access to all of the same foods).

Therefore biodiversity analyses are by definition simultaneously local, regional, and global in scope, with each level requiring differing but complementary approaches, units of analysis, and data. Local information is high in detail but has limited scope; global analyses provide understanding of cumulative relationships and broad scope, but little resolution. While the actual act of agricultural production necessarily has its most immediate effects on local and landscape biodiversity, the effects of food systems span from the local to the global – meaning sustainable local agricultural changes are necessary, but insufficient, for global sustainability. Extended discussion of the larger-scale effects of food production on the environment and economy (i.e., global climate change for one) are ignored here by necessity; the reader is referred to, among others, Lockeretz (1989), Steingraber (1997), Tilman (2002) and Pollock et al., (2008, special issue on sustainable agriculture). Given the evidence that global security is possible in a manner less antagonistic to biodiverse ecosystems than current agricultural practices and therefore local and global biodiversity conservation, the question before us reduces to the following: is it possible to guarantee local food security with alternative agricultural methods?

This is not by any means a simple question with an easy resolution. Having established the productive capability of alternative methods, the difficulty involved in local food security is in part a question of distribution in the increasingly globalized nature of today's economic and social world. Alternative agriculture was traditionally considered by its very nature to be different from the cash crop and export agriculture that characterizes much of food production today – though this is changing (Pollan 2006, see also Note 12). Even when it is possible to produce food using alternative agriculture in a fashion similarly oriented towards globalization and current export/import regimes, it is considered undesirable for a number of reasons by many

practitioners, researchers, and advocates of alternative methods. Present global food surpluses have customarily led to lowered global food prices, decreasing many small farmers' economic power and in turn decreasing their actual food security, as measured by the ability to obtain food (Drèze and Sen 1989, Heller and Keoleian 2000, Lappé et al. 1998, Rocha 2001). Pinstrup-Andersen (2003) notes that distribution of global food surpluses lacks feasibility due to infrastructure constraints and would ultimately hurt the 75 percent of the world's poor and food insecure populations living in rural areas by co-opting the food markets they depend on for income.

Further, it is often maintained today that food insecurity stems from a lack of food sovereignty (defined here earlier as the ability of a region or people to define their own agricultural, food, and land policies that are ecologically, socially, economically, and culturally appropriate, ISC-FFS 2003). The lack of such can be seen as a failure of economic markets (Rocha 2003), independent of the biological situation. A full analysis of forces combating or aiding food sovereignty and their motivations is beyond the scope of this paper; the reader is additionally referred to work by Patel et al., (2007), Daly (1996), Sen (1984), and relevant publications by the non-profit organization FoodFirst. A cursory examination can also be found in the Conclusions of the present work.

Regional food security and biodiversity conservation: Tentative successes

The obvious alternative to complete global redistribution of food is to enhance self-sufficiency on a regional basis. Under the current climate of globalization and liberalization, greater food self-reliance is a concept rather contrary to most trends. Despite the goals of the 1996 World Food summit, reaffirmed in 2003, Pinstrup-Andersen (2003) asserts that it is a myth that the eradication of food insecurity is truly treated as a high priority by national governments, especially in light of the dubious progress made since 1996. A very few countries, including Cuba (FAO 2006, Funes et al. 2002, Pretty 2002) and, arguably, Brazil (Hall 2006, Rocha 2003) appear to have taken sustainable regional food security as a serious goal. Many more countries in theory could provide food security at the national level but do not have local food security, much less food sovereignty, as a goal. Additionally, the direction of agricultural policy in the "Developing" World is still somewhat uncertain, 5 years after the breakdown of the World Trade Organization meeting in Cancun in 2003 (Jacobs 2003, Nederveen Pieterse 2004, Ryan et al. 2008). It is therefore instructive to examine case studies to see what has been achieved today in terms of regional food security and greater food self-reliance.[20] Of the two cases presented, Cuba has experienced widespread adoption of alternative methods, while adoption in the Brazilian case

has been variable – though as we have seen, in terms of productivity, alternative and conventional methods are apparently comparable.

The program in Cuba appears to be by far the most ambitious. Cuba's food security program includes significant land reform, in the form of breaking large, conventional state farms into smaller, cooperatively-owned organic ones, starting new organic farms, and fostering urban and peri-urban agriculture (pers. obs., Funes et al. 2002). Increases in internal production of roots, tubers, vegetables and beans have been reported (though there have been decreases in other food categories), and reports indicate that produce for the capital city of Havana is almost entirely supplied by alternative agriculture in, or on the periphery of, the city itself (see Note 4 for more general comments on urban agriculture). These gains have been made despite the exigencies created by the collapse of the socialist bloc and the "Special Period" beginning in 1991. Though Cuba is still heavily reliant on imported agricultural inputs and food, Funes et al. (2002), Koont (2004), and Rosset (1998) have reported that acute food shortages have been largely eradicated due to improved national production. Cuba has also already met the Millennium Development and World Food Summit Goals for 2015, with less than 2% of its population regarded as undernourished and an estimated availability of 3,200 calories/person/day (FAO 2006). In terms of biodiversity and agriculture in Cuba, some farms have up to 180 species under cultivation, and integrated polycultures appear to be becoming the norm (pers. obs.).

Belo Horizonte, in the state of Minas Gerais in Brazil, is home to 2.5 million people, and one of the most comprehensive and ambitious regional food security programs in the world. In 1993, the city committed itself to the concept of food security as a right of citizenship with the creation of a new Secretariat of Municipal (Food) Supply (*Secretaria Municipal de Abastecimento*, or *SMAB*). Nutrition, equitable and efficient food distribution, and local supply are among the major goals of the Secretariat's programs. SMAB has seen reductions in infant mortality and infant malnutrition of at least 50% since its inception, and boasts significant citizen participation in its programs, such as the 12,000 people per day served at the city's subsidized "Popular Restaurants" (pers. obs., Aranha 2000, Rocha 2001). SMAB's progress on malnutrition and infant mortality has already surpassed the Millennium Development and World Food Summit goals, while Brazil as a whole is still progressing towards them (FAO 2006, Prefeitura de Belo Horizonte 2006). Although the aims of the program include guaranteeing its citizens adequate access to and distribution of food, in part by encouraging local supply, alternative agriculture does not itself represent a fundamental tenet of the program. It is, however, informally encouraged – many producers use alternative methods out of tradition, personal preference, or in search of price premiums – and SMAB plans to set up an office for educational information on

alternative methods (pers. obs., Aranha 2003, Rocha 2003). Though its administrators view their work as having just begun and hesitate to call SMAB a success already, its programs nonetheless serve as tentative examples of the possibilities of increasing regional food security. Additionally, considering the research presented earlier, the program could theoretically be equally effective using solely or primarily alternative methods to encourage the preservation of biodiversity.

OTHER CONSIDERATIONS

A number of issues, especially those pertaining to the social structures of food systems and agriculture, have been ignored or only briefly elaborated thus far. This section hopes to address some of these in slightly more depth, and to alert the reader to other sources of information on the social history of alternative and conventional agriculture and the pertinent energy issues.

A brief social history of modern agriculture

Modern analyses of food issues and institutions and their connections to biology and biodiversity date back at least as far as Malthus' ideas and their influence on Darwin's formulation of natural selection. Malthus' conclusion that population growth would outpace food resources and that therefore some part of the population would necessarily suffer and die helped inspire Darwin to question what, precisely, determined which parts of a given population would survive. Pointing out the accepted observations of variation within and between species (i.e., biodiversity), Darwin developed the conclusion that in the "struggle for existence," those with some variations would survive and produce progeny, while others would die and/or produce less progeny – thus those with variations that helped them survive were "naturally selected."

These ideas, applied to human society, formed the backbone of what is now called "Social Darwinism," (though Darwin himself was ambivalent about such applications to humans), a close cousin indeed of the Malthusian ideas discussed in the Background section. As we have seen, however, the Social Darwinist/Malthusianist perspective faces fundamental challenges, as food production has outpaced population growth, and poverty is both a cause and result of much or most hunger (FAO 2006). The state of being chronically hungry can and does limit the ability of individuals to develop to their potential, rather than an individual's theoretical (biological or social) variations and potential dictating their ability to get food, survive, and thrive.

Despite such relatively uncontested facts, almost any modern analysis of food issues starts with the necessary premise that intensive, conventional agriculture is what has staved off

predicted Malthusian crises of even more widespread starvation and death; a doubling in the global population since 1960 has been met by a 2.5-fold increase in agricultural production in the same time period using only 7% more land (FAO 2007). There is no certain way, however, to know what the result would have been from the counterfactual: a world where agriculture did not so fully adopt a philosophy of "total warfare" and the chemical means to conduct it from World Wars I & II (Russell 2001) – a world where these global conflicts had not helped maintain and expand synthesized industrial nitrogen sources (in part because of their usefulness in bomb-making, though certainly also because of their usefulness in agricultural productivity), where the abilities to save, store, and select seeds and varieties by individual farmers weren't appropriated through the propagation of inbred-hybrid crop varieties (especially in corn), where these varieties didn't come to be tightly linked to a package of industrial inputs that would continue to need to be purchased periodically, and where they weren't eventually designed with planned obsolescence (Berlan 1999, Lewontin and Berlan 1990, Rangnekar 2002). The alternative circumstances of such a world are conjecture and as such simple assertions of the present (or an alternative) system's superiority must be viewed with an appropriate level of skepticism.[21]

Nevertheless, given the emergence of Industrial/Conventional agriculture, the institutions of alternative, organic, and sustainable agriculture were able to develop in their own right. That is, many of the principles that define modern alternative principles can be seen partly as a backlash against the concentration of money, power, and production in the hands of fewer and fewer agriculturists, to the point where many farms and a disproportionate amount of land are owned by companies and/or off-site proprietors. (For a more complete history of the origins of agroecology, a branch of alternative agriculture that highlights the social, technical, and natural contexts of food systems, see Altieri (1995)). Along with this has come a lengthened production chain, such that food typically travels 1000 miles or more from farm to table, passing from farms to centralized processing facilities and distribution warehouses to increasingly large centralized retail stores before being carried home by car for consumption (Heller and Keoleian 2000). Thus the focuses on local food, little or no use of synthetic industrial pesticides and fertilizers, land reform and redistribution, small and family farmers, and using "natural" ecosystem processes as much as possible stand out specifically as a rejection of a conventional, industrial, centralized system that expends greater energy producing and distributing food while creating new and different health and safety hazards. As elaborated by many researchers (see i.e., Altieri 1995, Netting 1993, Pretty 2002, Rosset 1999), many of the goals of alternative agriculture are shared in common with so-called traditional or indigenous agriculture, which still characterizes much of the world, and characterized even most of the Industrialized Countries before the new system of

plenty was put into motion by the Haber-Bosch process of synthesizing nitrogen, and consolidated under the plenty provided by the Green Revolution. Of course, whether sufficient food is produced alternatively or conventionally, the problems of fair distribution and acknowledgment of the right to food will still need to be resolved, and no amount of food production alone will change global and national political systems that leave those without money to try to live without food.

Energy

A general assessment of various production methods shows that small farms using alternative agricultural techniques (i.e., multi-cropping, manual labor, crop rotation, and natural fertilization) may be 2 to 4 times more energy efficient than large, modern, commercial farms. Alternative crop systems using hand labor and simple tools may obtain total energy output/input ratios from 11:1 (corn) to 7:1 (rice), while highly mechanized (modern/conventional) production systems often see output/input ratios from 2.5:1 (corn) to 1.5:1 (rice) (Pimentel and Pimentel 1996). In regards to livestock production, depending on the animal and feed type, conventional systems may yield as little as only 1 calorie of beef from the equivalent of 40 calories of inputs. Equivalent organic systems may have similar energy requirements in some cases, such as broiler chickens, but in other cases they may be as much as twice as efficient (i.e., output:input ratios of 1:20 for beef as opposed to 1:40) (Pimentel 2006). The comparatively low energy efficiency of conventional systems can be explained by its normative use of high inputs of nitrogen fertilizer, diesel fuel, pumped water, seeds, herbicides and insecticides – the manufacturing of chemical fertilizers and pesticides makes up almost 40% of the energy used in U.S. agricultural production, while diesel fuel accounts for 25% (Heller and Keoleian 2000).[22] Of course, agricultural production itself generally accounts for only 20% of the total energy consumed in the US food system – other energy in the food system is used to process, package, distribute, and prepare food. Minimal processing, packaging, and transportation (i.e., local, fresh-bought foods) therefore represent significant opportunities to increase energy efficiency outside of the farm, as well. As fossil fuels become scarcer and more expensive and as their effects on global climate change continue, the benefits of more energy-efficient diets containing less meat and focusing on local and alternative production will become ever more significant.

CONCLUSIONS

This article has made "in principle" arguments about food security and biodiversity, because at present only theoretical arguments are possible for a global system utilizing alternative

agriculture. What is shown here is that there is a strong scientific basis to suggest that a switch to alternatives should be able to provide global food security while supporting biodiversity conservation. But of course, this is not enough by itself – a number of scholars have elaborated the limitations of a "food security" framework in addressing the role of larger structural problems in causing hunger. As observed by Patel et al. (2007):

> "Food security is agnostic about the production regime, about the social and economic conditions under which food ends up on the table… The right to food, opposed only by the US government at the 2002 World Food Summit, is compatible with a range of policies that militate against human rights enshrined in the UDHR [Universal Declaration of Human Rights] including equality before the law regardless of property status; free of concerns of security and servitude; in peaceful assembly; with social security; and the right to work."

In contrast, alternative approaches that go beyond food security, such as food sovereignty

> "…might offer a richer account of what groups of individuals need – protections for their access to land and resources necessary to produce and to obtain foods that are part of their traditional diets and attention to environmental conditions that affect their ability to produce and process their food."

Providing just, equitable and sustainable solutions to widespread malnutrition is not the simple matter of proving that it can be done or providing enough food, with alternative or conventional agriculture. The present work should therefore not be mistaken as a direct proscription or as containing the necessarily extensive evaluation of the significant structural changes and democratization required in local, regional, national, and international institutions – though we agree with Dahlberg (1993) that such evaluations are insufficiently common and vitally important. Rather, we have looked to establish whether or not agricultural methods and systems – that is, practices, informed by but only one small part of the sociopolitics of food systems – could provide a feasible means to join food security with conservation. Though technical feasibility is usually not the limiting step in larger governmental and human rights institutions, it is nevertheless true that no sociopolitical solution can function in the absence of technical feasibility. We agree with Badgley et al. (2007) that

> "The debate should shift to how to allocate more resources for research on agroecological methods of food production and how to enhance the incentives for farmers and consumers to engage in a more sustainable production system… [but] production methods are but one component of a sustainable food system. The economic viability of farming methods, land tenure for farmers, accessibility of markets, availability of water, trends in food consumption, and alleviation of poverty are essential to the assessment and promotion of a sustainable food system."

Thus, while focusing on the technical and thereby hoping to serve as an informative tool for researchers in numerous different areas of study, this work also is a "call to arms" to researchers, especially those in the natural sciences, to realize that without participation in such larger questions, within and across disciplinary lines, our contributions to addressing the world's problems risk being ancillary. While it seems like a call to step out of not just our comfort zones, but also our areas of expertise, it is rather a challenge to continue to develop a broader notion of comfort and form cross-disciplinary alliances and expertise instead of, to butcher a phrase, "refining specialized expertise on the deck of the Titanic." Given the recognized magnitudes of the global problems in biodiversity, malnutrition, and beyond, and the importance of the social and technological along with natural contexts, such an arrogation of a scientist's responsibilities to society as a citizen and an intellectual should be seen as unacceptable. It is time to redouble our efforts on the cultural project of further research and change in not just how we farm, but how we view and structure the world's food systems at the local, regional, and global levels.

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NOTES

[1] The concept of food security used here and in the rest of this work is: physical and economic access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle. See, i.e. the Rome Declaration on World Food Security and Plan of Action (FAO 1996). Under this definition, obesity should be equally considered a food security problem as hunger; it has joined malnutrition as an acute, widespread global problem (Tanumihardjo et al., 2007). The co-

occurrence of obesity and malnutrition is not a coincidence. Both are related in great part to the structures of government subsidies, global trade, narrowing of the food base, inequality, poverty and lack of food sovereignty. And it may be possible to address both to a great extent by changing the focus from agricultural overproduction of high-energy cereals for export and simplified diets to a food system focused on substantive equality, local production, biodiversity and dietary diversity (Friel et al., 2007; Frison et al., 2006). Insofar as these issues converge, obesity will be (indirectly) addressed in the present work; but the primary focus will be on the hunger and nutritional insufficiency aspects of food security, still serious problems in their own right.

[2] A last method or component is more and more frequently enunciated as well, that being a specific call for locally focused food systems, such as the "nearness principle" of the Danish Research Centre for Organic Farming (DARCOF, 2000). Locally-based food systems may cut down on resource consumption and pollution produced by the long-distance transportation of foodstuffs and also may increase transparency and reduce alienation between producer and consumer by facilitating direct contact between these groups (DARCOF, 2000; Heller and Keoleian, 2000; Pretty et al., 2005). (See also Note 21.)

[3] Beyond the undercount one might expect from any survey, it is likely that additional organic farmers were overlooked due to the near-invisibility of many local and uncertified organic systems (such as home and urban gardens – such elements of the "informal economy" are quite often missed in large surveys, including the country-wide surveys of organizations like the FAO), as well as *de facto* organic systems where conventional inputs are either unaffordable or undesired (Pretty and Hine, 2001; Willer and Yussefi, 2007). Willer and Yussefi's work is based on information reported by state entities, civil society institutions and certification bodies – meaning there was not one concrete standard for "organic" in the study and that both certified and uncertified organic agriculture were counted to some extent. The growing importance and potential of informal, uncertified and/or small-scale efforts, including urban and community gardens, may be quite profound, contributing significantly to local food security, equity, and sustainability (Smit and Nasr 1992). Urban and informal agriculture could debatably be expanded in order to extend such benefits more broadly, but such potential is still poorly studied, and has been called into question by some researchers (Ellis and Sumberg 1998).

[4] There are various terms for the "Less Economically Developed Nations," including "Developing Countries/the Developing World," the "Third World," and the "Global South." For the sake of simplicity, the term "Developing" Countries will be used, with "Developing" in quotation marks to denote its use simply as a common reference point, and to counteract the chauvinist implication that international economic power has any necessary correlation with other forms of cultural or national development.

[5] The aspect of the precautionary principle relevant here may be briefly summarized as: the general dictum that new procedures and technologies that pose the risk of serious, irreversible, or widespread harm to public or environmental health or sustainability should be tightly regulated or even wholly prohibited, despite a lack of scientific certainty as to the likelihood, magnitude, or causation of such harm, until it can be affirmatively shown that the new technology poses no appreciable risk. Interestingly, in one study of 62 Scandinavian scientists, Kvakkestad et al. (2007) found that all ecologists and most publicly funded scientists in general characterized GM crops as having unpredictable risks, while all scientists employed by the GM industry and most scientists receiving some degree of private industry funding characterized GM crops as useful and presenting no distinct risks.

[6] It is important to note here that the advances of conventional agriculture include increasing yield per unit labor by 120 times (or 40-50 times, counting indirect labor cost) by replacing it with less energy-efficient subsidies (synthetic pesticides and fertilizers, mechanization). In contrast, alternative agricultural methods use increased labor inputs to increase yield per unit area (Pimentel and Dazhong 1990). See also the *Energy* section of Other Considerations.

[7] Looking at 293 examples comparing alternative and conventional agriculture from 91 studies from varying locations, conditions, and approaches, Badgley et al. (2007) concluded that the literature to date does not support the idea that a switch to alternative agriculture would drastically lower food production. Rather, they found that even under conservative estimates, alternative agriculture could on average provide almost as much food (on a caloric basis) at the global level as is produced today (2,641 as opposed to 2,786 kilocalories/person/day after losses). In their so-called more "realistic" estimation, alternative agriculture could actually increase global food production by as much as 50% (to 4,381 kilocalories/person/day). Note that the claim is not that alternative agriculture can necessarily produce higher yields than conventional – just that it can provide sufficient yields for food security. Though such results may appear unbelievable, the "realistic" scenario reflects the fact that many farmers in poorer nations use low-intensity methods (subsistence farming or other non-industrialized methods), and may not have adopted Green Revolution technology. Badgley et al.'s study also looked at the production of organically acceptable nitrogen and found, based on 77 studies, that no additional land would be needed to produce sufficient nitrogen to provide these yields. Thus, in principle, intensification to increase yields to higher levels could proceed using alternative or conventional methods, without more land, and the argument that it may only be done with conventional agriculture no longer fits the bulk of evidence at hand.

[8] This is further emphasized by the fact that the numbers used throughout this work for food availability do not take into account avoidable or recoverable wastes in the food system. Total food wastes at the levels of retailers, consumers, and foodservice in the U.S. may be as much as 27% of the total food supply; on-farm losses – including losses due to increasing mechanization – means total waste is higher still. It is unknown how much of these losses are recoverable, but even low levels of recovery in the U.S. would potentially feed tens of thousands of people a year (Kantor et al. 1997). Assuming wastes in other countries are on the same order of magnitude, widespread efforts at recovery would feed millions of people throughout the world.

[9] Dahlberg (1993) points out that genetic and biological diversity undergirds all of the functional resiliency and regeneration of living systems, upon which the subset of *human* systems are dependent for survival. In this way, biodiversity has primacy over simple resources (renewable and non-renewable). This is further reinforced by the non-substitutability of many biological systems and resources; that is, *contra* classic economic theory, many natural resources cannot be substituted by increased use of an alternative but rather are unique and irreplaceable. (Dahlberg likens this to the loss of one or two letters of the alphabet and the words that contain them, and the difficulties of language that would result.) Such non-substitutability applies to many crucial elements of production agriculture, especially biodiversity, and is a basic principle of the field of ecological economics; see i.e., Prugh et al. (2000) and Daly (1996) in addition to Dahlberg.

[10] Poverty, often seen as a factor in promoting deforestation and environmental degradation, may play much less of a role in these phenomena than was once thought, especially in comparison to the effects of non-poor land owners (Gray and Moseley, 2005; Ravnborg, 2003; Sloan, 2007).

[11] Citing Rosset, Vandermeer and Dietsch (2003) state "...if increasing production is your goal, breaking up large farms and giving the land to small producers would be the best short term solution." Land reform, that is, breaking up the unequal concentrations of land possession present in most of the world and providing small and family farmers with secure tenure, has significant potential to aid food production, in addition to its roles in democratization and larger political reform. Such issues will not be fully addressed here, but land reform is thus of a piece with food sovereignty and other larger food system issues that will need to be dealt with in order to achieve sustainability, food security, and conservation (see also Notes 13 and 21 and Conclusions in the present work).

[12] A full analysis of the dynamics of farm size is not possible in the present work. However, it is important to note the "Goldschmidt Hypothesis," that is, that community welfare will be significantly higher in regions where agriculture is organized around smaller-scale farms than in regions dominated by a small number of large farms (Goldschmidt 1978). In the 60 or so years since his original study in the

1940s, a number of restudies by sociologists have "offered at least tentative support for his conclusions" (Lyson et al., 2001).

[13] Although this may describe both conventional and alternative agriculture, alternative agriculture tends to emphasize rotations, increased fallows, and/or cover cropping rather than bare fallows.

[14] Although a normative narrative is attempted here, it is vital to note that there are considerably variable results in research on soil responses to cultivation in general. Hooper (2000) provides some indications of the complexities and disagreements within the literature; Neher (1999) provides a more specific review of soil community reactions to agriculture; a more recent but less specific overview is provided in Kibblewhite et al., (2008).

[15] Such loss of diversity may also compound future problems. A number of domesticated biological resources and genetic material are very likely *not* sustainable independent of the conservation of a stock of wild resources. Protection of on-farm cultivar diversity and wild relatives (*in situ* conservation), as well as a recognition of the importance of ethnographic and cultural knowledge in the use and propagation of biodiversity, will be needed along with off-site (*ex situ*) preservation in order to respond to the local needs of marginal farmers and future social or environmental changes (Almekinders and Elings, 2001; Altieri et al. 1987; Dahlberg 1993; Jarvis and Hodgkin 1999; Weissinger 1990).

[16] In a small number of cases, monocultural plots have maintained comparable levels of associated biodiversity in certain arthropod taxa (Butts et al., 2003; Melnychuk et al., 2003).

[17] Organic monocultures, of course, present many of the same problems as conventional ones do. The notable exceptions to this are a) lower run-off of agricultural nutrients (see Note 19), b) avoidance of synthetic pesticides' detrimental effects on health and biodiversity, and c) lower fossil energy use and costs. The latter of these benefits may also disappear if applied organic nutrients (i.e., from animal manure or "green manure" crops) are not sourced on-site or locally (Pimentel et al., 2005), emphasizing the contradictions of so-called Industrial Organic agriculture (Pollan, 2006).

[18] It is of course not necessarily true that the non-synthetic fertilizers and pesticides used in alternative agriculture are always applied appropriately; run-off doubtlessly occurs in such systems as well. However, recent studies have observed comparable or significantly lower levels of nutrient leaching in alternative systems (Kramer et al., 2006; Mondelaers et al., 2007; Tonitto et al., 2006; Van Huylenbroeck and Aertsens, 2007).

[19] In an extensive consensus review by Hooper et al. (2005), it was concluded as "certain" that system responses to biodiversity and biodiversity loss could be idiosyncratic (depending on ecosystem and its particular species and functional groups, for example), that some systems are initially insensitive to diversity, but that "more species are needed to insure a stable supply of ecosystem goods and services" over larger areas and time periods. They had "high confidence" that certain species combinations were complementary (meaning that they could increase productivity and nutrient retention as compared to a less diverse system), that under similar conditions, susceptibility to invasion by exotic species was generally lower with higher diversity, and that having a range of species with different responses to disturbance can help increase stability, meaning that maintaining a diversity of species with diverse characteristics helps maintain a range of management options. However, determining the relationships between biodiversity and different ecosystem properties was found to require significantly more research, greater experimental work, and incorporation with the effects of various other drivers of global change.

[20] Since the original writing of this paper, local food has gained increasing attention and popularity, especially in the US and European press. This can be seen in a number of recent popular books, such as *The 100 Mile Diet* (Smith and MacKinnon, 2007) and *The Omnivore's Dilemma* (Pollan, 2006). Groups such as Slow Food and various urban gardening movements seem to be on the upswing, as is

the growth of farmers' markets (United States Department of Agriculture (USDA), 2006). And of course, questions related to local food systems continue to be examined in the academic literature (see i.e., Pretty et al., 2005). It is not, however, solely scale or localness that are important, but also the democratization and effective decentralization of responsibility and power within local geographies – issues of social justice and equity that once again link to the production and distribution of food at scales involving, but extending beyond, the local (Batterbury and Fernando, 2006; Breitbach, 2007; Prugh et al., 2000). These issues cannot be fully addressed in the current work, but they do reinforce previous points regarding regional food security and food sovereignty. Additionally, the case studies to be presented from Brazil and Cuba remain considered local food initiatives *par excellence* by many, and can be considered of a piece with larger trends towards land reform and local and just food systems.

[21] The goal of appropriation of the control of seeds, which otherwise represent nominally replicable technology (like computer programs or music which, barring special measures, can be copied from their original media) is extensively outlined and argued in Berlan (1999) and Lewontin and Berlan (1990). These arguments are reinforced by Rangnekar (2002), an empirical study indicating increases in planned obsolescence of commercial wheat varieties in the UK over a period of 35 years. The imperative of appropriation can also be seen as a factor in the lawsuits against farmers by seed companies when farmers, advertently or inadvertently, find or save patented genetically modified plants on their property (see i.e., Kondro, 2004; Liptak, 2003). Lewontin and Berlan also examine the counterfactual, and their conclusion is that alternatives to the conventional inbred-hybrid method (i.e., mass selection) existed and held promise for a similar (if not greater) range of crop improvements, though in forms that would make it harder for corporations to capture large profits (the potential viability of alternatives was also confirmed in Crow, 2000). This was further supported by the fact that the alleged mechanism of yield increases exclusive to inbred-hybrid lines – overdominance – has had only tenuous support since its formal conception in the early 20th century, and significant evidence against its existence in a majority of cases has since been accumulated (Crow, 2000; Lewontin and Berlan 1990; Moll et al. 1964). Thus, the superiority of the current system or its counterfactual is hard to conclusively determine.

[22] Alternative systems also may have lower run-off of nutrients than conventional systems, meaning in turn higher resource use efficiency (see Note 19) – and from this efficiency, less energy use in order to recover, produce, transport, and apply nutrients.

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CHAPTER 3

AN INSTITUTIONAL ANALYSIS OF THE CREATION AND EFFECTIVENESS OF A CITY-WIDE FOOD SECURITY PROGRAM, AND ITS EFFECTS ON LOCAL FARMERS IN THE ATLANTIC RAINFOREST: THE CASE OF BELO HORIZONTE

ABSTRACT

In 1993 the city of Belo Horizonte, Brazil, a city of almost 2.5 million people, introduced an unprecedented, comprehensive suite of programs aimed at reducing food insecurity. The programs tie local producers directly to consumers, educate the populace about food security, and look to guarantee the right to healthy, high-quality food to all of its citizens, especially the most socially and biologically vulnerable populations in the city. These efforts were united under one municipal office, the Secretariat of Food Supply, whose programs now reach between 800,000 and 1 million people a year. Since the Secretariat's creation, it has presided significant increases in average consumption of fruits and vegetables, decreases in infant malnutrition, and a 50% or more drop in infant mortality reaching even the city's poorest *bairro* (neighborhood). For those curious or eager to understand the political dynamics of how such an effective range of programs work, and eventually, how or if they may be replicated elsewhere, several questions are pertinent: What institutional conditions allowed or enabled the creation and political sustainability of the food security programs in Belo Horizonte? What are the institutional characteristics supporting the success and effectiveness of their municipal food security programs? And, considering the intimate link between the city programs with local farmers, whose food production in the surrounding Atlantic Rainforest has the potential to aid or harm conservation: How do institutional characteristics and choices within SMAB affect the farmers' lives and choices, and in turn, their effects on conservation? These questions are examined using Kingdon's classic policy process framework, based on Cohen et al.'s original "garbage can model of institutional choice," and further informed by Evans' work on state-society synergy. Interviews and documentary research indicate that SMAB's formation and present slow-down in terms of the creation and expansion of programs can be well-explained using Kingdon's framework, while Evans' synergy

has a role in the maintenance of SMAB's programs and their effects on local farmers, giving insights that may allow some of SMAB's innovations to eventually be applied elsewhere.

KEY WORDS

Belo Horizonte, conservation, food security, garbage can model of institutional choice, policy process streams, state-society synergy, policy entrepreneurs, political ecology

INTRODUCTION

The objective of the present work is to examine sustainable development in the form of the ecological connections between food security in the city of Belo Horizonte, Brazil, and conservation in the surrounding rural areas where local farmers produce food for the city. Specifically, the municipal government of Belo Horizonte has made access to food a right of citizenship, and 15 years ago created the *Secretaria Municipal de Abastecimento* – the Secretariat of [Food] Supply (SMAB) – in order to guarantee this right. This program has had unprecedented success in providing an increased level of food security in Belo Horizonte, and is encouraging direct consumer connections with local conventional and organic farmers. One measure of their success has been the reduction of infant mortality and infant malnutrition by more than 50% since the Secretariat's start (Prefeitura Municipal de Belo Horizonte (PMBH) 2006, Alves et al. 2008).

The city's programs also connect it with local, small family farmers situated in the surrounding Atlantic Rainforest, implicating the important role local food may play in biodiversity conservation. That is, it has become increasingly clear in recent years how much agricultural land can affect fragments of native habitat located adjacent to or within an agricultural landscape (Chappell and LaValle, in revision, Perfecto and Vandermeer 2008, Vandermeer et al. 2008). The uniqueness and relative recentness of SMAB's programs provide an excellent starting point to examine the effects of a significant change in food policy on agricultural practices, and thus ecological processes, in a fragmented natural landscape.

Chapter Outline

Before I analyze the characteristics of and changes in food policy institutions in Belo Horizonte, and their affects on farms, farmers, and the Atlantic Rainforest of the agroecological landscape surrounding the city, I believe it will be useful to review the problem of hunger/food insecurity, and to place it in the context of sustainable development. The subsection Truly Sustainable Development: The Provision of Human Rights defines the specific development context I will use in the analysis, and gives a context for how SMAB's work on food security

may link to sustainability in terms of local biodiversity conservation. This is followed by a review of the specific questions I will address regarding SMAB in the **Research Overview**. Within the following section, Food Security and Belo Horizonte: A Singular Case Study, I briefly review the history of food security in Brazil between World War I and 1993, drawing heavily on Bentley (2006), Aranha (2000), Takagi (2006), and to a lesser extent, Hoffman (1995) and de Carvalho Filho (1995) to put SMAB's programs in the context of the long-term evolution of food policy institutions in Brazil. (For a more complete vision of the history of food security in Belo Horizonte and Brazil in general, please see their excellent works.) This section concludes with an elaboration of how SMAB came to be, what it does, and how it does it – SMAB's formation and organization. In the next major section, Institutional Theories: Background and Applications, I set up the framework for my examination of SMAB. The two primary analytical approaches I will use are the model of policy process streams and policy entrepreneurs, based on Kingdon (2003) and Cohen et al. (1972), and state-society synergy, based largely on Evans' (1996a) work. After laying out these frameworks, I will continue with An Analysis of Food Policy Institutions in Belo Horizonte, beginning with the methodology, followed by background information on my interviewees, and then an analysis of SMAB's goals, successes, and its challenges. This subsection applies the Kingdon framework by relating the three "process streams" Kingdon describes – problems, policies, and politics – to SMAB during the time of its formation, followed by reapplying the same model to look at SMAB's progress, or lack of progress, since then in the context of problems, policies, and politics within the Belo Horizonte city government at large, rather than simply within SMAB. Effects and Interactions of the SMAB Programs on Local Farmers ascertains how working with SMAB may have affected the livelihood and practices of SMAB partner farms based on interviews with both farmers that work with SMAB and some who do not. How this may affect sustainability is also addressed, along with other institutional influences on local farmers (besides SMAB), and a look at Evans' embeddedness within the context of the farmer-SMAB partnership. I then present the chapter's Conclusions and my final remarks.

Truly Sustainable Development: The Provision of Human Rights

Widespread deprivation of basic human needs continues to be a problem throughout the world, with much attention continuing to be focused on the so-called Developing World. Latin America in particular has seen a number of attempts at social justice reform frustrated in countries well-endowed in natural resources, including countries with megadiverse areas containing most of the world's biological diversity. In part through the efforts of international

environmental movements, the exploitation and imperilment of these areas have been brought to the fore of international discussion, where environmental problems are now considered alongside and as part and parcel of problems of human development (see i.e., Wapner 1995, Roddick 1999, Mittelman 2000, Wapner 2000, Runyan and Norderhaug 2002). Thus, in the past several decades, concerns over the environment and biodiversity conservation have been brought together with problems of human deprivation in the formulation of "sustainable development". The Brundtland Commission (1987) defined this as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Despite common concerns among political ecologists over the hegemonic and imperialistic implications of "sustainable development" as led by those from the "Global North" (Escobar 1995, 1998, Harvey 1998, Sullivan 2000, Zimmerer and Bassett 2003), I will accept this definition here in good faith as a framework for food security and conservation. It is nonetheless important to clarify how I view and use the concept in the present work.

The Brundtland Commission's definition is a widely used starting point for attempts at defining sustainable development. As a semantic matter, it is hard to precisely operationalize – it leaves open as to whose or which "needs of the present" it refers to, how to meet them, and what constitutes a "compromising" of the needs of future generations. Such definitions are famously important in the design and outcomes of development projects (Escobar 1995). It is also worth noting that "development" is part of the Commission's definition of "sustainable development", leaving one to wonder exactly what is involved in development per se. Perhaps, like an infamous United States Supreme Court ruling, one is supposed to "know it when [one] sees it."[1]

The Brundtland Commission's definition is also far from the only one. Prugh et al. (2000) review a number of definitions, many of which they note wander even farther from operationalizable terms. However, I would maintain that the essential heart of most "good-faith" definitions of sustainable development is the provision of economic opportunity to the poor and disadvantaged while minimizing or avoiding negative environmental impacts.[2] This interpretation implicitly assumes that economic opportunity correlates to the provision of others – that is, social, cultural, and educational opportunities. It also assumes that present forms of economic development and environmental sustainability can be mutually reinforcing, an assumption that is not necessarily warranted (Rees 2002, Khagram 2003).

Despite these complexities, there is reason to believe that the tension in such formulations between economic development and sustainability is not only unnecessary but also counterproductive. That is, such tension may be based on an unrealistic and ultimately undesirable view of development. Arturo Escobar (1995) and other critics have pointed out the

hegemonic aspects of both development and conservation perspectives, which they argue are ultimately aimed at maintaining the status quo. Specifically, the basic assumption of much of development theory as embodied by the neo-liberal market model is that continued economic growth across the globe will be necessary to supply the world with a First World-like standard of living (MacNeil 1990, Lomborg 2001). This assumption inexplicably fails to acknowledge that anything expanding indefinitely is not sustainable in a resource-limited world, and that economic growth often comes at the cost of environmental quality (Beckerman 1992, Costanza and Daly 1992, Panayotou 1993, Stern 1997). Research in the past two decades has implied that much of the economic growth of the past has come not only at the cost of further environmental damage, but also has played a major role in the growth of human inequality and continued deprivation across the world (Arrow et al. 1995, Rees 2002).

In the face of such critiques, especially in neo-liberal formulations, technology is often pointed to as a method to alleviate the trade-offs between economic growth, environmental damage and inequality.[3] While technology can certainly do much for economic growth and for the environment, there is no guarantee it can do both simultaneously while avoiding trade-offs. For example, there are serious concerns with both the use of industrial agriculture and genetically modified foods as opposed to "lower-tech" alternatives in terms of safety and efficiency (Yapa 1993, Rosset 1999b, Hart 2002, Independent Science Panel (ISP) 2003, Institute of Medicine and National Research Council (IM/NRC) 2004, Schubert and Freese 2004, Wilson et al. 2004, Chappell and LaValle, in revision). More fundamentally, technology does not change the underlying thermodynamics of the situation: there is a limited amount of resources in the world to use, and at some point (which we may have already passed), further use of these resources at the present rate or greater will degrade the natural environment, regardless of the technology (Costanza and Daly 1992, Stern 1997). Nor does technology address the distributional inequalities often cited as the true source of disparities seen in economic growth, human equality, and sustainability (Sen 1984, Drèze and Sen 1989, Sen 1992, Haddad et al., Rocha 2001, Lappé and Lappé 2002).

Under an alternative view, it is possible that the problems encountered in reconciling economic growth, human equality, and environmental sustainability under this type of neo-liberal "technological optimist" approach can be avoided entirely. Such a view may define sustainable development as focused on the evolution (as opposed to growth) of the world economic system in order to provide universal attainment of basic human rights, such as food security, self-determination, access to suitable education, fulfilling and gainful employment, and safe working

conditions in a manner designed for environmental benignity, sustainability and stability (see i.e., Olate).[4]

It is fair to ask if this formulation of sustainable development is consistent or feasible as it is usually interpreted, or if it is simply used and abused as a construct to co-opt environmentalism into the status quo (Hildyard 1991, Yapa 1993, Escobar 1998, Prugh et al. 2000). Past sustainable development projects have not necessarily contributed to environmental health, sustainability or equitable development (Stern 1997, Roddick 1999, Loker 2000, Gutman 2003, York et al. 2003). If, for example, one takes substantive equality as an inseparable factor of sustainable development, then the country of Brazil could be considered to be one of the worst in the world in terms of sustainable development.[5] Additionally, in terms of the environmental protection and environmental quality aspects of sustainable development, Brazil suffers from a number of ills.[6] Brazil is nonetheless usually considered one of the most "developed" of the Developing Countries.

SMAB's programs have been designed to directly address food security, a fundamental human right as well as a UN Millennium Development Goal (MDG) (PMBH 2006, Centrais de Abastecimento de Minas Gerais S/A (CeasaMinas) 2008, United Nations Development Program (UNDP) 2008). Food security, in this context, refers to the concept of physical and economic access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle (see, i.e. the Rome Declaration on World Food Security and Plan of Action, Food and Agriculture Organization of the United Nations (FAO) 1996, Canadian Home Economics Association 1999, Conselho Nacional de Segurança Alimentar e Nutricional (CONSAN) 2004). Further, Rocha (2003a, 2007) has delineated five themes – the "five A's" – to describe different aspects of food security: availability, accessibility, acceptability, appropriateness, and agency.[7] Under Rocha's framework,

- **Availability** refers to the sufficiency of a food supply to meet people's needs;
- **Accessibility** refers to people's economic and physical ability to acquire food;
- **Acceptability** addresses the cultural and nutritional suitability of the available food;
- **Appropriateness** evaluates the ecological sustainability and the safety of a food supply; and
- **Agency** is the "right to knowledge, and knowledge of rights," – access to accurate information on food supply, quality, and safety in order to make informed market choices, rights to such information and to the other aspects of food security, and a competent sociopolitical system to guarantee these rights.

The analysis of Belo Horizonte's programs will show how they have addressed all five aspects of food security – and how by doing so, they have also achieved other human rights-based development goals such as the Millennium Development Goals of reducing infant morality and improving maternal health, while possibly increasing local sustainability – one of the five A's (appropriateness) as well as an MDG (UNDP 2008).

Research Overview

In order to analyze Belo Horizonte's programs, I look to address three central questions:

1) What institutional conditions allowed or enabled the creation and maintenance (political sustainability) of the food security programs in Belo Horizonte?
2) What are the institutional characteristics supporting the success and effectiveness of their municipal food security program, especially in terms of working with civil society in order to address hunger (food insecurity)?
3) How do institutional characteristics and choices encourage or inhibit local (agroecological) conservation?

Brazil is a singularly appropriate area for the political ecological research of this dissertation for various reasons. The sizeable amount of biodiversity in Brazil holds immense value for scientific, economic, and humanistic reasons, and its many biodiverse regions adjacent to agriculture or other human-managed areas can serve as vital testing grounds for ecological theories (Lugo et al. 2001). Despite this rich endowment, one-fifth of the 180 million Brazilians live in absolute poverty. The combination of unique, unparalleled natural splendors and extreme human deprivation means that Brazil continues to need new, real sustainable development solutions as well as refinement of preexisting ones. A number of scholars have enumerated many possible institutional, structural and political sources of development problems, such as inequality, lack of or poor wealth distribution, unwieldy centralization or ineffective decentralization, and interference from "local elites" (see i.e., Prugh et. al 2000, Escobar 1995, Draibe 1997, Mészáros 2001, Wright and Wolford 2003, Montero 2005, 2007). An approach directly focusing on human rights, such as food security, seems promising in the case of Southeastern Brazil, and perhaps as a more broad development approach as well (Rosset 1999a, Schwind 2005, Chappell, unpublished manuscript). It is worth noting that within SMAB, food security is used in contrast to "hunger" deliberately, recognizing the multi-faceted approach of the food security concept and the important distinction that the effects of hunger can be addressed

simply by the distribution of raw calories, regardless of their appropriateness, adequacy, sustainability and reliability, whereas food security is a public good that requires addressing the social/communal aspects of hunger, as well as providing for reliable and suitable nutrition. Although this conception of food security is more complex than the idea of hunger per se, it is a more complete concept and may further generate other public goods (i.e. health, productivity, resistance to disease) important to any concerned governing body (American Dietetic Association (ADA) 2003, Rocha 2007, Tanumihardjo et al. 2007). Although these other public goods will, for the most part, not be explicitly analyzed in the present work, they are important to note in regards to the possibility of SMAB further supporting development of other human rights and as a potential area for future research.

Observing the gross average overconsumption of food in some areas of the world and simultaneous malnutrition in other areas that could be self-sufficient and potentially food secure, it is clear that food production and supply (that is, availability and accessibility) do not have a simple or direct relationship.[8] As observed by Sen in his seminal works on hunger and food security (Sen 1984, Drèze and Sen 1989), the ability to acquire food does not have a necessary relationship with its supply. This is especially apparent in urban centers, which are becoming the new loci of malnutrition (as opposed to rural areas) (Haddad et al. 1999, Ruel et al. 1999), leading many observers to propose that the problem of food insecurity is primarily one of distribution, and that political change is required to alleviate this problem (Drèze and Sen 1989, Haddad et al. 1999, Rocha 2001, Lappé and Lappé 2002).

FOOD SECURITY AND BELO HORIZONTE: A SINGULAR CASE STUDY

A Brief Look at Food Security in Brazil, from World War I to 1993

Everyone understands the concept of hunger – the grumbling in the belly, the simple desire to have food when there's none readily accessible. For those of us lucky enough to have enough food – and it is indeed some measure of luck when approximately one-sixth of the world's human population suffers from malnutrition of some kind (Food and Agriculture Organization of the United Nations (FAO) 2006) – we can perhaps, at the far reaches of our imagination, attempt to conceptualize the tragedy of acute and prolonged hunger. The concept of food security, although much more comprehensive than simple hunger and therefore more useful as an analytical theme and political agenda does, however, lack this immediate and vivid connection. The far more subtle understanding of modern malnutrition where hunger co-exists with sufficient food supply has thus perhaps naturally been a longer time in coming. Malthusianist views of a lack of food supply as a cause of hunger have, to a large extent, given

way to the more empirically supported analyses of food insecurity caused by poverty, entitlement failure, and war.[9] An entitlement, following the approach pioneered by economist Amartya Sen (1984), is defined as the ability to obtain "commodity bundles" such as varieties and amounts of food, through different avenues available to an individual or household. That is, one might gain enough food for one's family via production of your own food, trade in goods, selling your labor in return for food, or through transfers from familial ties or government-guaranteed rights or programs. Sen's approach was important, even revolutionary, because it reexamined the occurrence of famines and shifted the burden of explanation from the availability of food to the ability to acquire food. This contradicted previous concepts, descended from or kin to Malthusianism, such as "Food Availability Decline," wherein famines were thought to be caused by lack of available food (Devereux and Naeraa 1996). The alternative analysis focusing on "Food Entitlement Decline," has been highly influential, and led to further refinement and sophistication in regards to the conceptualization of food security. Patnaik (1991), in particular, agrees and presents empirical evidence that a lack of available food is rarely, if ever, at the bottom of food insecurity, although she does criticize Sen's approach for a lack of predictive hypotheses and analytical tractability, and disputes his implicit assumption of vulgar Malthusianism as the only alternative model.

And so it was that Brazil, despite seeing concerns over hunger going back to the beginning of the 20th century, nevertheless saw sporadic, contradictory, and variably effective efforts at addressing it. Despite the attention to hunger starting after World War I, and despite the fact that Brazil is a country that was and is more than capable of producing enough food for its population, its leaders, like many in the world at that time, took a Malthusian attitude to these problems, largely looking to production to address them (Aranha 2000, Bentley 2006). The ultimate sources of the hunger and food insecurity, chiefly, the profound inequality and poverty in Brazil, don't appear to have been directly addressed for decades thereafter. By neglecting these underlying problems, economic expansion in Brazil saw increases in exportation while internal food markets declined. Continuing and sometimes worsening economic inequality during industrialization and modernization meant that even when internal markets saw "sufficient" supply, the market price driving supply responses didn't reflect true demand but rather "effective" demand of the population that could afford foodstuffs (de Carvalho Filho 1995, Aranha 2000, similar effects were seen by Patnaik 1991 in post-World War II India).[10] At such points, further increases in general income of the populace increased effective demand by those with money such that market prices would increase to an equilibrium level where the poor could once again not afford food, even when there was sufficient per capita supply on a strict caloric basis (de

Carvalho Filho 1995, Nabuco 2007). Thus, the significant socioeconomic inequality in Brazil, and the failure of its leaders to address it as a foundation to addressing hunger, caused a persistent lack of entitlements (*sensu* Sen). As Aranha points out, then, this lack was not strictly just a lack of income, but a lack of urban infrastructure, such as water, light, sanitation, health, and education, exacerbating the problems of food security per se (and exemplifying a lack of agency) (Aranha 2000). In contrast with other countries that underwent similarly rapid processes of industrialization and urbanization, Brazil had a comparative lack of redistributive policies that would address this throughout the 20th century, as may be seen from a poverty level that, within the past 25 years, has fluctuated primarily around the level of 20% of the population (i.e. 22.5% in 1981; 21.5% *ca.* 2004) (Hoffmann 1995, Aranha 2000, UNDP 2007).

Against this backdrop of inequality, the political ground in Brazil was rapidly changing. The military dictatorship that came to power in 1964 issued a series of reforms over the course of the 1980s, many linked to decentralization. Having previously signed the United Nations' Universal Declaration of Human Rights (1948), Brazil joined in the 1966 Covenant on Cultural, Social, and Economic Rights, acknowledging the right to food and a government's responsibility to secure that right. Further, Bentley (2006) points out that municipal elections were maintained during the military regime in the 1960s and 1970s, and the military government often dealt directly with municipalities – meaning that city governments had both some amount of power and a democratic impetus to innovate as service providers. Concurrently, civil society in the 70s through the 80s had begun to form cohesive social movements and demand popular participation in an array of governance areas, coming to a head with the impeachment of President Fernando Collor de Melo (Doimo 1995, Bentley 2006). The Movement for Ethics in Politics that had a key role in Collor's impeachment maintained social mobilization as it transformed into the Citizens' Action Movement Against Hunger and Poverty and For Life (*Ação Cidadania Contra a Fome, a Miséria e pela Vida*). This movement (a good potential example of Hirshman's "Conservation of Social Energy" (Hirshman 1988)), headed by prominent sociologist Herbert "Betinho" de Souza, represented an extraordinary grassroots mobilization, with 7,000 local committees, and an emphasis on the responsibility of the state and all of its citizens, especially in regards to the right to food and realizing a broader agenda of civil rights (Rocha 2001, Bentley 2006).[11] The "*abertura*" (opening up, or liberalization) of the military dictatorship and building of social movements was made legally possible by the 1988 Brazilian Constitution. Besides allowing civil society to participate in governance, the new Constitution further mandated decentralization of power and responsibilities to municipalities, who were recognized as "federative entities," and to whom were delegated more prerogatives than the states containing them in many cases (Bentley

2006, Vaitsman et al. 2006). The politically left Workers' Party (*Partido dos Trabalhadores,* or the PT), within the "Parallel Government" built by their movement and invigorated by the *abertura*, societal mobilization, and new Constitution, proposed plans to combat hunger based on many principles aligning with the still-nascent but broader conceptualization of food security. Further, some of the PT's proposals strongly influenced creation of National Food Security Councils in 1993, advancing comprehensive food security further still (Bentley 2006).

Belo Horizonte: SMAB's Formation and Organization

The PT, who had taken up many parts of the participatory, equity, and rights-based agenda of the social movements of the time, won several key elections in the late 1980s and early 1990s, including mayoral elections in São Paulo, Porto Alegre, Vitória, and, in 1993, the election of Patrus Ananias de Souza in Belo Horizonte. Under the leadership of Ananias, Belo Horizonte initiated its city-wide food security program in 1993. Following on the period's high public attention to problems of hunger, poverty and nutrition in Brazil, Ananias and his founding SMAB Secretary, economist Maria Regina Nabuco held coordinating meetings between community leaders and professionals in health, education, nutrition, and social assistance in order to create the new government office to comprehensively administer all of the city's food security-related programs.

Based on gathered support from these private and public experts and community leaders, Ananias and Nabuco sought to take advantage of the growing knowledge in the area of food security, and to address problems at their root through instituting new programs and redesigning and improving old ones. Research showed that among Belo Horizonte's approximately two million citizens, the problem of food insecurity was largely a result of high prices, uneven distribution of food outlets throughout the 350 square-kilometer city, and various problems in urban infrastructure – unsurprising conclusions considering the background of food insecurity in Brazil reviewed above. In the city, nutritional imbalances largely reflected insufficient intake of protein (milk and meat) and vitamins (fruits and vegetables), although low-income citizens nonetheless spent almost 40% of their income on food – twice as much, proportionally, as citizens earning eight times the national minimum wage or more (Aranha 2000). Concurrently, almost 11% of their population lived in absolute poverty, 20% of children 5 years old and under were either malnourished or at risk of malnourishment, and infant mortality for children under 1 year old was 34.4 deaths per 1000 live births (as compared to 42.5 per 1000 in Brazil at large and 23.3 per 1000 in the more prosperous Rio de Janeiro) (Rocha 2001, Aranha 2003).[12] With an eye towards a comprehensive approach to food security, from the start SMAB set out to address

numerous different elements of food security in a coordinated manner. The scale of the programs and their success has been due in no small part to cooperation with the Municipal Secretariats of Health, Education, Finance and Social Assistance, working with their professionals and clinicians to identify at-risk children and families, provide immediate aid to those most at risk, distribute educational materials, and find ways to fit many programs into the pre-existing municipal budget. These initial processes benefited from SMAB's foundation in and creation from a multi-disciplinary, multi-stakeholder process. Related to this, its comprehensive suite of programs that simultaneously advance different, but equally important food security objectives, seem to have been key parts of SMAB's effectiveness. In this way, one might say that SMAB looked to attack food insecurity by simultaneously addressing all five of the "A's" of food security at once. Such a comprehensive approach to food security is, to my knowledge, unprecedented in a city of Belo Horizonte's size, and may explain the relatively rapid progress SMAB has seen.[13] Rocha and Aranha (2003) note that the centralization of food security functions under a distinct municipal office commanding its own budget was further necessary in order to plan, coordinate, and execute the programs effectively – a claim borne out in part by the ineffectiveness and contradictory nature of previous uncoordinated efforts to implement food security policies on the national level (Aranha 2000). Doing so also allowed

> "a fundamental review of how nutrition and food-related programs are perceived: from emergency (read 'temporary') and 'assistance' (read 'marginal') initiatives to regular policies deserving of the same status as other (more traditional) public policies in areas such as health and education," according to Rocha and Aranha. They point out that SMAB's founders and professional staff have called their greatest accomplishment to date the '[mainstreaming of] food security into municipal public policy (Pessoa and Machado 1999).'"

From the start, SMAB was proposed and designed to engage in three "lines of action," each represented by a department within the larger Secretariat: promotion of food consumption and nutrition, food distribution, and incentives for basic food production. These mandates can be clearly seen from the text of the law governing its founding, Municipal Law #6,352 of July 15, 1993, which gave it the following duties:

- Coordinate the educational aspects of school lunches; and secure nutritional assistance to the groups having the greatest biological vulnerability to malnutrition: children, the elderly, expectant and nursing mothers.
- Plan and coordinate initiatives in the realm of food supply and combating hunger, including supplying information and direction to the population in order to advance their understanding with respect to the market, prices, and nutritional value.

- Plan and coordinate initiatives in the areas of credit, finance, and administration of the tools and programs the make up the municipal (food) supply system.
- Plan and coordinate initiatives organizing and incentivizing the production of basic foodstuffs.
- Regulate the market, directly or indirectly, through the statutory power of the City, with the option of reducing the prices of different food categories, while at the same time looking to reduce the distance between producers and the consumer, benefiting the former and latter.

  (quoted from Machado 2003, and Lei Municipal 6.352 de Belo Horizonte)

Within these statutory powers, one can immediately see elements of two of the "Five As" – incentives for production (availability), and direct nutritional aid to vulnerable populations, along with reduction of the distance between producer and consumers (accessibility). The "Five A's" analysis/approach elaborated by Rocha (2003a, 2007)[14] is also closely matched to that defined by Adriana Aranha, a former SMAB program manager, in her Master's Thesis on SMAB's programs:

> "The necessary requisites of Food Security are sufficient **availability** of foodstuffs, which presupposes a food system integrated from the point of production to consumption, that supplies, in a stable nature and at **accessible** prices, essential foods for human consumption, produced in a **sustainable** manner; and **accessibility** to food, which presupposes access to sufficient income to acquire food, and to essential public services, to **information** on **nutritional quality** and to **social rights**." (Aranha 2000, emphasis added)

The organization of SMAB *ca.* 2005 can be seen in the organizational chart shown in Figure 3.1, although the specific orientation and organization of the program offices seems to change frequently (compare i.e., to the organizational chart found in Aranha, 2000). A list and summary of their primary programs, informed by Machado (2003), Aranha (2000), Rocha (2000), and de Araújo and Alessio (2005) as well as my research, is presented here:

- One of SMAB's most notable programs is its Popular Restaurant program. In cooperation with the Secretariat of Social Assistance and with aid from the Federal government, SMAB reinvigorated this decades-old Brazilian institution. The Popular Restaurant program (*Restaurante Popular*, also translatable as "The People's Restaurant") which today in Belo Horizonte has three main facilities, several smaller "lunchrooms", and new facilities under construction (participant observation, seminar by Mayor Fernando Pimentel, April 10, 2008; Câmara Municipal de Belo Horizonte (CMBH) 2006), serves in total over 12,000 meals each day, primarily lunches –

traditionally the largest meal for Brazilians. The menus are prepared from fresh ingredients and planned by both local chefs and nutritionists. Each 1,000 – 1,200 calorie lunch consists of rice, beans, a meat or vegetarian option, and salad or fruit, and costs the consumer one Brazilian Real (R$1 = US$0.46 as of November 7, 2008). (The small breakfasts and dinners at the Restaurants are R$0.25 and R$0.50, respectively.) To maintain the low cost of the meals, which is meant to promote "food with dignity", the federal and municipal governments subsidize the program to cover staff, training, and equipment costs that exceed the Restaurants' incomes. The popular high-quality, low-cost meals draw in a mixed clientele: approximately 86.4% of those who eat at the restaurants could be considered low and very-low income citizens (earning up to ~US$10,000/yr, with 34.9% of all patrons earning below US$4,000/yr), but the rest of the patrons are a mix of students and professionals from the middle- and upper-middle class. The fact that patrons pay for the meals, even at a subsidized price, and the mix of income levels among the patrons, follows the SMAB concept of "food with dignity"; there is likely much less or none of the social stigma sometimes associated with assistance programs (SMAB internal study, cited in Aranha (2000); the study was conducted in 1999; all monetary amounts are in 2008 dollars and at 2008 wages, converted from the common Brazilian practice of expressing income in "number of times the minimum wage").

- Like the Popular Restaurant program, the School Meals program serves meals made from fresh ingredients to thousands of citizens each day – all of the 157,000 children in the municipal school system. Also subsidized by the federal government, the School Meals provide at least 15% of the daily nutritional requirements of the children in municipal schools (Brazilian schoolchildren only attend school for half the day). Younger children who attend private daycares that partner with the city receive 100% of their daily nutritional requirements, while other programs more specifically target and supplement the meals of older public schoolchildren for whom the School Lunch may be their only or primary meal (participant observation, seminar by Adriana Aranha, 6/9/04; Aranha 2000).
- The School Meal and Popular Restaurant programs require a significant amount of food each day, especially vegetables, of which local farmers provide nearly 100%. There are many local, small and family-owned vegetable farms in Greater Belo, and in cooperation with five municipalities in the area, SMAB buys as much produce as possible from associations of such farms. This avoids sales through third-party intermediaries, meaning

that the city receives a lower price while the small farmers receive a higher income. This tactic has the added benefit of promoting rural social sustainability – especially important in a country that saw poverty and social policy push it from approximately 60% rural to 80% urban in the past 50 years (Rocha and Aranha 2003).

- In addition to selling directly to the city, the SMAB partner farms, which are all less than 50 hectares and mostly under 10 hectares in area, have the opportunity to participate in the "Straight from the Countryside" (*Direito da Roça*) program. In this program, farmers are granted sales spaces throughout the city of Belo Horizonte, usually close to major thoroughfares and other highly frequented areas. Many farmers supply the Restaurants, School Meals, and other SMAB programs, but others participate only in Straight from the Countryside or the Organic Fairs throughout the city, which have the same dual purposes of supporting local production and encouraging direct interaction between the consumers and the farmers. Such interactions have proven very valuable in other programs more familiar in the Global North, such as the recent trends towards CSAs (Community Supported Agriculture groups) (McCullum et al. 2005, Schnell 2007).
- Besides the Popular Restaurants and School Meals, several other programs address the needs of populations "at-risk" for malnutrition. These include the distribution of enriched flour – wheat along with manioc, pulverized eggshells, and seeds – which has been of special note in improving the diets of expectant and nursing mothers and their young children. This is accompanied by nutrition, hygiene, and infant care programs conducted in cooperation between SMAB, community groups, and the Secretariat of Health, offering educational events at health posts throughout the city (though this is most notable/important in the poorer neighborhoods, called *favelas*, or more properly, *aglomerados*).
- Two other projects look to allow lower-income and at-risk groups better access to higher variety and quality of foods. "ABasteCer/ABC" and the "Workers' Convoy" stimulate the commercialization of basic foodstuffs in Belo Horizonte and the diversification of the network of food outlets. The ABC (which also stands for "Alimentos a Baixo Custo") program is made up by a number of fixed produce stores throughout the city, although generally located near major thoroughfares, where the price of 20-25 products is controlled by SMAB. The makeup of the price-controlled products is determined by SMAB, while the storeowner may sell whatever selection of other products at whatever price they wish (José, pers. comm.). The price-controlled products are served at a fixed price per kilogram (R$0.59 in 2006, as compared to a then-market price of R$0.89 – this

is approximately US$0.19 and US$0.28, respectively). The purpose of selling a variety of produce at the same price is to encourage mixing-and-matching and variety, helping to maintain cultural traditions of the use of various foods as well as encouraging a nutritious diet acquired from the different nutrients offered by different vegetables and fruits (L. L. Smith, pers. comm.; pers. obs.; Deckelbaum et al. 2006)

- The other project, the Workers' Convoy (*O Comboio do Trabalhador*) occurs at four centrally located points in the city throughout the week. The city provides use of these four points in prime, high-traffic downtown locations in exchange with the grocers' participation in the Convoy. These grocers are obligated to go to peripheral neighborhoods and sell produce on weekends at the fixed prices. The "Big Popular Basket" (*Cestão Popular*) similarly consists of moving markets, run by SMAB employees, where 24 essential non-perishables and cleaning products are sold at low prices to residents of extremely poor neighborhoods who have met certain requirements and enrolled in the program.
- One of the priorities of SMAB is education of adult consumers and children, through school programs, community shows, average and lowest food price lists for consumers, workshops, cooking classes and more. These activities look to promote citizen ownership of the basic human right to food security as guaranteed under the UN Charter, among other international agreements, and to teach fundamental principles of nutrition to those who might not otherwise have received it. This is an especially important component in a world socioeconomic climate where increasing wealth is leading to obesity and nutrient-poor, high calorie diets in not just the Global North, but also in other countries that are still simultaneously dealing with persistent under- and malnutrition among their population.
- Specific examples of the above are the training and education for a healthy and nutritional diet that SMAB has developed together with the population, to promote healthy eating habits, stimulate diversity and variety as part of a healthy diet, and to disseminate the concepts of food security. For example, regular courses are offered to disseminate information on nutrition and proper preparation of foods, orienting the population towards planning healthy menus at low cost that also can help to prevent illness directly or indirectly related to dietary habits, such as high cholesterol, diabetes, hypertension and osteoporosis. Thus, SMAB looks towards the improvement of the quality of life of Belo Horizonte's citizens by addressing food security more broadly, such that not just hunger but other elements of health related to food are included.

- SMAB helps in the implementation and maintenance of gardens in community spaces to stimulate urban agriculture and self-sufficiency. In the public schools, gardens function as classrooms for nutritional education, and the food produced is integrated into the menu of the schools themselves.
- A number of additional programs work to supply food to community organizations, retirement homes and facilities for the care of the elderly, and philanthropic groups. However, SMAB also acts to accompany, supervise, and promote the training and empowerment of the relevant professionals in food service, preparation, and care, and encourages and follows the nutritional evaluation of the beneficiaries of these "third-party" programs.

It is important to note that these are only some of the most prominent programs, and that all of the food security secretariat's programs in Belo Horizonte have made up less than 2% of the city's annual budget, at approximately US$9-10 million dollars per year. Even given the current level of success, there is ample opportunity to expand the comprehensiveness and size of the programs (Nabuco and Souki 2004). Nevertheless, in addition to addressing food security within the city in a comprehensive, systematic manner that goes to the roots of the problems, SMAB's Straight from the Countryside (and a smaller number organic produce fairs similarly working with by local family farmers) have provided unique opportunities for small farmers and consumers by eliminating the "middle man." SMAB addresses accessibility from two angles as locating the fairs and other programs throughout the city eases logistical and practical problems of access and transportation, and price controls address restricted access due to economic limitations. And in accordance with a human rights and equity-based development approach, food policy should simultaneously be aimed at providing living wages for farmers and reasonable food prices for poor consumers. Indeed, this "double benefit" to two disadvantaged groups – the small farmer and the poor city dweller – seems to be emblematic of the mission of societal reform expressed by SMAB's programs, and the party of SMAB's founders, the PT. Additionally, although the city government does not have direct political control in the municipalities where the farmers are located, SMAB's connections with them, and its partnerships with the state extension agency EMATER has potentially brought benefits to the communities around Belo Horizonte. SMAB's partners at EMATER tend to encourage agricultural practices which may be considered more "ecological" or sustainable, although this is not the general approach of EMATER. Producers' interactions directly with consumers also seem to provide direct incentives for them to avoid using synthetic pesticides or other practices that may "turn off" consumers (based on interviews with local farmers, and functionaries at SMAB).

With this understanding of SMAB in mind, I will turn to an analysis of the institutions at work in Belo Horizonte and how they may have affected the creation and effectives of SMAB. This examination of theoretical frameworks will look to further break down and explain how and why SMAB has been able to do what it has done with these programs, and to answer the important question of what specific factors enabled SMAB to be created when it was and where it was, so that we may be able to generalize from Belo Horizonte into understanding other situations and contexts.

INSTITUTIONAL THEORIES: BACKGROUND AND APPLICATION

Institutions, as an evolving set of rules, conventions, and norms of behavior that help govern and organize groups of people, have increasingly been a major subject of study as part of the dynamics of organizations and society. This contrasts with previous theories of more strictly rational, utilitarian behavior in societal organization and decision-making (March and Olsen 1984). Recent institutional research has in turn increasingly emphasized the importance of local institutions in development, conservation, and sustainability. Theory indicates a number of reasons for this shift from the previous preferred structure of centralization: local institutions' relatively greater responsiveness to and knowledge of local conditions, increased engagement by local actors in local institutions in which they have a personal stake rather than following orders "from on high", greater citizen participation and accountability, and the possibility of more equitable outcomes (Ostrom 1990, Escobar 1998, Agrawal and Ribot 1999, Ribot 1999, Prugh et al. 2000, Mészáros 2001, Gibson and Lehoucq 2003, Andersson 2004). Indeed, decentralization is a major part of the 1988 Brazilian Constitution (see, i.e. Bentley 2006, see, i.e. Vaitsman et al. 2006), marking it from the beginning as a factor in the present work. However, it is not necessarily my intent here to engage in this portion (decentralization/devolution) of the state-institution debates. Rather, it is the backdrop in which my study will take place, focused on the intersection of a specific group of social policies and their interaction with ecological and socioeconomic processes in Belo Horizonte. Thus against this backdrop, my analysis will start with a focus on Kingdon's classic work on public policy process streams and entrepreneurship within institutions. My approach to this institutional analysis will also be informed by the pertinent literature on synergy (complementarity and embeddedness). From these contexts, I hope to develop a theoretical framework for understanding how Belo Horizonte's municipal food security institutions come to be, and how they may affect and be affected by the agricultural practices of local farmers supplying the municipalities.

Case Study Rationale

Given the role of a prominent political figure in the founding of SMAB (former mayor Patrus Ananias de Souza), the explicit attempts by SMAB to make use of extensive private/public interpenetration, and the timely role as well of a social movement near the beginning of SMAB's founding (Betinho's Citizens' Action Movement Against Hunger and Poverty and For Life), an analysis using the ideas of Policy Entrepreneurship and [Policy] Process Streams (Cohen et al. 1972, Kingdon 2003) as well as the concepts of social capital and synergy as developed by Evans (1995, 1996a, 1996b) and Ostrom (1996) seems appropriate. Further, the case of Belo Horizonte and SMAB matches Yin's three rationales for a single-case study (Yin 1986): it is a critical case (testing a well-formulated theory, here, the Kingdon/Cohen Process Streams, Evan's synergy); it is a unique case (SMAB is a program with few, if any, direct equivalents in the world), and it is a revelatory case (a situation exists where an investigator can observe and analyze something previously inaccessible to scientific investigation – in this case, only Cuba has had a similar step-change in food policy with direct local agroecological links in recent years, though in Cuba's case at a national rather than municipal level, and Cuba remains relatively inaccessible to US researchers).

Policy Streams and Policy Entrepreneurs

Kingdon (2003), in his extensive examination of public policy workings of the United States Federal Government, emphasized the importance of policy windows, or periods where three political process "streams" join to create significant agenda change. The streams here are described as problems, policies, and politics streams, modified from the classic work of Cohen et al. (1972) on decision making in universities. Here, the problem stream is a growing or sudden realization of a condition that society would like to see changed; the policy stream represents the knowledge and perspectives of specialists and experts in a given area of public concern, and the political stream represents the currents of public office, such as national mood, public opinion, election results, changes of administration and other political turnovers. Kingdon finds, as Cohen et al. (1972) did, that these streams can act independently to a significant extent, and may join together to allow effective action at unpredictable times. When this occurs, it creates a window of opportunity – a policy window. As counterintuitive as it seems, Kingdon's empirical work and Cohen et al.'s simulation models provide compelling testimony to the commonness of this kind of "untidy" decision making in what they describe as "organized anarchies."

Organized anarchies are typified by inconsistent and often ill-defined priorities, unclear technology where internal processes are not understood by an organization's own members and

must operate, to some extent, on trial-and-error, and fluid participation, where participants vary in the how much time and resources they can devote to a given problem, making the exact boundaries of the organization uncertain and changing. "Organized anarchy" does not refer to a necessarily permanent state within an organization, but rather, as Cohen et al. say,

> "They are characteristic of any organization in part – [and for] part of the time. They are particularly conspicuous in **public**, **educational**, and illegitimate organizations. A theory of organized anarchy will describe a portion of almost any organization's activities, but will not describe all of them." (*emphasis added*)

It is thus also empirically open whether or not SMAB conforms with this description in the specific areas and times being studied here, but considering the fact that SMAB exhibits both public and educational functions, and represents the construction of a new organization and new institutions, it does not seem a stretch to hypothesize that Cohen et al. and Kingdon's refinements of their theories will be applicable.[15]

Expanding on the nature of the three streams, both Kingdon and Cohen et al. find that they largely evolve and change independently. This relative independence in organized anarchies is empirically observable, but also can be abstracted to a semi-theoretical framework. Problems, conditions in society that people in the public or government may wish to see changed, are common, changeable, multi-faceted, and potentially overwhelming to would-be problem-solvers. Practically, this means not all problems garner equal attention at all times, and as one set of problems rather than another comes to occupy attention, the potential for the problem to be resolved arises.

However, policies – potential solutions to problems – do not always, or even commonly develop in response to the most prominent problem at a given time. Rather, in this stream, academics, technocrats/career bureaucrats, independent organizations and others come up with solutions that most concern them, due to personal interests, concerns, or agendas, or in response to problems or political imperatives that had risen to the top of the agenda in a previous time period. This stream is semi-independent of the other two at least in part because a societal problem is not usually solvable within the time frame it garners widespread attention, and as such inertia and independent interests somewhat dictate what solutions continue to be developed before and after the time period where "their problem" may be at the top of the agenda. This process of policy solutions being created before or after a relevant problem has widespread attention, and thus accumulating without necessarily being applied or enacted, is akin to what Cohen, March and Olsen (hereafter CMO) referred to as the "garbage can model." Here, proposals and ideas are dumped into different garbage cans, or "containers", as they accumulate,

where they are later examined somewhat haphazardly when a problem is at the top of an agenda and thus actively "looking for" a solution.

Finally, the stream of politics represent the vagaries of public mood and public officials, as elections bring different groups and people into power, politicians perceive a new mood from their constituents, shifts occur in partisan or ideological distributions within a governing body, and politicians respond to interest groups or personal motives.

Despite their independence, the three streams quite obviously interact with and affect one another. Although "Solutions are developed whether or not they respond to a problem" and "The political stream may change suddenly whether or not the policy community is ready or the problems facing the country have changed," their interaction can be seen in various instances. For example

> "The criteria for selecting ideas in the policy stream, for instance, are affected by specialists' anticipation of what the political or budgetary constraints might be. Or election outcomes in the political stream might be affected by the public's perception of the problems facing the country."

However "Despite these hints of connection, the streams still are largely separate from one another, largely governed by different forces, different considerations, and different styles" (Kingdon 2003). These characteristics therefore make what Kingdon calls policy windows and policy entrepreneurs – times when the streams align, and people who are able to effectively influence and make use of such alignments – so important. Those prepared to address a given agenda change and ready to spend resources advocating and organizing for it, the policy entrepreneurs, come to fore as a factor in coupling the streams during an open policy window. Policy entrepreneurs are advocates for proposals or ideas, who invest their resources in hope of a future return. Policy windows are unique chances to advance agenda change caused by some noticeable shift in one of the streams – a problem brimming to crisis, a change of administration, or perhaps a shift in the mood of the polity. Policy entrepreneurs are able to quickly seize on such openings, attach solutions to problems, overcome constraints, and take advantage of politically fortuitous events. Out of 23 case studies, Kingdon found policy entrepreneurs to be very or somewhat important in 15 and unimportant only in three. They were, in effect, figures that would not have been sufficient to change policy alone, but nonetheless had a central role in its enactment.

State-Society Synergy

Peter Evans (1995, 1996b, 1996a) and Elinor Ostrom (1996), among others have found that partnerships across the state-societal divide can enhance policy effectiveness and efficiency. Synergy can be an enabler to effective policies and public action – the more conditions fostering synergy are present, the more likely it is that synergy will form, and the more synergy present the more likely a program will be successful. Evans (1996a) distinguishes between two forms of synergy: complementarity and embeddedness. Complementarity depends on the principle that certain (collective) goods can be better provided by governments, and other goods may be more efficiently provided by private enterprise. Hence, complementarity allows for more effective production and greater output than either could deliver without the other. Embeddedness, a trickier concept, is the principle that interpersonal ties connecting private citizens and public officials across the government/society boundary can act as great repositories of social capital, the "soft technology" composed of trust, friendship, and other informal connections that allows things to get done while decreasing free-riding and rent-seeking.

Although embeddedness itself works as an enabling factor for effective policy action, embeddedness in turn also to some degree relies on other societal and institutional factors for its creation, maintenance, and effective use. Drawing on the work of Tendler (1995), Lam (1996), Ostrom (1996), Heller (1996), Fox (1996), Shanmugam (1991), Myrada (1992), and Burawoy (1996), Evans' analysis yields five conditions that enable effective use of embeddedness in public-private relationships: a competent government bureaucracy, democratic and competitive politics, "rules of the game" regulating how politicians compete with each other and interact with society (i.e., that "quintessential complementary good," the rule of law, making corruption and state violence uncommon or marginal), egalitarian social structures (giving the poor and powerless access to decision makers in order to minimize the ability of the elite and wealthy to maintain the status quo), and complementarity itself. Complementarity acting as an enabler to embeddedness may seem to be contradictory, since embeddness and complementarity were listed as two different types of synergy. The resolution of this tension is that embeddedness (personal relationships of trust, confidence and even friendliness across the public-private divide) is more likely to occur when there is relevant complementarity (the ability of public and private actors to co-produce goods, by each "doing what they do best," in effect but not necessarily working directly together on the same elements of a project). One may enable the other, and still remain distinct from it. [16] For example, in terms of complementarity, an effective legal system and police force providing for the rule of law allows private, individual commerce to be safely conducted and secure contracts to be agreed upon, thus generating a variety of public goods like a degree of

stability and higher employment. Embeddedness, where a community trusts and even has friends within a legal system and police force, may allow the efficient generation of further public goods, such as even greater stability and freedom from repression or legal discrimination. The latter benefits from embeddedness would be less likely to occur where the police force was ineffective in providing its complementary function of maintaining the rule of law. (The many historical and contemporary examples of repression involving police forces also seem to at least *prima facie* represent a lack of egalitarian access, and it is easy to think of examples of police repression where competent bureaucracy and democratic and competitive politics are lacking as well.) Thus, examining synergy within Belo Horizonte will require scrutinizing these elements and enablers of complementarity and embeddedness, in order to operationalize them and determine their effects on food policy.

METHODOLOGY

Consistent with Geertz (1993), my research was conducted in a variety of contexts in order to follow the diverse strands in the "webs of significance" spun around SMAB and Belo Horizonte. This involved analyzing the food policy institutions in Belo Horizonte as informed by interviews, participant observation with members of SMAB's staff and management, cultural immersion and interactions with area farmers who are partners of SMAB and farmers who are not. This approach of "thick descriptions" was used in search of deeper causal links found beneath the perceptions and appearances of SMAB and its partnerships. Research on the institutional structure of the creation and maintenance of SMAB was primarily conducted via interviews with public administrators and staff at SMAB and farmers in the area around Belo Horizonte, both those participating in SMAB's "Straight from the Countryside" and Organic Fair programs and the neighboring non-participating farmers located in the fragmented Atlantic Forest around the city.

In 2003, I started my preliminary fieldwork in Belo Horizonte through participation in an online course on nutrition and food policy taught by Ryerson University nutrition researcher and economist Cecilia Rocha, which culminated in an intensive one-week site visit to Belo Horizonte. During this visit, the class was hosted by then-manager of the office for Coordination of the Food Assistance Programs of SMAB, Adriana Veiga Aranha, who is now Chief of Staff to the Federal Minister of Social Development and the Fight Against Hunger, Patrus Ananias de Souza – the former Mayor who originated SMAB. Led by Rocha and Aranha, the course was composed of daily seminars and visits to SMAB offices and programs such as the Abastecers, Popular Restaurant, organic and Straight from the Countryside fairs, School Meals, and Municipal Central

Food Supply Center, along with site visits to two SMAB farmers, one who was a member of Straight from the Countryside and another who was a member of the organic fairs. The experiences from this course were logged over the course of the week and served as a basis for later work and further participant observations. Returning from August 2004 to April 2005 for my first independent field season, I spent a significant part of the eight months refining my ability to communicate in Portuguese. During this time, I engaged in a number of unlogged casual interactions with the functionaries in the SMAB offices, including going to lunch, sharing coffee, and brief visits, in order to establish that I was able to clearly communicate with them in Portuguese, and to gain entry to the field and access to the individuals, documentation, and locations involved in the SMAB programs. Over the course of two more field seasons (2006 and 2007), six in-depth interviews were conducted with five employees of SMAB, along with participant observations of work at the SMAB offices. An additional eight in-depth interviews, five brief interviews, and participant observations with 13 farmers were conducted by myself or a field assistant between 2004 and 2008 (University of Michigan IRB ID B04-00006385-I; see Tables 3.1 – 3.3 for demographic and background information on interviewees and farms and the Appendices A and B for interview instruments). Participant observations were also conducted at a meeting of the Association of Farm Producers of Straight from the Countryside, an academic conference on organic and family agriculture, a week of visits to regional agricultural programs in Minas Gerais, and a meeting of the monthly organic agriculture working group in Belo Horizonte held by the Federal Ministry of Agriculture. Finally, in 2008 I was fortunate to attend a presentation on municipal renovation projects given by the outgoing Mayor of Belo Horizonte, Fernando da Mata Pimentel, at the University of Michigan, Ann Arbor. After his presentation, I was able to conduct a brief, informal conversation, logged as a participant observation. Further information was obtained through documentary research in local and national newspapers and national and international scholarly journals, and government and non-profit organization records (many accessible online as well as through my contacts at the relevant organizations). All formal interviews were loosely based on the semi-structured interview approach of Kingdon (2003), although the results here were analyzed qualitatively, as opposed to the quantitative approach used by Kingdon.

Using the methods outlined above, I will employ the theoretical frameworks developed previously in the subsection **State-Society Energy**: embeddedness and its five enablers, competent bureaucracy, competitive and democratic politics, "rules of the game," egalitarian social structures, and complementarity between state and private actors, organized anarchical institutions, and the importance and role(s) of policy entrepreneur(s) and the workings of the

policy process streams. These approaches allowed me to analyze some of the mechanisms for building and maintaining social capital and institutional sustainability (or the lack of such mechanisms) and whether and which policy entrepreneurs played a role in the creation of SMAB.

SMAB: Brief Interviewee Background

Note that because there are only five interviewees within SMAB, I have disaggregated their demographics and pseudonyms to prevent identification and preserve confidentiality. Demographic and descriptive information is found in Table 3.3; their research aliases are listed here separately, along with their educational background and position. Names were assigned randomly, without regards to sex; where a subject had multiple positions over the research period (2003 – 2007) all are listed.

- José: economist, administrator/manager (2004, 2007 – present), administrative assistant (2005-2006)
- Eliane: nutritionist, educator
- Antônio: nutritionist, administrator/manager (2005), facility coordinator (2003-2005, 2006 – present)
- Jairo: biologist, educator
- Rubens: social worker, administrator/manager

Extensive time was spent in their offices, observing and talking with them and their colleagues. The general themes and points observed from the experiences are outlined below.

GOALS, SUCCESSES, AND CHALLENGES WITHIN THE MUNICIPAL SECRETARIAT OF FOOD SUPPLY OF BELO HORIZONTE

There was a high degree of congruence in what the interviewees within SMAB saw as its grand objectives. Each gave an answer that, in their own words, reflected the goal of advancing food security ("*segurança alimentar*") in terms of making sure all parts of the population, especially "biologically vulnerable" segments of the population had access to food at fair or low prices, and of good quality. Each additionally focused to some degree on their own area, from "Promoting family agriculture… and the practice of organic agriculture," to "training target populations" in Belo Horizonte in nurseries, schools, businesses as well as those who work in the Secretariat's programs like the Popular Restaurants and School Meals, etc. If one reviews the documentation written about and by SMAB (i.e. work by Aranha 2000, Rocha 2000, Aranha 2003, Machado 2003, Rocha and Aranha 2003, de Araújo and Alessio 2005), the expressed sentiments also align with the goals as described in those works and in the background and

programs of SMAB I outlined above in the section **Belo Horizonte: SMAB's Formation and Organization**.

All participants stated that SMAB was successful in advancing its objectives, pointing to a variety of its programs and innovations as specific examples. All mentioned that SMAB's programs had brought high quality, low-cost food to low-income, poor, and vulnerable populations with the School Meals and Popular Restaurant programs as the most frequently mentioned. Several also mentioned the involvement of and support for small, local producers in terms of bringing them into the city to sell directly to the consumer, with José adding SMAB's support for organic agriculture as an additional success. Antônio indicated the Straight from the Countryside and ABC programs as being more significant successes than the School Meals, because the prior two represented innovations and new approaches, rather than simply making pre-existing programs work effectively. There was additional consensus on SMAB's success in terms of educational support and empowering people to understand their own rights to food; Rubens expressed it in terms of having created a general "culture of food security."

However, despite these perceived successes, all of the interviewees expressed concerns regarding significant challenges for SMAB in terms of a need for more financial, physical and human capital. Each person indicated challenges and areas for improvement within their own area of specialization, from resources to form a partnership with the Municipal Secretary of the Culture to design and perform skits to teach food security to children (Eliane) to an independent lab to analyze water quality and safety on partner farms (José). While a need for more resources is a common and expected challenge within government, beyond being mentioned by each interviewee, the limitations noted by my subjects also reflect critiques from de Araújo and Alessio (2005), who found that "The Secretariat, however, doesn't possess sufficient capacity in order to attend to the demands of the population, due to scarcity in human resources and infrastructure."

Outside of the general need for more financial support and staff was a uniform call for more dissemination of information on the Secretariat's work. All subjects agreed that the "general public" probably had only a vague notion of SMAB at best. Interviewees stated that it was likely most of the public interacted with or was aware of at least one program. For example, a given citizen may have children who receive School Meals at a municipal primary school, citizens with lower income or simply seeking low prices may shop at the Abastecers, or the citizens who make up the more than 11,000 patrons served by the Popular Restaurant programs each day, but a recurrent theme in the interviews was a lack of broad awareness of the existence of the Secretariat itself. Every interviewee cited a lack of media exposure and the general need

for more dissemination of information about the Secretariat. A quote from Jairo is representative of this assessment:

> "[Knowledge of SMAB] is [based on] word-of-mouth… We don't advertise, that is, mass media, television, things like that… around elections, there's more talk about our programs… Sometimes, people know of a project: "Ah, I know the Popular Restaurant!" "Do you know which Secretariat is in charge of it?" "No." …[So] I believe that, yes, the majority of the population knows [a program well], but sometimes they don't know that it's the Secretariat of Food Supply that runs them. That's the truth. Many times, they don't know which Secretariat is behind whatever project. They think sometimes that it's the Health Secretariat. So, I believe there would need to be more publicity/dissemination, of what's done by whom. Sometimes, within the City Government itself, the functionaries themselves don't know who's in charge of a given project."

Accordingly, Eliane explained that, with the lack of publicized information, before she had entered the Secretariat 6 months prior to our interview, she also did not know what the Secretariat did, on the whole – and she came from undergraduate study of nutrition. "Look what I studied, I had access to the studies," she said. "**I** didn't know what the Secretariat of Food Supply did, you see?" An experience involving what José called the city's flagship program, the Popular Restaurant, is perhaps the most notable example of the insufficiency of information about SMAB its citizens have. In his interview, Rubens told a story of how

> "I was there, I talked with a patron that was in line. And I said, 'Do you know whose restaurant this is?' He told me that it was run by some businessman… [So] dissemination of information is not being done well, communication is not being done well, right? So, we need to step it up… so that people will know who runs what program; [otherwise] if there's something wrong, who are they going to complain to, you see? The population has a right to know this, so we need to be a little more daring and aggressive in our information… to show the population what's happening in the city and who is doing it."

What ties these concerns together, besides the need for monetary resources to hire more staff in the first cases (i.e., more educators, lab staff, etc.) and generate publicity and disseminate information in the second, is the fact that together these issues have the ability to further compromise SMAB's mission. In terms of Rocha's Five A's, without awareness of the programs conducted by SMAB, the agency of the public is limited – if they are not aware of who is running what program, or even what programs are available, then those who suffer from food insecurity will not be able to effectively access the resources SMAB is attempting to provide, nor will they be able to effectively demand changes or air grievances. This in turn can come to affect appropriateness and acceptability – during my site visits in 2003, citizens at an Abastecer complained to Aranha that the store owners had on occasion raised prices above legal limits and would sell lower-quality produce than the SMAB standards demanded. de Araújo and Alessio

similarly state that some markets that are not actual participants in the SMAB program have used the Abastecer/SMAB seal in their establishments and sell products at the price-controlled rates, but then may sell products not meeting quality or hygiene standards, causing citizens to, at that point, complain of the poor quality service. Effective communication between the city government and the people would help alert consumers to scams at an earlier point, and possibly allow sufficient agency such that such scams would not persist – the citizens complaining to Aranha stated that they had been making those same complaints through proper channels for weeks without an effective response from the Secretariat, and de Araújo and Alessio note that, at the time of their writing in 2005, no steps had been taken to sanction transgressors or bring them into compliance. Similarly, the Big Popular Basket, a program that targets the poorest groups by selling subsidized food and hygiene products in some areas, seems compromised by a lack of human and dissemination resources. de Araújo and Alessio recount how the program was beset by violence in a series of robberies and assaults on the trucks distributing the baskets – conducted by the very beneficiaries of the program. They hypothesize "One possible reason for it is the lack of identification with the program." They also observed that the registration process is non-functional, threatening that those who do not really need the program may nevertheless be taking advantage of the resources spent on it. Additionally, the distribution of the Baskets required, in some cases, police protection, and de Araújo and Alessio amplify that, though the program's manager pointed out the existence of significant popular participation and an expressive relationship between SMAB functionaries and local leaders, it appears that "What exists is a close relationship between two or three of the functionaries and a given 'leader'" who does not actually represent the community. In de Araújo and Alessio's interviews, SMAB managers said that this reflects a lack of mobilization within the community, rather than a failure of the program or the Secretariat. Rubens had a similar analysis of participation in SMAB programs, discussing the responsibilities of SMAB in terms of capacity-building for citizens through education, but stating that their responsibilities, to some extent, stopped there:

> "So we, in our day-to-day work, or in our [joint citizen-government] councils, or when we give a presentation, a course, a seminar… we carry a little of this information [on food security policies and programs] to them… The Secretariat isn't going to call people and say something like, 'Come here [as a] group, you have to make demands, because the City is very bad."

With such a lack of information among possible patrons and beneficiaries remaining present, and a lack of sufficient staff resources within SMAB to more aggressively pursue education efforts, engage in the community, or even efficiently register all of the potential

beneficiaries, the framework of Kingdon/CMO in terms of organized anarchies appears to be apt. In the next section, I will analyze in detail how the information I gained from interviews and documentation fits into this framework, and what its implications are for SMAB's origins and present and future effectiveness.

ORGANIZING ANARCHIES: THE PROBLEMS STREAM AND THE FOUNDING OF SMAB

> "People do disagree about what they want government to accomplish, and often are obliged to act before they have the luxury of defining their preferences precisely." (Kingdon 2003, p. 85)

In terms of SMAB and Belo Horizonte's food security organizations, Kingdon's above description, written with the United States Federal Government in mind, seems equally applicable to the case before us. Kingdon reminds us that different actors, with different agendas, moving in and out of the decision making process fit very well with the CMO model of "garbage cans" in institutional choice. Kingdon describes the problem stream as being composed of issues that need to be addressed within a society and the process where they are recognized (or fail to be recognized) as such. This phenomenon can be observed within the SMAB structure in several ways and at several points, with the conditions for its creation lining up well with the problem stream framework laid out by Kingdon.

Problems in society are affected by politics and policies, but many if not most societal problems pre-date any given political administration or current policy approach. That is, problems with hunger may be exacerbated or ameliorated by policies enacted by a given administration, or altogether ignored, but hunger was likely a pre-existing problem, and the current state of the problem depends on a large number of factors outside of current policies and politics (i.e., weather, infrastructure, inequality).[17] There are also any number of problems within society to address at any given time – "Problems abound out there in the government's environment, and officials pay serious attention to only a fraction of them," (Kingdon 2003, p. 114). Meaning that which problems get addressed during a policy window is a function not just of the problem identity itself, but also policies and politics, which will be addressed in the following two sections in reference to the creation of SMAB.

In terms of the problem stream itself, however, there is still the question of its development before and during the initial organization of SMAB in 1993. Bringing attention to an old problem, or a new one, has a number of requirements (making it "a major conceptual and political accomplishment" to do so, according to Kingdon). One avenue for bringing recognition to a problem is to recategorize or reframe the problem, especially in such a way that the public

and decision makers come to see it as a problem "appropriate for government action." In the 1990s, as Aranha (2000) points out, the analyses and government actions in Brazil around food security were still diverse and incoherent, and the right to food was still associated with a negative clientalist/welfare state connotation. As I reviewed above in the section **A brief look at food security in Brazil, from World War I to 1993**, the problem of hunger/food insecurity in Brazil had long been considered an important and appropriate one, but had not been systematically addressed, especially not from the view point of its basis in inequality and poverty as opposed to supposedly insufficient production. The PT and its Parallel Government gave some recognition to the greater breadth of the problem beyond simple problems in insufficient availability, and the ideas of food as a human right gained strength as Neo-Malthusianist perspectives decreased somewhat in prominence after the World Food Crisis of 1972-1974 (Aranha 2000). In fact, the Parallel Government's stance on food security was grounded in the broad, multi-sectoral approach to food security and the right to food elaborated in their 1991 document "A National Food Policy," itself based in part on an almost revolutionary 1985 proposal from the Brazilian Federal Ministry of Agriculture (Takagi 2006).[18] This laid down part of the foundation for a later widespread reframing of the issues.

The reformulation of food security as a right and the prominence it was given within the PT is certainly part of the reason it was near the top of the agenda when PT member Patrus Ananias won the mayoralty in Belo Horizonte in 1993. Besides his membership in the PT, Ananias had a further personal commitment to the issue. Ananias reportedly saw addressing the right to food as not just an important sociopolitical goal, but an important part of honoring his Catholic faith (participant observation, seminar by Adriana Aranha, 6/13/03).[19] Thus Ananias had clear reasons to recognize hunger/food insecurity as a problem when he became mayor. An additional factor at work encouraging problem recognition was, in accordance with Kingdon's framework, the fact that systematic indicators pointed to major problems connected to food security (see the section **Belo Horizonte: SMAB's Formation and Organization**, above, for a review of problems and problem indicators in Belo Horizonte in regards to food insecurity). And lastly, although major crises can be important in problem recognition, Kingdon points out that universal and visible problems are less dependent on crises for recognition. While not universal, malnutrition was hardly uncommon (a joint study found 15.5% of the population of Belo Horizonte suffered from malnutrition in 1993, according to Aranha (2000)), and 12.3% of the infant mortality rate was reported to be due to malnutrition, when infant mortality was 34.4 per 1000 live births city-wide, and as high as 64.6 per 1000 live births in the poor *aglomerado* of Taquaril (Somarriba et al. 1998, and Belo Horizonte Municipal Secretariat of Health 1999, in

Aranha 2000). Thus, one could reasonably view the problem stream as being primed for action in regards to food security in Belo Horizonte in 1993.

Policies and Policy Entrepreneurs in Food Security During the Formation of SMAB

> "They often don't know how to accomplish what they want to accomplish, even if they can define their goals. If they want to eliminate poverty, for instance, the technology to do so is quite elusive; it's not like making widgets." (Kingdon 2003, p. 85)

During SMAB's founding, there seems to have been a significant amount of innovation and contributions from the functionaries and partners of SMAB. Fifteen programs were created in the first 2 years of its functioning (Straight from the Countryside, School & Community Gardens, Workshops for Gardening in Alternative Spaces, Promotion of Orchards, Center for Municipal Food Supply & Distribution, Abastecer, Workers' Convoy, Model Fairs, School Meals, Popular Restaurant, Malnutrition Prevention and Combat, Food for Community Support Centers, Big Popular Basket, Distribution of Carry-out Lunches, and Consumer Education) and 12 more by 1996, making up 89% of all of the programs run by SMAB by 2003 (24 of 27), as identified by SMAB staffer Moisés Machado in his report, "10 years of City Supply and Food Security Policy, Belo Horizonte 1993 – 2003" (see Tables 3.4 – 3.6). de Araújo and Alessio point out a number of examples where SMAB programs have not worked as intended, or fallen short of their initial goals, and a few more can (and will) be outlined from the interviews. As in Kingdon/CMO, the "technology" to address the difficulties in providing full food security for the entire population of Belo Horizonte is, it could be said, unclear – that is, within the policy stream, it is not readily apparent what solutions to apply to all of the problems facing SMAB as an organization and as the office in charge of guaranteeing the right to food. Paraphrasing Kingdon, providing food security is not like making widgets – you cannot just plug in established, pre-designed (policy) machinery and necessarily get a positive or predictable result. SMAB's attempts at addressing food security through a variety of programs and policies and their different levels of success align with the Kingdon/CMO description of policy streams in an organized anarchy.

Kingdon points out that, in regards to policy, a sort of natural selection in a "policy primeval soup" takes place, where a large pool of ideas float around and recombine, new policy ideas form and some old policy ideas fade, and some survive and prosper. Eventually some policy proposals may be taken more seriously than others or meet criteria relevant to decision makers at that time, and over time the public and the community of specialists are "softened up" in regards to certain proposals. Such a "softening up" consists of, to some extent, ideas floating in and out of fashion for a period of time, as "government does not work on ideas quickly. To

become a basis for action, an idea must both sweep a community and endure" (Kingdon 2003, p. 130). To this point, the history of food security I have reference several times above shows that the concepts later employed by SMAB had been in a sort of "primeval soup" for some time, including the 1985 document from the Ministry of Agriculture and its modification and adoption by the PT's Parallel Government in 1991. In fact, several of the SMAB successful policies and programs laid in re-invigorating or redesigning preexisting ideas, such as Popular Restaurants – which had antecedents that operated in Brazil in the 1950s and 60s before being closed down during the military dictatorship, and a Popular Restaurant in Belo Horizonte that operated for two years between 1988 and 1992. This Restaurant was closed in 1992, staying that way until the city rebooted the program as part of SMAB (Aranha 2000, Pessanha 2002, Ribeiro 2002, Bentley 2006). Also, there is the School Meal program, a federal program that was "municipalized" and reconceptualized under SMAB (Belik 2003; Aranha 2000; Takagi 2006; multiple interviews).

Kingdon additionally points out the importance of the characteristics of the policies themselves in contrast to the raw workings of power, influence, pressure and strategy. "If we try to understand public policy solely in terms of these concepts, however, we miss a great deal… Government officials often judge the merits of a case as well as its political costs and benefits." Thus, he gives three criteria for survival of ideas in the policy primeval soup: technical feasibility, value acceptability within the community of specialists, and anticipation of future constraints, especially budgetary constraints. In some cases, the strict technical feasibility of the initial SMAB programs was plain: they were pre-existing programs, showing that they had at least some minimal level of feasibility. Many other SMAB programs had some antecedents – the National Program for Food and Nutrition (*Programa Nacional de Alimentação e Nutrição*, or *Pronan*) started under the military dictatorship in the 1970s looked to support and buy from small farmers, address inequality, distribute unprocessed foods to vulnerable groups like pregnant and nursing mothers and young children, and encourage, subsidize or legally mandate lower prices in poor areas, among other approaches (Takagi 2006). However, such programs suffered from poor planning and underfunding, lack of focus on low income groups and less-developed regions of the country, inconsistent service, excessive centralized federal control, contradictory or even redundant efforts distributed among various institutions, a confusing alphabet soup of acronyms, problematic federal centralization of food purchases, and the use of processed foods in some programs that contributed to poor nutritional habits in the population (Aranha 2000, Takagi 2006). Of course, besides possibly demonstrating a level of minimal technical feasibility, the prior existence of the relevant ideas helped in the "softening up" of policy communities and public support. "Then when a short-run opportunity to push their proposals comes, the way has

been paved, the important people softened up. Without this preliminary work, a proposal sprung even at a propitious time is likely to fall on deaf ideas," (Kingdon 2003). As far as budgeting, to jump ahead slightly, savvy planning and significant federal funding and contributions for several programs (including the school meals program and a small contribution towards food purchases for the Popular Restaurant) keep costs a small part of the city budget – approximately 1-2% of all expenditures (Rocha 2000, Machado 2003, Nabuco and Souki 2004). Of course, the low cost and subsidies depend in large part on the strategic consolidation of food policy into SMAB and extensive cooperation with other departments, especially the Municipal Secretariats of Health and Education -- departments that did not necessarily already share the analysis of Nabuco and Ananias as they were forming SMAB. "It wasn't easy to break the internal resistances… from a secretariat that has been established and consolidated for some years, like Education, for a new secretariat, still in the implementation phase," (Aranha 2000). Further, Kingdon emphasizes how policies are facilitated by close-knit policy communities, and slowed down somewhat in fragmented ones. Although the food security policy community was not large in 1993, nutrition was already part of the Secretariat of Health's remit, and the budget for school meals was located in the Secretariat of Education – meaning that their policy specialists had to be convinced, as well. In such a case, a policy entrepreneur can be invaluable. In Kingdon's definition, a policy entrepreneur's defining characteristic is

> "their willingness to invest their resources – time, energy, reputation, and sometimes money – in the hope of a future return. That return might come to them in the form of policies of which they approve, satisfaction from participation, or even personal aggrandizement in the form of job security or career promotion."

That is, according to Kingdon, policy entrepreneurs may be advocating "pet solutions," personal interests such as boosting a career or expanding bureaucratic turf, promoting their values and shaping public policy, or they may be what Kingdon also describes as "policy groupies", people who enjoy advocacy, being part of the action, being part of "the game." From the evidence thus far, it could be reasonably, if only tentatively, concluded that Ananias and Nabuco were looking to advance their "pet solutions," (Nabuco having been an economist with a focus on food policy and nutrition) as well as promoting the values and interests of the PT, both in terms of the egalitarian and reformist goals of the PT and in terms of its electoral interests in fulfilling promises and raising the profile of their new wave of prominent politicians. In my interview with Rubens, he recounted Ananias' role in similar terms:

> "He had a true obsession, he wanted to do something very visible, very palpable, that gave results, in the area of food security. So, he created the Secretariat… that was the

> great landmark, to my understanding, it was the political determination of the PT and of Mayor Patrus Ananias. It was from that vision that he created the basis for creating the Secretariat in the mold of what it is today."

To be certain, Ananias had a vested personal and political interest in the success of the PT as one of the founders of the party, and as a politician who went on to higher elective office in the national Congress before being appointed Minister of Social Development and the Combat Against Hunger under PT President Luiz "Lula" da Silva. There is also reason to think that he enjoyed, or at least placed a premium on activism, as he participated in the "democratic and social fights that resulted in the formation of the PT", and as a lawyer focused on the areas of workers' rights and social security rights (Ministério do Desenvolvimento Social e Combate à Fome da República do Brasil (MDS) 2008). And Nabuco was, if not a policy groupie, someone with an academic background and therefore vested interests in food policy in both its theory and application. Further, all interviewees mentioned the key role of Ananias in the creation of SMAB, with most of them also emphatically highlighting the importance of Nabuco as equal or even greater than that of Ananias. In regards to their motivations and SMAB's creation, José put it this way:

> "The governing politicians wanted it, and had food security as [their] priority at that time. Why? With this political will, they invested financial resources, assembled a good team. I believe that whatever the public policy, if you do not have political will, it's not going to go forward."

José essentially describes here the role of a policy entrepreneur in bringing an idea to fruition while the problem, policy and political streams are aligned.

Returning from policy entrepreneurship to our focus on the progress of the policies stream, realizing SMAB's creation was naturally complicated by the need for cooperation from other departments to develop its initial programs like reform of the pre-existing federal School Meals program. The Health and Education Secretariats eventually helped research, design and plan nutrition strategies, as well as partnering for the Project to Prevent and Combat Malnutrition and ceding supervision and financial control over the federal funds for the School Meals program, respectively. But before they spent their resources and ceded funds, their agendas and the sentiments of their policy community had to be aligned with that of Nabuco and Ananias, even while many health officials were not yet familiar with the concepts of food security (Jairo interview). That is, it is very likely that the problems and policies streams within the Secretariats of Health and Education were not in the same place as within the fledgling SMAB, or completely of a piece with the agendas of Nabuco and Ananias, who, as policy entrepreneurs, had to build agreement on the problems, policies, and solutions with their partners. For this reason, the two

founders of SMAB organized a Study Commission, made up of economists, social workers, educators, health professionals, and functionaries of the Urban Activities Secretariat's Department of Food Supply. Over a series of seminars, the group discussed malnutrition and food security, with Nabuco and Ananias reportedly acting as coordinators rather than dictating their analysis and simply overruling the analysis of the other professionals (participant observation, seminar by Adriana Aranha, 6/13/03; de Araújo and Alessio 2005).

> "The search for consensus was a distinctive characteristic of these social projects in the area of food security and, along with that, one observes that they were establishing the divisions of attributes and functions between the secretariats. If the integration of social policies is one of the challenges put before public figures, in the area of food and nutrition it becomes fundamental. The success of a public intervention around food security depends on the interdisciplinarity of diverse public policies." (Aranha 2000)

Through the efforts of policy entrepreneurs Nabuco and Ananias, not only was relative consensus achieved, such that the Secretariat of Education agreed to redirect their funds for School Meals to the new Secretariat of Food Supply, but also an ongoing partnership with the Secretariat of Health was established to help SMAB identify and gain access to the most vulnerable and poor parts of the city. This was both important and potentially effective because Brazil's universal health care system meant that the Secretariat of Health had posts in practically all parts of Belo Horizonte. Additionally, Nabuco and Ananias reportedly hired many nutritionists during the initial formation of SMAB, eventually employing more nutritionists than the Secretariat of Health, as they found that professionals from other disciplines such as health and social work found it difficult to follow the new and expanding conceptualization of "food security", rather than a more classic welfare/clientalist approach based on social work (Aranha 2000).[20]

Thus, as in Kingdon's policy stream, at some point, a "tipping point" is reached, as proposals may suddenly gain in popularity as more and more people discuss it and this repetition sees it being taken increasingly seriously. This dynamic is quite visible in the evolution of the concepts of food security in Brazil, reviewed above in "A Brief Look at Food Security in Brazil, from World War I to 1993", as ideas around addressing hunger grew and changed after World War II until the present time. Long-held beliefs about availability – the first A – as a root cause of hunger grew and faded in the community of specialists, while consensus slowly grew within a part of the policy community and within the public sphere (i.e. the platform of the Parallel Government) in terms of the importance of accessibility, acceptability, appropriateness and agency. In the early 1990s, these terms were not necessarily used as part of a consistent "Five A's" approach, but the analysis employed by Nabuco, Aranha, Ananias, the Citizens' Action Movement Against Hunger, and others highlighted the importance of moderating the market

through price control and wider distribution of foodstuffs – accessibility via, i.e., Abastecers, the Popular Restaurant, and the Big Popular Basket; monitoring the quality, hygiene, and nutritional sufficiency of food, or acceptability, as seen in the standards demanded in all SMAB programs, especially the Popular Restaurant, Abastecers, and School Meals working to get food from small farmers and encouraging organic agriculture, or appropriateness as can be seen in the Straight from the Countryside program, organic fairs, and disseminating ideas in terms of the right to food and encouraging popular participation; and agency as supported by SMAB education programs, requirements for Straight from the Countryside farmers to be part of a Farmers' Association, and joint citizen-government oversight groups, such as the Food Security Council (*Conselho de Segurança Alimentar,* or *COMUSAM*) and the School Meals Council (*Conselho de Alimentação Escolar*, or *CAE*). The relatively large number of programs enacted in the first two years of SMAB also implies that there was a process ("snowballing") as Nabuco and Ananias proposed and generated ideas within the Secretariat and with their partnering groups (i.e. enriched flour for expectant mothers and malnourished children, distributed at health posts, reportedly grew out of the initial planning seminars with health, social work, and education professionals). The multi-pronged approach of SMAB since even its early days reflects yet another aspect of Kingdon policy streams, that aspect being "the importance of a viable alternative." Food security was a problem that had moved up the agenda, but as Kingdon notes, "items are sometimes found on a governmental agenda without a solution attached to them… it is not enough that there is a problem, even a quite pressing problem… the subject with an 'available alternative' is the one that rises on the agenda, crowding out equally worthy subjects that do not have a viable, worked proposal attached." Food security was not only a problem that had arisen repeatedly and was in the public eye in 1993 due to social movements, urgency and consensus-building by Nabuco and Ananias – it was a problem with a seemingly "deep bench" of possible solutions.

Even with a "deep bench," a perhaps surprising number of food security policies were passed in the early days of SMAB, at a clip that far outmatches the progress of the following 12 years (Tables 3.4 – 3.6). Why was this possible then? Why has it not seemed to be replicable since then? These questions bring us to the importance of the politics stream, which I will review in reference to the time of SMAB's formation, before I transition to an overview of all three streams in the present time.

The Politics of Food Policy in SMAB

> "Flowing along independently of the problems and policy streams is the political stream, composed of such things as public mood, pressure group campaigns, election results, partisan or ideological distributions in Congress, and changes of administration. Quite

> apart from what happens in the community of specialists, and quite apart from bringing problems to the attention of people in and around government, such events as a new majority in Congress or a new administration occur." (Kingdon 2003)

In his seminal work, Kingdon uses what he calls a narrow, "intra-Washington" definition of politics, that is, politics in regards to electoral, partisan, or pressure group factors. Due to Ananias and Nabuco's roles as policy entrepreneurs, we have already reviewed some of the politics of the situation in explaining how and why food security was a prominent issue and how it moved forward. In this way, the policy and political streams were connected, but it is important to note that they still developed somewhat independently: Professor Nabuco was developing the literature on nutrition and policy before being tapped for Secretary; the academic discourse on hunger and its move away from Malthusianism predated the PT's Parallel Government and rise to power (perhaps most notably influenced by the ideas of Sen); Brazilians had been worried about, and developing policies to address, problems of hunger, poverty and inequality for decades. But the PT's rise to power, particularly the election of Ananias in Belo Horizonte, and his interest in food security, coincided with a take-off in the academic bases of food security itself (see i.e., Note 9), the long history of hunger in Brazil, and the popularity of Betinho's Citizens' Action Movement and its dedication to issues of human rights and equality all came together; the three streams aligned in such a way that policy entrepreneurs were available in the persons of an elected politician and his appointee to head the new Secretariat. It was not a *fait accompli*; President Fernando Collor de Melo dismantled much of "Brazil's nascent welfare state", privatized a number of government functions, and cut back or deemphasized a number of policies and policy instruments around health and nutrition in a bid to control inflation (Bentley 2006). In 1995, Fernando Henrique Cardoso ended National Food Security Councils in favor of an alternate approach arguably focused on poverty and "integrated action with different social actors" in terms of public/governmental and civil/private partnerships (Pessanha 2002, see also, Bentley 2006). That is to say, in regards to Belo Horizonte, other politicians may have put hunger as a secondary priority, as happened on the federal level under Collor and Cardoso. Both Collor and Cardoso arguably did so in response to rampant inflationary problems, although Pessanha argues that they also offered an insufficient break from earlier national policies fixated on clientalism and assistentialism, in order to strengthen their political and electoral power. Thus, even though the constitution of SMAB coincided with a desire to address food security among a large part of the polity and within the PT, the political fate of food security institutions in Belo Horizonte and Brazil at large were hardly predestined.

Looking at other political influences, prior research, as well as Rubens, recognized the

importance of the Citizens' Action Movement Against Hunger and Poverty and For Life (Aranha 2000, Rocha 2000, Takagi 2006). But as with the varying agendas between different politicians, academics, Health and Education professionals, this movement itself had a multi-faceted agenda targeted at a variety of problems, including not just support for the collection and redistribution of foods to low-income Brazilians (de Araújo and Alessio 2005), but there were also agendas focused on capacity-building, income generation, urban agriculture, and agrarian reform within its over 7,000 local committees (Bentley 2006). Indeed, it was originally formed in large part around the Movement for Ethics in Politics, which successfully fomented the impeachment of President Collor for corruption in 1992 (Valente et al. 2001, in Bentley 2006). In 1993, President Itamar Franco responded to the Citizens' Movement and pressure from the PT Parallel Government by initiating programs around the "Map of Hunger." The Map did not fully respond to the requests of movement leader Herbert "Betinho" de Souza, who had been pushing for a survey of both national nutrition deficits and areas of food production, in order to bring those lacking food together with channels of production (Takagi 2006).

The Citizens' Action Movement could be considered both a "public interest group" and a legitimate expression of "the national mood" under Kingdon's framework. That is, it clearly counts as the former as a group advocating reform and government policy targeted at providing basic human rights. But the enormous popularity of the Movement and its leader Betinho and the seeming depth of participation imply that it addressed the concerns and opinions of many Brazilians. Whereas Kingdon points out that public interest groups often have a surprisingly small number of adherents, and that national mood only vaguely resides in the mass public due to differing perceptions among politicians, the media, and groups of the public themselves, the Citizens' Action Movement could certainly make a legitimate claim of representing a large portion of the population. And as a public interest group with stated, if rather varied, objectives, the national mood as reflected by the movement would have a certain amount of clarity. However, besides interest groups who are simply and honestly advocating for or against change, interest groups within the political stream also may include what Kingdon refers to as "pseudoadvocates." Pseudoadvocates are interest groups that jump into the arena when an issue is already gaining popularity, in order to play a part in the outcome in the case that the status quo truly is abandoned. A possible example of pseudoadvocates within the area of food security is the Brazilian Association of Agribusiness and its Administrative Council, representing the industries of fertilizers, pesticides, heavy machinery, seeds, large producers, fiber and food processing industry, supermarkets, importers and exporters, etc. The Association, formed in 1993, presented its own position paper on food security. Focusing on its economic aspects, the

Association asserted that the state should not directly intervene in food and agriculture, but rather guarantee food security through support of modernization and dynamism within the agricultural sector. In this way, they argued, the market could create a supply of the necessary supplements and higher food production to generate food security for the Brazilian population (Pessanha 2002). Pessanha goes on to note that Marques (1996) identified this notion of food security by agribusiness as "nothing more than an instrument for the legitimization of the modern discourse employed by the Brazilian agro-industrial complex." This completely exemplifies Kingdon's definition of pseudoadvocates, who "are not genuinely interested in pushing the cause. They advocate their own plans in the event, likely or unlikely, that an issue of concern to them becomes a serious threat to their interests," as "Even enemies of change introduce their own proposals in an attempt to bend the outcomes as much as they can to their own purposes." However, although there were potentially – likely – pseudoadvocates in the case of Belo Horizonte, none were mentioned or seem readily apparent.

The evolution of thought on hunger in Brazil and in the literature, the pressure from and extreme popularity of the Citizens' Action Movement, the recombination of ideas old and new within policy communities, the commitments and aspirations of the PT and PT leaders such as Ananias all affected the political stream. However, there is at least one more possible factor – multiple jurisdictions. That is, a last enabler in the Kingdon political stream model is the fact that, when an idea or proposal cuts across multiple agendas, it can act either as a spur or it can slow things down. It may spur action by engendering a certain competition among politicians – if an issue is perceived as popular, no one wants to be perceived as being late to the game, and bureaucrats often want to take action first in order to have some control over events. Collor and then Cardoso's reactions and initiatives left a space open for another politician or bureaucrat to go further and more effectively address an issue that was prominent in both the public eye and in a pressure group with historic levels of mobilization. The potential for a tripping up was the fact that food security was going to require a multi-sectoral approach, eventually involving the Secretariats of Education and Health among others. Specialized agendas (i.e. a health or education-focused remit) meant that certain important items might not be paid attention to, "even though they could easily be [high on an agenda] in some conceptual sense," because interest in certain cross-disciplinary issues may be based in other parts of the government structure (Kingdon 2003). Ananias and Nabuco, in addition to all of the other organizational and anarchical factors, worked to bring agendas together, and in part convinced the Secretariats of Education and Health to chip in expressly because food security was not actually their primary area of expertise. For example, Aranha pointed out to me in 2003 that they were able to convince

these other Secretariats to chip in, because why would they want to spend their resources administering programs that were not their remit? According to Aranha, Ananias and Nabuco asked them why they would want to spend resources designing nutritional school lunches when their focus was on effective ways to teach children, not feed them? Casting the problem in this light, and their work on building a consensus across normal disciplinary lines, seemed to pay off in terms of eventual cooperation from these other city departments.

So although the importance of Ananias and Nabuco may "make it tempting to attribute policy change to the actions of prominent individuals", as Kingdon says, what is actually involved are driving forces that are structural and not just personal. Indeed, this can be seen in the number of items and agendas that had to come together such that a policy entrepreneur and a politician (Nabuco and Ananias) could move things forward as decision makers, despite the organized anarchy of the problems, the policy primeval soup, and the vagaries of electoral politics. Nabuco and Ananias were able to capitalize on a large number of factors to get SMAB off the ground – and as I will show in the next section, a possible lack of these factors points to the explanatory power of the Kingdon/CMO organized anarchy model in today's SMAB, where its staffers perceive some degree of stagnation rather than similar rates of progress as the early days of its work.

SMAB: Progress and Problems

> "Policy windows, the opportunities for action on given initiatives, present themselves and stay open for only short periods… the three separate streams [of problems, policies, and politics] come together and are coupled at these times. Participants dump their conceptions of problems, their proposals, and political forces into the choice opportunity, and the outcomes depend on the mix elements present and how the various elements are coupled." (Kingdon 2003)

We have seen above how various elements and events aligned during the time of the creation of Belo Horizonte's Municipal Secretariat of Food Supply/SMAB. Since 1993, its comprehensive and oft innovative initiatives and policies have produced some impressive results and successes, including:

- Annual participation of 20-40 local small family farmers in the Straight from the Countryside Program. In 2006, approximately 550 tons of food were sold through the program to 53,000 consumer families (PMBH 2006)
- Participation of 10 local family farmers in the Organic Fairs, selling a total of 96 tons of food to ~8,000 families (PMBH 2006)
- Sales of 53,000 tons of food at 34 sales points to 185,000 families/year in the price-controlled Abastecer produce shops (PMBH 2006)

- 20,000 families served in the "Big Popular Basket" assistance program (PMBH 2006)
- 190,000 meals served/day within the Municipal Education system (PMBH 2006)
- 10,300 meals/day through the Popular Restaurant programs, open 248 days/year (PMBH 2006)
- ~800,000 citizens/year in total benefit from SMAB programs, or almost 40% of the population of Belo Horizonte (Aranha 2003)
- Maintenance or decreases in prices of foods purchased in SMAB price-controlled programs, even as food prices in private stores increased, such that at some points SMAB prices represented ~50% mark-down versus similar private stores (Aranha 2000, 2003)
- A decrease in infant mortality since 1993 by as much as 63% (depending on the sources used), from ~35 deaths/1000 live births to between 13 and 20 deaths/1000 live births between 2004 and 2006, including the dramatic decrease of infant mortality in the poorest area of Belo Horizonte, Taquaril, from 66.8/1000 in 1993 to 26.3/1000 in 1997. This means that it was, at the time, brought from almost double the citywide average to approximate parity (Aranha 2000, 2003, Prefeitura Municipal de Belo Horizonte (PMBH) 2006, Alves et al. 2008).
- A 50% decrease in infant malnutrition was seen over a 6 month study in 1999, including a 91% rate of recovered weight among children suffering from severe malnutrition (Aranha 2000, 2003)
- Belo Horizonte was the only locality where fruit and vegetable consumption increased between 1993 and 2002. The city went from 6th to 1st highest consumption of green vegetables, and 8th to 1st in consumption of fruits (participant observation, seminar by Adriana Aranha, 6/9/03, Aranha 2000)

Yet, despite such notable successes, a number of parts of their comprehensive approach are struggling, need further support from the City Government, or leave important gaps in the coverage of food security issues.

There of course always remains more to be done in an area like food security. There are long-term goals like going beyond improving accessibility to providing for universal access, or further improving nutritional balance and dietary intake as well as encouraging and preserving traditions in food preparation and the use of a wide variety of fruits and vegetables (i.e. acceptability). In conversations with Aranha during and after her time at SMAB, there clearly remains an ethic of striving for constant improvement, with Aranha hesitating to ever use the word "success" in reference to SMAB's work, as "success" would mean that they have completed their job and that food security was no longer a problem. Similarly, in my second interview with

Rubens, in response to a question regarding the need for civil society to pressure, evaluate, and make demands of their government, he commented, "We're never going to reach a certain degree of excellence in our work. I believe that. We always have to improve. We're never going to reach perfection. We have to seek perfection. And we are able to reach these objectives when society is also pressuring us to." But beyond "perfection" or "excellence," there are a number of areas that were critiqued by those interviewed within SMAB, as well as by independent organizations, and in interviews of some of their partnering local producers. A partial list of these concerns include:

- Some "small family farmers" in Straight from the Countryside have, through their participation, become so successful as to no longer need the program or be accurately characterized as small family farmers. Yet they remain in the program, to the possible exclusion of the entry of other small farmers who may better represent those whom the program is meant to help (de Araújo and Alessio 2005).
- Leadership for the farmers' cooperative association, the Association of Producers of Straight from the Countryside, which was created as a forum for communication between producers and the city, does not appear to be truly meaningful or representative. SMAB functionaries apparently viewed the election for Association president to be a formality as only two of the 20-30 farmers ran for the office (de Araújo and Alessio 2005). Attending one of their regular meetings in 2005, I only observed five farmers in attendance, out of approximately 25 farmers in the program that year. I did not get the impression that such low attendance was an irregular occurrence, but I was not able to confirm that. Further, during my work in Belo Horizonte the association presidency was held by one of the largest and the most successful of the farmers; their gross receipts from participation in the SMAB programs were 5 and 3 times the average of other participant farmers in 2002 and 2003, respectively (participant observation, Meeting of the Association of Farmers of Straight from the Countryside, March 23, 2004, "Programa Direito da Roça – Resultado Geral por Produtor e Ponto, 2004" SMAB internal document).
- Arrangements and payment for transportation of farm goods to the market may be left to the small farmers themselves, meaning that some potential participants in the programs that are not able to pay or arrange for transportation cannot participate. In other words, some of the poorer small farmers may be too poor to join a program explicitly targeted at support for farmers like themselves (de Araújo and Alessio, 2005, interviews with farmers Seu Marquinho, Seu Herbert, and Os Santos).

- SMAB nominally has programs to support community gardening. Despite this, however, several groups have criticized the city, saying that they have not been able to count on actual substantive support from the city and have had to acquire all of their inputs and technical support from other community groups. My own contacts within a Belo Horizonte non-profit, Rede de Intercâmbio de Tecnologias Alternativas commented that they did not renew their partnership with SMAB in regards to community gardens and agroecological education because the city, in their opinion, was not devoting enough time or resources to including and expanding participation within the community. My contacts at SMAB in turn felt that it was beyond their capacity to engage in broad community partnerships, and that the pertinent communities needed to organize themselves such that SMAB could interact with representative leadership; direct involvement in creating community organizations was neither within their resources or purview (participant observations, Nabuco and Souki 2004, de Araújo and Alessio 2005).
- The small (10) number of organic farmers participating in the Organic Fairs (which, like Straight from the Countryside, has farmers come to the city to sell directly to consumers, with no retailers, wholesalers or other intermediaries) complain that the price of certification is artificially and almost prohibitively high; accordingly, there may be many local small farmers that are effectively organic (i.e. no synthetic inputs), but cannot afford to enter the program because of the costs of certification. Farmers voiced this complaint despite the availability of a free certification program in the state of Minas Gerais, perhaps because of a lack of knowledge about the free certification, or because of a lack of time or other resource (other than money) necessary to seek and procure this certification. Additionally, de Araújo and Alessio found that of the 10 participants, only two represent family farmers who depend on the fair for their income and way of life, the others being "businesspeople or technicians" who do not need to depend on SMAB to sell their products.[21] One farmer not affiliated with SMAB, when interviewed by de Araújo and Alessio, stated that if the program truly was targeted at small farmers, who on the whole could not afford to be certified on their own, the city should facilitate certification if they were going to demand it as a pre-requisite to entering the program (participant observation, Organic Agriculture Working Group Monthly Meeting, March 10, 2006, and interview with Seu Edmar; de Araújo and Alessio 2005).
- Besides the problems related to, essentially, consumer fraud in the Abastecers mentioned previously (in SMAB: Goals, successes, and challenges), de Araújo and Alessio point to a contradiction in the designated goals of the price-controlled stores. That is, interviews

and analyses by SMAB point out the benefit of these produce stores to poor and low-income consumers (i.e. Aranha 2000, Rocha 2001, interviews with Rubens and Antônio), but in de Araújo and Alessio's study, they reported

> "…the objective of the Abastecers isn't to attend to the residents of [Belo Horizonte's] pockets of poverty. Questioned in regards to this fact, the technicians and managers of the Secretariat emphatically emphasize that Abastecers cannot support themselves in locations where the population has the lowest incomes. There were some experiences in this and the produce shops ended up failing because the local population didn't have the financial means to acquire such products. These technicians and managers admit that in these locations, some type of assistentialist [direct aid/welfare] program is still needed in order to meet, in the short term, the basic needs of the population."

- Similar problems affect the Workers' Convoy program, where, as in the case of the Big Popular Basket discussed earlier, poverty along with a lack of knowledge of and identification with the program can result in violence and difficulty in maintaining service in the poorest areas (de Araújo and Alessio 2005). This is aggravated by the lack of sufficient resources to register all potential participants, along with the fact that even though the total amount of service offered has decreased (in frequency and service points) the costs of the program in staff and the total subsidy required has increased, with part of the increase going towards contracted personnel and inflation rather than directly to the consumers (Nabuco and Souki 2004).
- Generally, within the Support for Food Production arm of SMAB, almost 95% of the City's expenses went to contractors and sub-contractors between 2001 and 2003, while the resources to pay these groups was reduced by SMAB's financial management office. Nabuco and Souki state: "This withdrawal of resources to apply to this arm of SMAB negatively impacted the capacity to expand programs and actions in this area, principally in reference to the numbers of points of service – with exception of the Organic Fair program," a SMAB program that happens to target middle- to high-income citizens. SMAB looked to "overcome this obstacle – scarcity of financial resources – [through] the realization of more partnerships, principally with farmers' associations." Nevertheless, a consistent refrain among my interviews of farmers was the lack of information dissemination about SMAB programs. In the interview of one aspiring, but not yet present SMAB partner farm, there was criticism over the difficultly in registering or even in finding out how to register for them.

Recognition of the various challenges faced by SMAB was present in all of the interviews, where concerns generally echoed these above; as with Nabuco and Souki and de Araújo and Alessio, a

lack of personnel and financial resources seems to be the common theme. Problems of this sort are to be expected in any bureaucracy, especially perhaps in one as comprehensive and novel as SMAB's. We have already explored SMAB's many significant successes; why haven't they been able to continue and build on these successes, such that in his interview, 14-year SMAB veteran José stated that he no longer "consider[ed] Food Security Policy to be the priority of the city government"? The analysis of SMAB's creation from the point of view of Kingdon's framework also sheds light on this question.

A Shift in the Policy Process Streams in Belo Horizonte

> "[F]or a city that had absolutely no [food] policy, I believe that we've given a good first pass at its management. In the first four years, what we did was implement the policies per se, of the basic programs of the Secretariat… After these four years, we had a period of program consolidation, which was under the administration of [Mayor] Célio de Castro, until '91 [*sic*]. Now, I think that we can do more, Jahi. I believe that, today, I don't consider Food Security Policy to be the priority of the city government. Why? Because there are few resources for us, there's not an investment around our policies. So, now, from '98 until now, we practically haven't created a single new program. With the exception of the Organic Fair and the present Reference Center [for Food Security], that is still in construction… Two programs in seven, six years. So, I'm thinking that the policies are slowed down." –José

Starting around the re-election of acting Mayor Fernando da Mata Pimentel[22], the morale of SMAB functionaries during my time there was relatively low. Besides significant problems of corruption and a number of scandals weathered by the PT at the national level that left the PT-heavy office somewhat worried and disillusioned, Pimentel implemented "organizational reforms" in 2005, where appointments, management, staff, and organizational structure were shifted. In fact, SMAB was shifted from a Secretariat in its own right to an adjunct Secretariat, organizationally now part of the Secretariat of Social Policy. It is unclear how much real effect this had on SMAB within the city government; SMAB functionaries expressed the opinion that they had been growing farther and farther from the person of the Mayor, and thus were not able to get their concerns aired. The reforms therefore did little to ease their concerns over the fate of SMAB, but rather exacerbated them within the cohort of my interviewees. Many expressed the view that Pimentel was looking to consolidate the popular programs, such as the Popular Restaurant, and to some extent use other positions within SMAB to place political friends and supporters while getting rid of employees without political connections and employees who were "squeaky wheels" (interviews with Eliane and Rubens; participant observations March 3, 2004, April 4, 2005, and March 6, 2006). Indeed, insofar as Pimentel's re-election campaign mentioned SMAB, it seemed primarily to mention only the Popular Restaurant, as well as underestimate the

amount of people it attended to (pers. obs.). However, it is at least, if not more likely that Pimentel, an economist and former Municipal Finance Secretary, was concerned with the large budget deficits left by his predecessors and with bringing the city closer to solvency (City Mayors 2005, Revista Cristã 2004, in FernandoPimentel.com 2007). This latter position is tentatively supported by the participant observation on April 4, 2005. During a discussion of the politicization of SMAB, several functionaries proposed the idea that Pimentel was perhaps simply unfamiliar with the details of the secretariat and therefore making uninformed changes. One had a contact at the Municipal Secretariat of the Treasury who had shared various bits of information with them: their contact's view was that there were reforms taking place in all of the secretariats. From the contact's point of view in the Treasury (as expressed by the SMAB functionary), the reforms in other secretariats were even more blatantly political, turning the city into a political machine to support Pimentel. However, this secondhand information must be interpreted cautiously, and the reorganization of SMAB may appear different from another perspective (this idea will be returned to shortly). Regardless of the cause however, the reforms, tight financial situation, sense of ulterior political motives and lack of personal political capital invested in SMAB by Pimentel left SMAB workers worried.

Thus, in 2005, there was a feeling of stagnation, which recovered a bit in following years, but was still most vividly reflected in a participant observation in 2007, when I asked Eliane how the energy level in the office seemed. She replied that people did seem to be behaving like "The Living Dead." Jairo similarly expressed such worries, which he mentioned in response to my question of what he saw as the primary objectives of SMAB. "Now, I think we're in a period of stability. So, we need to search for new fronts to work on… we need new programs, to do things differently now." As I described earlier, of the 27 distinct programs listed in Machado's summary of SMAB (see Tables 3.4 to 3.6, from 2003) 24, or 89%, were created in 1996 or before – during the Administration of the originating Mayor of SMAB, Patrus Ananias de Sousa. This seems utterly consistent with an evaluation by Eliane: "I think that there are already some points where the Secretariat of Food Supply has already excelled quite a bit, like, for example, the Popular Restaurant. So, I think that the Mayor thinks like this: 'The Popular Restaurant is working out, I don't really need to mess with anything else, you know?'"

Aside from concerns of solvency, it seems easy to conclude that Mayor Pimentel, having little personal stake in SMAB, being two political "generations" removed from its creation, simply does not fully understand the innovation and achievement it represents. Pimentel has engaged in a number of infrastructure projects in Belo Horizonte, leading José to comment "The evaluation we have is that there's money [for SMAB], but, presently, the City's priority, the

municipal government's priority is investment in public works, in roads, not in social politics. In infrastructure politics." Some time after this interview with José, I was able to try to ascertain this for myself. In a propitious meeting with Mayor Pimentel himself, I was able to observe him give a public presentation at the invitation of the Latin American and Caribbean Studies Department and Taubman College of Architecture and Planning at the University of Michigan in April of 2008 on his administration's work on the *Vila Viva, Transforming Aglomerados into Neighborhoods* program. I wrote at the time,

> "According to the Mayor's administration, the reconstruction plan he is spearheading is perhaps the second-largest urban renovation/renewal project in South America, advancing past the *aglomerado* 'regularization' taking place in São Paulo, the largest city in Brazil and one of the largest cities in the world. Mayor Pimentel was additionally in the running for the 'World's Best Mayor' in 2005. All of this is despite what may be called a lack of consciousness in terms of food security; in a short conversation with the Mayor himself after his presentation, my impressions were similar to that of his employees within SMAB, that is, that the Mayor was not familiar with food security in its full conception, even insofar as it is seen by his office. When questioned about future plans and directions for SMAB and food security in Belo Horizonte, the Mayor's responses dealt with maintaining and expanding present programs, such as the Popular Restaurants and School Meals, and continuing educational efforts within the municipal schools to teach proper nutrition and the right to food. However, the huge repository of new ideas and directions I had seen represented within SMAB – resources for more expansive educational materials, the food security Reference Center, further engaging and expanding local farmers, reigning in and reforming organic markets – none of these seemed on the agenda, as not only did he not mention any of them during our brief conversation, but he indicated no awareness of alternatives beyond expansion of the programs as they are now."

However, my interpretation and that of the SMAB functionaries are possibly premature and grounded in expressly the rationalistic institutional models Kingdon and CMO empirically and theoretically refuted in organized anarchies. That is, we perceive remaining problems, and wonder why they are not being addressed and solved by the Mayor. We see a still-present problem important to us and at the top of our own agenda – food security – and think of possible policies to address them. But the Kingdon model tells us to consider not just problems and solutions, but rather the problems stream in an organized anarchy, along with policies and politics. [23]

Starting with indicators of problems, Kingdon's work showed that in his system they "[were] not used primarily to determine whether or not a given problem exists; such determination is a matter of interpretation." Rather, decision makers use indicators to assess the magnitude of a problem and to become aware of changes in the problem. As we have seen, SMAB has been successful in reducing the magnitude of the problems of food security in Belo Horizonte; as far as changes in the numbers, "a steady state is viewed as less problematic than

changing figures" according to Kingdon. Even more inhibiting to action still, the figures on food insecurity are changing for the positive in Belo. Meanwhile, world acclaim has rolled in for the past 15 years, SMAB's programs are considered inspirations for those in other cities, and its originating Mayor is the present Minister for Combating Hunger and in charge of the National Zero Hunger Program – and Belo Horizonte is meeting and surpassing the United Nations' Millennium Development Goals in infant mortality (Aranha 2000, Machado 2003, City Mayors 2005, Prefeitura Municipal de Belo Horizonte (PMBH) 2006). Such results, while welcome, also mean that SMAB's work, proposals for expansions and new policy solutions are taking place in the context of a problem stream without the characteristics of urgency that would help motivate action.[24]

It can in fact be argued that Pimentel is moving on to the guarantee of other human rights – matching part of my original definition for sustainable development in those terms, even if the human rights he is choosing to address are not in the area of the right to food. To whit, in terms of problems, *aglomerados*, originally illegal shanty-towns and still areas of much irregular development, poverty, and crime are quite certainly an obvious and visible problem, such that Kingdon's model would tell us that there would be motivation for action from these very characteristics. The *Vila Viva* program and housing issues, arguably Mayor Pimentel's chief focuses, are also somewhat crisis-driven. Crisis is of course another Kingdonian enabler for action. Attention to urban architecture in the *aglomerados* contains measures to address the dangers of mudslides and rapid erosion, which have caused significant property damage and a number of deaths in Belo Horizonte in the past 8 years (BBC News 2003, Vieira 2008). *Vila Viva* and other projects also address improved sanitation, a Millennium Development Goal and certainly a human right implicated by the Universal Declaration of Human Rights and the International Covenant on Economic, Social, and Cultural Rights in their calls for an adequate standard of living, housing, and reduction of infant mortality. (Lampreia 1995, found that the level of infant mortality doubled from approximately 50 to 100 deaths/1000 live births among families earning the same wages – ½ of one minimum wage – if they lacked basic water and sanitation services.) In terms of public opinion and popular support, Pimentel's infrastructure projects featured prominently on his City Mayor biography as a finalist for World's Best Mayor:

> "Under the model Participating [*sic*] Budget, the various communities decide on the investments to be made by the regional public authorities. In the Habitation Participating Budget, unique in Brazil, district policies are directly defined by the people. In the past 13 years, under this budget, some 1,000 public works have been implemented costing around US$170 million. Under the Habitation Participating Budget, some 2,479 houses have been built for the poor at a cost of US$21 million. And some US$9 has been

> allocated for the construction of more than 1,800 houses over the next few years." (City Mayors 2005)

The participatory budget, a much-noted system used by some cities in Brazil, allows citizens to directly determine how to spend some part of the overall city budget (Albuquerque Carvalho 1998, Baiocchi et al. 2008). As such, his projects doubly fit into the public's mood (i.e. corresponding to Kingdon's "National Mood") – they are determined to a degree directly by the people themselves, and the scale of these projects when paired with sanitation and efforts to clean local water sources will, supposedly, benefit nearly 50% of the city population (City Mayors 2005). The political calculus does not seem difficult, though the details of these projects, which are beyond the scope the present work, may yield contradictory or confirmatory details.

It is also almost certainly enabling to Pimentel's attention to *Vila Viva* that it has federal support, and the contracts for the work done in cooperation with the Federal government are such that "even if re-election changes the administration, the contracts MUST be completed, even if the FEDERAL government changes," (participant observation, presentation by Mayor Fernando Pimentel, April 4, 2008). In contrast, SMAB is already making significant use of federal money and other sources of funds to defray the costs of its program. The fact that it occupies 1-2% of the city's budget may also be acting as much as an inhibitor as a benefit – it is not hard to imagine that a city leader concerned with balanced budgets would not necessarily seek to increase the share of a highly effective array of city programs that account for little of the city budget at present, and seems likely to increase in costs simply to maintain at its present level. That is, Pimentel did oversee the expansion of some SMAB programs, including the Popular Restaurant program, where additional facilities have been and are being built, even while the amount of money required to subsidize the individual meal price at the Restaurants increases every year (Nabuco and Souki 2004). Thus, it would be understandable if he did not look to further increase costs, a point highlighted by Nabuco and Souki. In fact, Nabuco and Souki state that neither the originating administration of Ananias nor the following administration of de Castro substantially increased the SMAB budget above its original size during their administrations; it has never surpassed 2% of the city budget, and actually decreased in nominal as well as real value between 2001 and 2003. It is particularly unsurprising, then, that the resources for SMAB have not significantly increased under Pimentel. Such an increase would be unprecedented, even in terms of one the original policy entrepreneurs, Ananias, reinforcing the idea that budget constraints are further inhibiting actions in the present-day food security problems stream.

In the **policies** stream, the array of potential policies in housing and urban renewal are significantly beyond the scope of the present work, but it must be noted that Federal Law 10.257,

passed in 2001, specifically addresses and seeks to support urban planning of the type *Vila Viva*'s regularization of the *aglomerados* envisions (Fernandes 2001). Further, improved housing and living standards are also old and venerable demands from the stratified Brazilian society, with movements and policy proposals going back at least into the 60s and 70s, if not earlier still (Doimo 1995).

Additionally, although we have no direct information on fragmentation with the housing community in Brazil or Belo Horizonte, there has been an increase in fragmentation within the food policy community. Ironically, by helping to increase the number of food security specialists, SMAB perhaps increased the possibility of policy fragmentation and its inhibitory effects. Whether it is because of progress on consensus, "low-hanging fruits" of food security, or for other reasons, the staff within SMAB now have many different ideas on priorities and directions for SMAB's future. Meanwhile, it has been made more difficult for a prospective policy entrepreneur to advance SMAB's agenda. SMAB lost status within the City Administrative structure as an Adjunct Secretariat under the Secretariat of Social Policy rather than a Secretariat in and of itself, and action was perhaps further stifled by the replacement of the innovative Maria Regina Nabuco with Rogério Colombini, a politician from a rival party (Republican Party of Brazil, *Partido Republicano do Brasil*) with a background in business administration and sociology. Nabuco, in the previous section, was shown to almost certainly have been a policy entrepreneur for SMAB; Colombini may have had a similar potential, but he did not come from a career focused on studying food security as Nabuco did. Further, his management style, according to participant observation and interviews, did not match Nabuco's in terms of quality or in terms of generating creativity and consensus. My notes from participant observation show another SMAB functionary (whom I will call "Mangabeira") complaining about Colombini in the following terms:

> "Mangabeira remarks that Regina Nabuco knew their names, and José sort of snorts and says that she knew ALL their names, she knew pretty much everything going on. [They go on about Regina a bit more], it boiling down to her seemingly knowing and understanding everyone's work and name and function, and how it tied in to the SMAB mission in general, which their tone implies has not happened since in anything like the same way – someone who had all of the disparate parts of SMAB in mind and understood them." (participant observation, 4/19/06)

More generally within the Mayor's administration, newspapers from my second trip there, in 2004, reported that it contained 26 **or more** secretariats, depending how you counted them – and that Mayor Pimentel himself could not give a certain number to how many there definitely were. This may have been true under Ananias and de Castro as well, but as the creator of SMAB,

Ananias almost certainly had a closer relationship to it, giving it and its policies more prominence among the other secretariats than would have been the case with Pimentel. In any case, Mangabeira and José agree that Nabuco listened, encouraged creativity, incorporated ideas from everyone into the Secretariat's actions, and held regular meetings. In Jairo's interview, he said that he "didn't even know what [his] neighbor" at SMAB was doing, what kind of project he worked on or had in mind. Under Colombini, there were no regular meetings between the various managers in order to integrate their work, and under Jairo's boss, his section did not even meet such that he wasn't really sure of all that was going on in just his part of SMAB. "Imagine," he said, "if this is happening in my own section, can you imagine what it's like in the Secretariat [as a whole]?"

So while the creation of SMAB was able to depend on motivated entrepreneurs in Nabuco and Ananias, as well as accumulated, unified and developed policy, it appears that Colombini did not provide similar strength as a policy entrepreneur within his job as Secretary. As far as Pimentel, it is quite possible, if not likely, that he is a policy entrepreneur – just not one within SMAB and the area of food security.

In terms of politics, Kingdon points out that political agendas are always ripe for change during a change in administration. SMAB experienced two changes in administration – from Ananias to Castro, then Castro to Pimentel – as well as a less pronounced change, when Pimentel was re-elected in his own right and would no longer likely have any motivation as a "caretaker" administration to maintain the status quo. Within SMAB, the Secretary's position shifted from originator Maria Regina Nabuco to Rogério Colombini, a politician from another party who eventually ran for a Congressional seat (unsuccessfully) and is presently the state president of PT rival, the PRB. Jairo, in his interview, accused Colombini of only paying attention to projects that might bring him (Colombini) personal attention or political capital, and neglect of programs that may not have been as publicly known but possibly more important.

In terms of pressure groups outside of the government, it is unclear in the context of the present study what the exact mechanics of the political shifts were within groups concerned with housing and quality of life in *aglomerados* – but there are assuredly such groups, including the inheritors of Betinho's Citizen Action Movement and a number of other groups that were or are organized around such causes. Additionally, attention to infrastructure and housing has clearly been good for Pimentel – he was nominated for World's Best Mayor in 2005 in part because of his burgeoning *Vila Viva* program. He also was one of the founders of the PT, and had a history as a militant protester during the dictatorship, and is a native of Belo Horizonte. Perhaps 5 to 10 years from now, an analysis of "Pimentel's amazing progress in housing" and sanitation will be

done, and questions will be raised as to why the Mayor in 2018 is not paying attention to housing and is, instead, working on innovations in food security.

Kingdon's model of problems, policies and politics streams seems to provide a relatively comprehensive picture of not just how SMAB was formed, but a strong tentative picture of why SMAB's development has slowed somewhat since its heady first years. Going into this research with the presumption that such a fundamental and innovative program should be getting all the support it needs, the Kingdon/CMO framework proved a good model for understanding the actual events as they have occurred, rather than how one might have wished them to – at least, one within the field of food security. However, given this analysis, does this mean that there is nothing to do but wait 5 to 10 years for the wheel to come back around to food security? Does it mean that a new movement must be built and unified around food security to raise and maintain pressure on the City government? While the answer to these may be a heavily qualified "yes" to some degree, in my next section, I will turn to how an institutional analysis looks from the point of view of the SMAB partner farms, before returning in my conclusion to these questions, and to look at how, within the Evans' synergy/embeddedness framework, we might answer these questions in terms of the relationships SMAB has developed across the state-society divide, how they help maintain SMAB and what could be done within the area of embeddedness to push SMAB's progress further, without necessarily waiting for the casual turning of the streams until they fortuitously join again by chance.

EFFECTS AND INTERACTIONS OF THE SMAB PROGRAMS ON LOCAL FARMERS

Background and Context

The interactions between smallholder agriculture and biodiversity in fragmented landscapes, and the possibilities of each providing benefits to the other, constitute an exciting and growing area of study in the fields of ecology and natural resources (see i.e., Vandermeer et al. 1998, see i.e., Harvey et al. 2007, Chappell and LaValle, in revision, Chappell 2009, Chapter 4, Vandermeer et al. 2008). A review by Rosset (1999a) suggested that the small family farm is central to long-term management and agricultural sustainability in Developing Countries, especially when such systems use agroecological approaches, whose methods are often based thousands of years of experience (Ucko and Dimbleby 1969, Struever 1971, Altieri et al. 1987, Netting 1993). Small farmers' prolonged tenure on the same land means that they risk collapse of their farm in the long-term due to ecological degradation when they wager short-term gain against sustainability. Awareness of this long-term risk and, vitally, secure land tenure, can lead to higher and more stable production from family farms in comparison to larger farms in the same

region, in part due to practices to minimize and reduce degradation (D'Souza and Ikerd 1996, Rosset 1999a, Templeton and Scherr 1999). In general, as well, smaller farms have been found across a number of studies to be more productive than larger farms, what economists have called the "inverse relationship between farm size and output" (Barrett 1996, and a review by Heltberg 1998, Assunção and Braido 2007), leading Vandermeer and Dietsch (2003) to state "…if increasing production is your goal, breaking up large farms and giving the land to small producers would be the best short term solution."[25] Among the reasons cited for this relationship are: 1) multiple cropping; 2) more efficient use of irrigation; 3) relatively higher labor quality and better supervision (likely due to the use of family labor with a greater stake in farm success rather than alienated outside workers), and 4) non-purchased inputs as opposed to the agrochemicals of large-scale intensive agriculture (Netting 1993, but see, Benjamin 1995, Lamb 2003, Oduol and Tsuji 2005, Kirner and Kratochvil 2006). On small family farms, labor-intensive practices may be used to enhance soil conservation and fertility, allowing harvesting with minimal reliance on industrial inputs, and may generate food 2-5 times more efficiently (Netting 1993, Pimentel and Pimentel 1996, Chappell and LaValle, in revision). Heller and Keoleian's 2003 study in the United States also showed that ~25% of the energy expended producing food and bringing it farm to plate came from the fuel for transportation (the average distance food traveled between production and consumption has been estimated to be over 1000 miles). Although I am not aware of any similar studies conducted in Brazil, it can be reasonably expected that transport from Belo Horizonte's local farmers would save energy over shipping it from farther afield. CEASA-MG, a state food-supply agency, is one of the most significant food purchasers and retailers in Minas Gerais, and sells food grown throughout the state as well as grown in several neighboring states. This means that SMAB's Straight from the Countryside program, with most farmers located within 50 km of the city, should represent significant energy savings and therefore some greater degree of sustainability.

Given the normatively positive effect of economic and land tenure security on sustainability, if SMAB's partnerships with local farmers provides them with economic benefits relative to selling to other buyers (usually CEASA-MG), there is reason to suspect that the partner farms may support higher levels of biodiversity. SMAB does specifically look to support small family farms for a number of reasons. For one, Brazil has seen a dramatic in-migration of rural residents into cities in the past several decades, going from two-thirds rural to 80% urban in a small amount of time (Rocha and Aranha 2003, Wright and Wolford 2003, Instituto Brasileiro de Geografia e Estatística (IBGE) 2006). This migration has been linked to uncontrolled expansion of cities, including expansion of the fore-mentioned poor *aglomerados*, and increased strain on

city services. There also seems to be a cultural imperative in Brazil for support of small farms, in part out of a desire to preserve the social and cultural heritage they represent, a competitive marketplace, and to address centuries of inequality and exploitation of rural workers and small farmers (Azzi 2004, Branford and Rocha 2002, Wright and Wolford 2003, interview with José, pers. comm. by Valdir Altair Guimarães). Such support for small farms therefore represents the play of a number of different values, including echoes of work in the mid-20th century by Goldschmidt in agricultural regions of the United States. This work generated what is called the "Goldschmidt Hypothesis," – community welfare will be significantly higher in regions where agriculture is organized around smaller-scale farms than in regions dominated by a small number of large farms (Goldschmidt 1978). This work has largely stood up in the 60 or so years since his original study, with a number of sociological studies re-examining his work and showing "at least tentative support for his conclusions" (Lyson et al. 2001).

The majority of farmers around Belo Horizonte who do not work with SMAB typically sell to CEASA or other large retailers, as they often don't have the means to go to the city and sell themselves, nor the means to rent a place to sell; the retailers or other intermediaries often absorb the majority of profits from the sale of the products while the competition among small farmers allows retailers to dictate low prices on the supply side (Rocha and Aranha 2003, Nabuco and Souki 2004, de Araújo and Alessio 2005). SMAB has supported its efforts in this case to get food to low-income urban consumers at lower prices by connecting small producers with consumers through Straight from the Countryside, with the city providing support for farmers such that they can come to the city to directly sell their products. It has been estimated that the intermediaries that this avoids had engaged in up to 100% mark-ups of the food they bought from the farmers. Avoiding this market distortion has the potential to help both the urban and rural poor (Rocha and Aranha 2003).[26]

The local farmer-consumer connection is all the more significant considering increasing concentration on export agriculture and globalization around the world, with negative impacts often falling disproportionately on small farmers, as with lower prices from global food surpluses that have decreased many small farmers' economic power and their own food security in turn (or rather, lower prices paid to farmers, which is still problematic despite the higher prices paid for food by consumers in recent years due to factors like food crops being used to create ethanol) (Drèze and Sen 1989, Lappé et al. 1998, Heller and Keoleian 2000, Rocha 2001, Eakin 2005, Bentley 2006). Indeed, the idea of global redistribution of food, which is already produced in sufficient amounts to adequately feed the present world population, was criticized by Pinstrup-Andersen (2003), who noted that the idea is not just technically unfeasible but would also

ultimately hurt the 75 percent of the world's poor and food insecure populations living in rural areas by co-opting the food markets they depend on for income. SMAB's efforts to localize the food system of a quite large city flies in the face of many current trends, but by the same token helps address the problems for farmers and consumers in a globalized food system by removing the aforementioned intermediaries, bringing lower prices to consumers while farmers simultaneously receive higher prices for their food – in essence, redistribution from retailers to consumers and farmers of the 100% markup previously common in Belo Horizonte.

If, in addition to enhanced economic security and regional food security, SMAB programs encouraged or supported pre-existing agroecological or alternative agricultural practices – such as low or no use of synthetic inputs, replacing them with natural ecological processes, green and animal manure, and other measures – the relevant literature in agroecology implies that SMAB should then be indirectly supporting biodiversity, through their support of these practices. And indeed, in both direct participant observation with SMAB's staff on its partner and prospective partner farms, and in the interviews with SMAB functionaries, this possibility of supporting biodiversity and sustainability in the Atlantic Rainforest is explicitly acknowledged and promoted (interviews with José and Rubens). Although the specific "Five A's" of food security terminology was not used, this environmental awareness reflects Rocha's use of the term appropriateness – food produced sustainably and safely – and reflects SMAB's approach to comprehensive food security that embraces all parts of the Five A framework in its own manner. However, SMAB's present lack of additional staff and financial resources, as well as the Belo Horizonte city government's lack of jurisdiction over rural areas inhibit their ability to aggressively push a rural agenda beyond linking local farmers with consumers (interview with former manager of SMAB's department of Incentives for Basic Production, which manages Straight from the Countryside and related programs; see also Nabuco 2004; de Araújo and Alessio]. SMAB indeed was only able to set up its Straight from the Countryside and similar programs with significant help from the state extension agency, EMATER (*Empresa de Assistência Técnica e Extensão Rural*, or the State Company for Technical Assistance and Rural Extension), whose agents helped find and recruit the original participant farms, and who have an agent permanently positioned at SMAB to aid in communication and enforcement of standards between SMAB and the allied producers.

A Brief Profile of Greater Belo Horizonte's Farmers

Putting the information from the previous section within the context of my work, the dual purpose of studying these sites was to examine how the relationships between SMAB and local

farmers were formed and institutionally maintained, and whether or not participation in the SMAB programs by local farmers would produce a significant difference in the levels of ant biodiversity in their fields and the adjoining forests on the farmers' properties (analyzed in Chapter 3 of the present work). By comparing "SMAB" vs. "Non-SMAB" farms, I used them as rough proxies for what has been referred to as "syndromes of production" (after Vandermeer (1997), and Andow and Hidaka (1989)). That is, sets of practices that may act together to optimize productivity – and may additionally support higher or lower levels of biodiversity – where different optimums may be reached using different sets. The studied farms were of similar sizes and backgrounds, in same region, forming a sort of "natural experiment" or case study examining how interacting with SMAB may have affected the farmers, and how providing greater local food security may have also led to differences in biodiversity within the local agroecological matrix (see Chappell 2009, Chapters 2 and 4).

There are approximately 323,000 farms growing temporary crops (that is, crops grown and harvested within the course of one year, such as the vegetable farmers of my study) in the state of Minas Gerais, on 4,272,000 hectares, giving an average size of 13.2 hectares for each farm. Of course, given the high degree of inequality between landowners in Brazil, it is likely that the median size is much smaller – that is, it's estimated that four per cent of Brazil's population owns fifty per cent of its land, meaning that most farms are very small, and a relatively few extremely large farms pull the average up from a truly representative number (Rocha 2003b, Wright and Wolford 2003). Median (50^{th} percentile) per capita income in rural areas of Southeastern Brazil fell between ½ and 1 "minimum wage" in 2004 (IBGE 2006); at today's minimum wage in Brazil, this falls between R$208 and R$415/month, or between US$97 and US$193.

Studied Farms

All of the farms visited for this study primarily grew vegetables, mostly lettuce varieties, though some variously grew other vegetables such as spinach, broccoli, endives, arugula, beets, and carrots. Seven sites on six farms (three SMAB partners, three non-partners) were sampled for ant biodiversity to examine effects of participation in SMAB (see Chappell 2009, Chapter 4). All of the 13 visited farms are located in the Mata Atlântica (Atlantic Rainforest) life zone, 20-40 km from Belo Horizonte. As with SMAB interviewees, the farmers' names have been changed to preserve confidentiality. All farms lie between 730 – 840 m in elevation and receive approximately 1500 mm of rainfall a year (Instituto Nacional de Metereologia (INMET) 2008). All farmers in the Atlantic Rainforest region are required to keep 20% of their land set aside for

preservation of any extant Rainforest fragments (Congresso Nacional do Brasil 1965). Nevertheless, there were no fragments at two locations; it is possible that the forest in those sites had been cleared several decades earlier, before the law was passed. Total farm area ranged from 0.01 to 30 hectares, with most (8 of the 13) being under 15 ha. The proportion of area under production varied from 32 to 90% (one property used ~100% of their land, but it was all in greenhouses). Fragments of the Atlantic Rainforest on farmers' properties can be generally characterized as established secondary, closed-canopy forest, such that understory growth and light gaps are relatively rare in the interior of the fragments. Overall, the Atlantic Rainforest is widely described as being 90% deforested, though it is possible that this is an overestimate as very small fragments that nevertheless may be ecologically significant may have been overlooked (J. Vandermeer, pers. comm., pers. obs.). Social characteristics among the studied SMAB and non-SMAB farmers were broadly similar – all were small family farmers, meaning that at least 80% of their income came from farming or forestry-related activities, labor is primarily family-provided, and total property size is not greater than 30 hectares. One SMAB-affiliated farm was certified organic; one non-SMAB farm was experimenting with organic methods for health reasons and a possible future transition to becoming a certified organic farm; all other surveyed farms have no formal designation or certification as "organic" or related labels, and indeed seem to base their farm practices on individual perceptions of market conditions (what the consumers want, and what they will pay for it), family background, and personal ideals. Additionally, several farmers effectively sharecropped their land, subletting it in a manner that the workers (*meieros*) helped out throughout the property, but had their own area to tend and harvest food from. One farmer, "Ricardo", who had sharecroppers, has presently turned over day-to-day operation of the farm to them. Ricardo thus no longer really fits the original targeted group of "small family farmers" as envisioned by SMAB (de Araújo and Alessio 2005). Unfortunately, this also meant that they were often not present on the farm, and an interview had to be conducted with one of his sharecroppers in their stead. (For more complete farmer profiles, see Tables 3.1-3.2.)

Economic Effects on SMAB Partner Farms

Only one SMAB farmer, Marquinho, was willing and able to disclose his income, of ~R$1,000/month. If his family size is in the median size range of 4-6 for Southeastern rural regions (IBGE 2006), their family's possible per capita income (R$166 to R$250) would put them between somewhat below to within the median per capita income range of R$208 to R$415. Five non-SMAB farmers responded quantitatively to the question of their average monthly

income; reported numbers ranged from -R$100 (negative) to R$3,000 in net income, that is, income after expenses. (The R$3,000 figure comes from a farm with two families on it, meaning the per family income would be R$1,500.) Using the R$1,500 figure, income of these five farms averaged at R$655/month. Calculating their median per capita income as above, then, would yield estimates of R$164 to R$109.

With only one sample for SMAB, and a very small number of non-SMAB farms, a valid quantitative comparison of incomes is not possible. However, at least in the case of the one SMAB farm that disclosed their income, they reported that their income and economic security has increased since they joined SMAB. Indeed, the farmer, Marquinho, said that he had been able to expand the number of crops he grew since he joined Straight from the Countryside in 1996. Saying that before that time, he sold to CEASA, Marquinho told me that they had to concentrate on growing large quantities of one or two crops to sell to CEASA but now they have branched out to 8-14 different crops on his 1-2 ha plot (he also owned another plot a few miles away where he mainly grew lettuce). In interviews in 2005 and 2006, Marquinho seemed relatively confident about his present and future economic security – although he did say he wasn't sure what he would do if SMAB or their partnership ended. He was one of the two farmers with share-croppers, six of them, but it appeared that he still tended his own areas as well and still ran day-to-day operations, as opposed to the farmer whose share-croppers essentially ran all farm functions.

Budget information was difficult to get from farmers, with several simply replying "I don't know," or "I couldn't really say right now," in regards to how much they spend in inputs and expenses each month, or what their monthly income was. Although there are a number of possible reasons for this, Carneiro (2004) stated that most producers were made uncomfortable by the topic of income and expenses, thinking that for the most part that it is filled with bureaucracy and too complicated for their comprehension. According to Carneiro, "It's rare to encounter producers that, at least, have a notion of the cost of their activities." Most commonly, rather, you find a producer with only temporary or intermittent tracking of their ledgers. Although there is insufficient information from my interviews to conclude that, as Carneiro says, my interviewees were uncomfortable with the topic because they did not keep close track of their ledger or felt that it was too complicated for their comprehension, it is useful to note that of the eight farmers for whom I obtained educational information, five had a 4th grade education or less; one had completed high school, and her brother was completing a degree in agronomy; and two farmers, both organic farmers working with SMAB, had graduated from college.

Despite the lack of hard data, it is suggestive that one SMAB farmer (Ricardo, as previously mentioned) has grown such that he is able to essentially retire to being only a landowner for his sharecroppers and thus become someone no longer fitting the intention of Straight from the Countryside to support small family farmers, and that in 2005 and 2006 Marquinho expressed a relatively high degree of economic security and had plans to further diversify their offerings. In contrast, interviews in 2006 with a family of non-SMAB ("Santos") farmers showed them struggling:

> "Yes, [it's complicated]. I'm even thinking that we may stop [farming]. It's not working, it's not worth it. There's a lot of exploitation, no? A lot of exploitation. The reseller [*atravessador*] comes to buy…"
>
> "We're suffering here. It keeps getting worse. Years ago, we still went there to the market. Now, they've found a way, they have people that carry products directly to the supermarket, they sell it there… It's only those people that sell, everyone else can't get in there, you see? So that's how it is here. The market is in the hands of the few."

As was stated earlier, resellers, retailers and other market intermediaries can absorb a significant amount of the profits from the sales of produce.[26] de Araújo and Alessio report that producers view these intermediaries as a "necessary evil" that, nevertheless, make it possible for the producers to sell what they produce, generally echoing the statement made by the Santos. In 2006, non-SMAB farmer "Herbert" said that he didn't have the resources to go into the city or send someone into the city to sell for him, so he sold produce to CEASA, estimating that he lost R$100 a month in the process. Incidentally, he blamed his problems in part on the "weakness" of the newer hybrid lettuce varieties, feeling like they needed excess care to survive in comparison to an heirloom variety that he was sure was unavailable, but that he characterized as being able to grow pretty much wherever you threw it. Of the four other farmers who characterized the state of the market and their profits (all in 2007), two characterized sales, or sales prices, as very bad; one sold his products to CEASA ("Henri"), and it was unclear to whom the other ("Davi") sold.[27] The two others characterized sales as "Normal" or "Reasonable", although one of them did call the year's sales overall "weak." Neither of these farmers, however, sold to large intermediaries, CEASA or otherwise – one was able to sell his products directly in the Central Market of Belo Horizonte, while the other, "Rafael," had stopped selling directly in the market, becoming instead a share-cropper, saying that it was better to sell to his landowner, leaving him (the landowner) to sell at the market, but also to organize and pay for transport and the fees to sell in the market. From the limited evidence at hand, it is suggestive at least that farmers who are able to sell directly (or for the sharecroppers, almost directly) to markets seem to be more optimistic and/or evaluate the present economic situation as being "reasonable." The farmers selling to CEASA or

wholesalers (the Santos, Henri, Herbert), for their part, seemed to evaluate the economic situation more negatively than Rafael or Marquinho.[28] Henri, in fact, stopped growing lettuce in 2006, diversifying instead into three crops (beets, yams, and cabbage), with plans to start selling directly to the consumer rather than CEASA: "I'm going to sell, as someone said, frankly, 'only to the consumers themselves.'"

The Association of Farmers of the Straight from the Countryside program, meeting in 2005, did also complain about low market prices saying, however, that it was hard to meet consumer demands season to season, as both hard rains in the wet season and hot weather in the dry damaged a significant part of their crops. They felt that other producers and sellers undercut the prices they're selling their products at; the EMATER extensionist assigned to SMAB, Valdir Altair Guimarães, says that the larger producers intentionally undercut the SMAB farmers with lower prices on smaller, lower-quality produce. Guimarães' comments align with the Santos' perceptions – as non-SMAB members, they nonetheless felt that selling directly in the city would put them in competition with large producers who would still undercut SMAB's prices. One could argue this as a positive side effect, increasing accessibility by lowering prices at even non-controlled stores, and indeed this has been noted by SMAB and others (de Araújo and Alessio 2005). The problem that arises is in appropriateness and acceptability, in that other sellers do not have to meet the same safety and quality standards, as Guimarães noted, and so SMAB arguably could be preoccupied with these characteristics rather than with competition per se, or with unfair competition in the form of private retailers selling produce at a loss or by forcing lower purchase prices on other local farmers. Further, although it cannot be shown with the present evidence, these observations support the pattern pointed out by Marquinho earlier, where farmers grow a large amount of one thing to sell to intermediaries, while the intermediaries force down the price they pay farmers who cannot afford to go directly market; if they were indeed generating 100-200% mark-ups on the price of the produce, that leaves them a substantial cushion to cut their prices. In any case, it does appear from the small number of producers interviewed here that: a) selling to SMAB should generate more security as there is a near-guarantee of sales at the Straight from the Countryside markets and SMAB programs like School Meals and the Popular Restaurant; b) selling directly to consumers, or in one case to the landowner who then sold directly to consumers, seemed to achieve better prices for the farmers who felt in turn that prices were "normal" or "reasonable" as opposed to farmers selling to intermediaries, be they private, or a public company like CEASA.[29] It also appears that there is the potential for many more partners, if indeed large buyers are continuing to exert oligopoly price control on other local

farmers. Nevertheless, SMAB's problems in recruiting new farmers have already been mentioned and will be discussed again presently.

Given the differences in biodiversity between SMAB and non-SMAB farms (see Chappell 2009, Chapter 4), it is possible that differences in producers' security and vision of the future help explain the higher diversity in SMAB farms. As discussed earlier, greater economic and land security tend to be tied to more sustainable practices, and similar to some of the theories around the inverse relationship between farm size and output, it has been hypothesized that family workers on smaller farms are better supervised or more motivated by family ties to work diligently and efficiently. It is possible that such diligence and care may also carry into sustainable practices.

Sustainable Practices and SMAB

Although security may help encourage more sustainable practices, are there any more direct effects of SMAB on farmers' practices? From the case of Marquinho, not only did he diversify his crops,[30] but in his interview said that he also cut down on pesticide use after he entered the program, "because we wanted to sell a much fresher, healthier product, so we are avoiding using pesticides as much as we can. We hardly ever use it now." Henri, who said he used hardly any pesticides and fertilized his plants with both animal manure and synthetic fertilizers, also diversified his crops, although it was in an attempt to entice consumers in direct sales and because he felt that lettuce farming had become too unprofitable. He also voiced agreement with the statement that the rainforest, which he thought was important to preserve, helped maintain equilibrium on his farm with a very low level of pests, and had the additional benefit of forming a windbreaker. The organic farmer, "Edmar," grows ~15 kinds of vegetables, and refrains from using pesticides, originally simply because he and his wife were growing only for themselves and avoided external inputs due to concerns of their health effects. In contrast, Ricardo used synthetic pesticides and chemical fertilizers, though in an interview, one of his sharecroppers was unable to name which ones. Thus, overall synthetic pesticide and fertilizer use varied, with several non-SMAB farmers worried about their health and environmental effects or expressing aspirations to be organic, while Ricardo seemingly used pesticides slightly more often than others who said they "hardly ever used it." From on-site observations, it appears that all of the farmers tilled their soil, and the occasional heavy rain contributes greatly to erosion. Only one farm used green manure (though a brief visit to an organic farm in 2003 that was not subsequently studied showed that they used green manure as well); most used chicken manure, with cow manure being used by some as well. Also commonly used was "leaf fertilizer," that is,

a synthetic fertilizer applied directly to the leaves in a spray, with the brand name *Ouro Verde* ("Green Gold"). Nevertheless, both the former manager of the Incentives for Basic Production programs and the EMATER extensionist working with SMAB often quite clearly encouraged farmers to reduce synthetic inputs and move towards organic production. However, the present manager and former co-manager of these programs, Desidério Junqueira Neto, stated at a monthly meeting on organic agriculture in Belo Horizonte facilitated by the Federal Ministry of Agriculture, SMAB deals, and has to deal, in price rather than whether or not food is organic. That is, an examination of the goals of SMAB makes it clear that meeting the Five A's is key to their approach, but appropriateness in terms of sustainable/organic production is clearly an area of difficulty for them. They have neither jurisdiction nor staff in the rural areas around Belo Horizonte, relying primarily on Guimarães – who enthusiastically endorses alternative/organic agriculture – and the one car dedicated to the Secretariat's use to contact and encourage farmers to engage in such methods. For example, the Santos were actually applying to SMAB during some of my time in Belo Horizonte. However, they told me the next year that they were unable to stay in consistent contact with SMAB (including Guimarães) or clarify the requirements for entry into SMAB programs, making a transition to organic more difficult and less likely as they simultaneously saw their economic security eroding. Their brother, who was taking agronomy courses, was enthusiastic about organic methods, but he felt that some of their family members resisted it, preferring to stay with the methods they knew and were comfortable with, especially in the context of relative hardship.

Given the above, effects of participation in SMAB on biodiversity may be hard to entirely reconcile. That is, there are not clearly or consistently defined differences between the two farm groups (SMAB and non-SMAB): all till, some use chemical inputs on both sides and some don't, some grow many varieties of vegetables, some sell fewer, and though it does seem that SMAB encourages diversification, some independent farmers have diversified for their own reasons. Limited staff and financial resources do not allow those within SMAB to encourage sustainable practices as much as they would like, or even disseminate information on such practices within SMAB itself such that functionaries in other sections and program areas can understand and buy into this thrust as well. A lack of effective dissemination of information to local farmers was indeed an incredibly consistent complaint among farmers, SMAB and non-SMAB, as well as several functionaries within SMAB like José and Antônio. This fact notwithstanding, the attitude even among some non-SMAB farmers that pesticides are to be avoided or minimized is not terribly surprising when put into a larger context. Interviewed farmers supported the Brazilian law requiring them to keep 20% of their land in Atlantic

Rainforest, although interestingly, many felt that other farmers did not share their views or understand the importance of forest conservation. Almost all of them mentioned the essential nature of the forest fragments in maintaining their sources of water, with Marquinho and the Santos pointing out that they had observed some streams drying up as development encroached into the rural areas and residential neighborhoods were built where forests used to be. The Santos were concerned that rapid development of their area into residential zones would affect the amount and quality of water they were going to be able to obtain, especially considering that pumping water for irrigation was, apparently, the largest expense in their budget (~R$1,400/month). All of the farmers agreed that there was less Atlantic Rainforest now than when they began farming or when they were youths, and most said that they see less native animals and plants on and around the farm now than in the past. The reasons the farmers supported the preservation of the Atlantic Rainforest usually started with its vital role in maintaining sources of water, but their concerns also extended beyond the ecosystem services it provided to them. Several expressed appreciation of the Rainforest as the patrimony of Brazil, or even explaining that it was simply necessary to conserve it, to protect the natural areas. For example, non-SMAB farmer Rafael, a sharecropper with 3 or 4 ha under production, expressed it this way:

> "The environment is what you have to fight for the most, the environment. Because some years from now, these little kids you see, they're not going to even live as long as we live today. They'll live to… people won't live longer than 60 years… [the Atlantic Rainforest] has value for my farm and as a national heritage in itself. Because, people… for us, if you didn't have the forest, cleared everything away, you wouldn't have any pleasure… The value it has to us, it has no [certain] value because you can't carry it away, you can't sell it, you can't do anything with it. It's nature… Of course you have to preserve [it]."

Similarly, in a series of comments, Henri stated it rather simply: "It's a future, to leave it here… You have to preserve it, because of our children. So, we keep letting it be, we keep working, and we'll be leaving it for them." These general attitudes of the interviewed farmers align well with the findings of a survey of the Brazilian population in (2001). Simões found that Brazilians, in general, support preserving the environment and to varying degrees value it for its own existence and feel that it's worth an individual cost (i.e. higher taxes) to do so.[31]

Given this backdrop of general support for conservation, and within this study, near-universal consciousness of the negative effects of chemical inputs, there seems to be a solid base to spread alternative and organic agricultural measures. All farmers cited guidance and interactions from EMATER as being fundamental in both their understanding of how to use

pesticides effectively and safely, from both courses offered by EMATER and site visits by extension agents, and often in how to reduce pesticide use or use agroecological methods. Given this, why hasn't SMAB recruited more farmers? Why aren't there more SMAB partners or more support for organic farmers? And what other institutions are affecting farmer practices and viewpoints? We will examine these questions next.

Institutional Influences on Farmers of Greater Belo Horizonte

In the interviews with the farmers, one organization stood out as having the most prominent influences on them: EMATER, the state extension agency. Most had taken a class with EMATER at some point, often on how to treat pest outbreaks and how to safely and effectively use pesticides. The majority commented that if they had questions about a new method, or how to treat a new pest, they would inform EMATER and would then follow whatever procedures they recommended. Several explicitly pointed to EMATER as the only government organization that they interacted with, although several of these did nonetheless sell to CEASA, a semi-public entity linked to the national Agriculture Ministry. Also, the Santos and Marquinho mentioned EMATER explicitly as their source of familiarity with the relevant concepts related to agroecology and organic production, while Rafael said he used less of a less potent pesticide because of guidance from an EMATER agronomist. Generally, he said, he learned how to treat pests through trial and error, by "living and learning," but that occasionally someone from EMATER would come and explain how to improve their practices, and then they would watch and follow the advice of the extensionist. One of the members of the Santos' family was within one year of finishing an agronomy degree, saying that he's learning a lot "about what we do wrong!" Previously, they said, EMATER would come into their area and give classes; one of the Santos, a 44-year-old woman ("Marília") said "I actually like the people from EMATER a lot. They're… all my life, they've given us a good lot of attention… We were well covered. They gave classes on cheese, meat, when we wanted to smoke meat, on that, they gave all those classes." But, she added, "Lately they're kind of halfway gone, but before we had a lot of assistance. They gave a lot of courses. They've stopped now, I don't know why." This last reflects a recurring comment among the farmers – that it has become harder and harder to find and take EMATER classes, and that it is difficult to get extensionists to the farm promptly. Several observed that you can call EMATER if you have a problem, but you're not sure when they'll get there, and that until recently they were "everywhere" – like in an office next to Horácio's church. Now, he said, he has no idea where to find them, that they're slower to come, that they will come eventually, but that there's a delay.

These observations are reflected in interviews from the SMAB side, as well, in that the SMAB functionaries repeatedly highlighted the importance of EMATER one of their most important partners, who allowed them to recruit farmers for Straight from the Countryside to start with. José and Antônio wished that they could work with EMATER more to recruit, support, and encourage farmers, especially in regards to sustainable and organic practices. Edmar, the SMAB organic farmer, had similarly said that outreach and information dissemination from SMAB needed to be greater, especially in educating consumers, and perhaps school children, in the benefits of organic food. And both Marquinho and the Santos desired to see SMAB and EMATER come into the countryside more often, and to resume recruiting and registering new farmers for the program. As it was, it appeared that SMAB depended on their one dedicated EMATER agronomist, Guimarães, and one car that they shared between the entire Secretariat, in order to conduct such specific outreach and educational efforts (pers. obs., interview with José). Guimarães certainly did encourage organic practices, but as the single technician assigned to the ~35 farmers in Straight from the Countryside and the Organic fairs, with one inconsistently available car, it is easy to see his difficulty. Meanwhile, EMATER itself appears to be going through a financial and staffing crunch; the perception by the Santos was that the state was devolving responsibilities for EMATER to the local governments, such that it now depended on whether local mayors paid attention to the issues of the small farmers and dedicated resources to supporting EMATER agents for that region. Although I was unable to confirm this, it aligns with other farmers' perceptions, and is highly possible considering that in many ways, municipalities were given more decentralized powers and responsibilities than states, stemming from the tendencies during the dictatorship to bypass state governments, and further reinforced in the 1988 Constitution that formalized many of the devolved powers from federal to local governments, skipping over state governments. Such a devolution, if true, would suggest growing problems for SMAB and small, family farmers; SMAB partnered with EMATER because of its ubiquity within the state of Minas Gerais, its ability to reach small farmers in every part of the state and bypass the significant number of "latifundios" and plantations of large landowners to directly recruit small farmers. The farmers' impression were that coverage was much more spotty now, and none of them had seen an EMATER-SMAB recruiting group spend significant time in the countryside since, according to Marquinho, he was part of a big recruiting drive around 1995-1996. Nabuco and Souki (2004) confirmed that "The Straight from the Countryside Program, after an expansion between the years 1994 and 1999, suffered a contraction between 2000 and 2003. This fact can be explained as a function of the decrease in the number of technicians [agronomists] contracted with EMATER."

This contraction, which made things difficult for SMAB and local farmers in several ways, it seems, also has the potential to further hurt SMAB's efforts by affecting the embeddedness of their program.

Embeddedness Between SMAB and Local Farmers

Embeddedness, as represented by the enabling factors previously mentioned (competent government bureaucracy, democratic and competitive politics, "rules of the game" or the rule of law within politics, egalitarian social structures, and complementarity – the pairing of functions conducted efficiently by private actors with functions conducted more efficiently by the government) is an apparent part of the way SMAB has set up its successful programs. Taking the presence of the enablers of a competent bureaucracy and the rule of law for granted here, I will concentrate on competitive politics, egalitarian social structures, and complementarity.

Complementarity in SMAB's programs with local farmers is represented by three intersecting areas of activity. First, SMAB has addressed what it considers a systemic economic inefficiency, that is, the problems of intermediaries, wholesalers, and expensive retailers in the areas of basic food (i.e. fruits and vegetables). In a bit of intra-governmental complementarity, SMAB paired with EMATER in order to gain access to local small farmers, who were already engaged with EMATER to a seemingly great extent considering how commonly classes and advice from EMATER was mentioned by them. EMATER had the experience, expertise, and knowledge to find and develop partners among small local farmers, as well as the infrastructure and placement throughout the rural areas around Belo Horizonte. Thus each was able to do what it did best, with the city creating and promoting places for the small farmers to sell directly to consumers, as well as engaging in some degree of information dissemination regarding the new programs in 1993 and beyond, while EMATER helped locate and work with local farmers to give them advice on and pressure to adopt more agroecological methods, as well as support in producing safe and high-quality food to SMAB's standards. SMAB and EMATER's cooperation allowed them to take advantage with complementarity with the local farmers – that is, as acknowledged in the right to food, the government does not have the responsibility to produce or distribute food, but rather create conditions where people are able to reasonably access safe, healthy, and culturally acceptable foods. The local farmers were able to do what they were suited and situated to do – produce food – while the city helped develop the market such that the farmers were able to receive higher prices for their product while simultaneously providing a lower price to poorer Belo Horizonte citizens. Contracts with the Abastecers and Workers' Convoy partnering businesses – who are distinct from and do not necessarily buy from the SMAB-allied

local producers -- allowed those businesses to obtain spaces to sell in populous areas of the city in return for selling a number of basic foodstuffs at controlled prices, and/or traveling to more remote areas of the city on weekends in the case of the Convoy. In regards to the partnering local producers, however, Abastecers generally also were able to complement the Straight from the Countryside farmers because in most cases, the Abastecers have a Straight from the Countryside stand in front, and a general agreement to largely sell different products from each other (de Araújo and Alessio 2005).[32] There is also a certain complementarity with SMAB and the smaller farmers, in that several seemed happy at the chance to grow a larger variety of crops; since the local farmers have their own stands, and some amass products together for sale to the Popular Restaurant, such that they do not have to simply grow lots of one crop to satisfy a wholesaler.

In terms of competitive politics and egalitarian structures, we can see sources of some of the current roadblocks for SMAB and future problems. Direct competitive politics per se in this case are not really possible in regards to SMAB, as the pertinent levels of government – that is, the municipalities – are separated between local farmers and SMAB. Belo Horizonte's government has no direct influence with the local farmers, and the local farmers do not form part of the city's constituency and therefore cannot develop the direct pressure to, say, demand more resources for their programs, more recruitment, or stand space, or regulation of Abastecer retailers. A further mismatch between entities is seen in the SMAB-EMATER-producer triangle, as EMATER is influenced by politics at the local, state and national levels, and as such it would be exceedingly difficult for the local SMAB farmers to exert significant pressure for their specific agenda. It is likely, based on my interviews, that the small farmers in general do want EMATER to be more expansive, rather than less, but the influences of other factions, like large landowners and farmers, as well as financial pressures on state and federal governments with a number of other problems, policies and political influences flowing through them, along with the still profound problems with inequality in wealth and land ownership imply that problems relating to small farmers' political influence and material needs extend significantly beyond the difficulties before SMAB and may be a long time in being addressed. In addition to this, the Santos and SMAB functionaries themselves expressed significant disappointment, even disillusionment in the national PT government of President Lula. Although there are other parties that can and are challenging the PT, it would seem difficult for those that want greater support for small farmers and other vulnerable populations to effectively compete, as the PT is presently the most powerful and influential left party, holding the office of the president, and the party is tied for the most governorships in the country (6), and holds the fourth most mayoralties. That is, they were the party most likely to have the will and ability to further redistributive and support programs

pertinent to small farmers (and citizens suffering from food insecurity). Although the national politics in Brazil are seemingly quite competitive indeed (see i.e., Agência Estado 2008), it is possible to conclude that there is insufficient competition in regards to providing for the needs of the groups discussed here, with there being no party with comparable influence offering a more aggressive agenda in this area. This ties immediately to egalitarian social structures, which speaks to the ability of the less wealthy and less powerful to communicate directly with decision makers within the government, that is, to advocate for their specific problems and thereby influence the politics stream. Looking at the class differences between SMAB functionaries – all those interviewed were college educated – and the farmers, who often had only a fourth-grade conversation, there is some social barrier to free communication. José also pointed out that, as the issuer of the contracts and the instigator of partnership with farmers, there was an inherent inequality in their relationship, something not contradicted, at least, by the notably awed and very respectful tone of Marquinho when speaking of SMAB and its staff. The lack of frequent contact between the groups, due to staff and transportation limits, moves us further from egalitarianism. One final barrier here seems to also be the change of management within SMAB itself – that is, commentary by its functionaries on how Nabuco made much more effort to listen to ideas from everyone within SMAB, and had a greater focus on staff meetings to allow people to understand work in other parts of SMAB and also express their perceptions and ideas to management. Without this internal avenue of communication, another possible area for some degree of egalitarianism is obstructed, as those who work most closely with the farmers and EMATER partners have less chances to exchange information or advocate for their partners within the SMAB organization in order to have their needs met.

So of our factors encouraging embeddedness, we see clear examples of complementarity, and have assumed the rule of law and competent bureaucracy (though one could consider the lack of internal communication in SMAB to be of a piece with the latter, in addition to a problem with egalitarian social structures). On the other hand, competitive politics and egalitarianism seemed to be lacking as enabling factors. Direct questioning and observations show a certain lack of embeddedness in the relationships between producers and SMAB proper in terms of personal relationships and links of trust between the individuals within the program. While there seemed to be individual good will and a relatively large amount of trust, the simple enabler of frequent contact was not present – the opportunities for producers and SMAB functionaries to get together were limited, and the relationships between EMATER and SMAB face similar barriers while EMATER's relationship with farmers has been weakened by staff and service cutbacks where it appears they are spending less time with individual producers, making trust and these same

relationships of personal, friendly connections more difficult. It does seem like there is some potential to build further embeddedness – for example, SMAB's requirement that farmers join associations in order to sell to SMAB programs seemed to be in part connected to the revitalization of Marquinho's local, independent rural association, and the Santos were looking to become active within the same organization in order to buy inputs in bulk and receive corresponding discounts, as well as to consolidate various products such that they could be in the position to sell in bulk to wholesalers or city programs, being able to offer variety and quantity, and exert a higher degree of power versus large retailers, or perhaps the city itself. Such associations may also help address their ability to make demands of state and local governments as farmers join their voices together. SMAB's requirement of associations and its possible influence on reinvigorating another association could also be considered to be an example of Hirshman's conservation of social energy. So while we see a lack of certain enablers for embeddedness, and a resulting limited amount of embeddedness between SMAB and local farmers, there may be potential for SMAB to build this synergy, despite such obstacles.

Summary

Observation and analysis suggest that SMAB may be influencing more sustainable practices on the part of their partnering farms. A lack of embeddedness, and its restricted resources on the part of the extension agency EMATER seems to be a barrier to further and more direct influence by SMAB on the practices of local farmers, not just in restricting their relationships with present partners but in restricting their ability to identify and incorporate new small farmers who may benefit economically from SMAB's programs, and may as well be encouraged to diversify their crops, reduce pesticide use, and pressure to organize – even though there are problems within the existing Association of Producers for Straight from the Countryside (see the section **SMAB: Progress and problems**). However, not only are there reasons to think that SMAB's work may have already had some positive effects, but the almost uniformly concerned and positive attitude of local farmers on environmental protection and conservation of the Atlantic Rainforest provides another type of "social capital" for SMAB and EMATER to build on. In terms of deepening SMAB's successes and moving a sustainability and human rights agenda forward (for the citizens of Belo Horizonte benefiting from SMAB as well as the local farmers who are seemingly better able to make a living), one hopes that this potential encourages and enables action when and if the relevant problem, policy and political streams come together in this area, and that any possible policy entrepreneurs are ready when it comes.

CONCLUSIONS

Belo Horizonte represents a case of extraordinary accomplishment in social policy, as has been recognized by diverse organizations within Brazil and outside of it; those analyzing it from afar and those who have studied it close up (see i.e., the list of recognitions and awards in Machado 2003). The interviewed functionaries within SMAB share and are passionate about their vision of food security, a vision that closely parallels Rocha's Five A's (availability, accessibility, acceptability, appropriateness, and agency); a vision that was enshrined in the very creation of SMAB, and advanced by the work of its originators, former BH Mayor Patrus Ananias de Souza and former SMAB Secretary, the late Dr. Maria Regina Nabuco. A vision that has lasted, at the point of this writing, a decade and a half, with numerous major and substantive gains to point to in their multi-sectoral approach, from supporting availability as relates to local production from small farmers; a strong focus on economic and spatial accessibility for lower-income groups in Belo Horizonte, the children in its School Meals programs, the 11,000 people/day that patronize its Popular Restaurant program, the communities served by the Big Popular Basket, the Workers' Convoy, support for urban agriculture, and more; dedication and significant efforts with regards to acceptability through its initial partnerships with the City Secretariat of Education, and its own staff of nutritionists and sub-contracted cooks who design and re-design meals in city programs to be appetizing, healthy, and high quality, design standards and inspect produce shops to ensure them, and focusing on preserving and amplifying local and traditional foods and recipes; the strong sense of the importance of appropriateness in terms of high standards for food safety and quality, an awareness of the environmental connections between food and the environment and a passion for making food production more sustainable; and a commitment to agency through the advancement of a "right to food" agenda, its dedication to "food with dignity," and to supporting deep and participatory democracy in terms of providing information and educational opportunities to citizens and schoolchildren to learn about proper nutrition and fomenting of public-private deliberative and counseling bodies to monitor and continually improve SMAB's programs, to maintain pressure and push for more, always, from those who work to guarantee the human rights to the citizens of Belo Horizonte.

SMAB's creation represented the coming together of many independent factors facilitated by the right people in the right place at the right time, yet it was not simple luck that allowed it to happen, but rather a much more complex interplay of developing public and political awareness of the problems of food security and how they were different from a more neo-Malthusian approach represented by the simpler term "hunger", years of policy attempts, failures, advances, developments, and ideas, with old ones ready to be honed or updated and moved

towards implementation and new ones to try out in more daring attempts to address the problems, and the ebb and flow of political currents where hunger and food insecurity rose and fell on the agenda for decades and was tackled by many different leaders on different levels before being taken on by the entrepreneurial Ananias and Nabuco. It was a messy, uncertain, and unpredictable process that led to SMAB's creation in 1993 and its work since then, but to provide that process with the ability of a success like SMAB required a great deal of work from a great many people before such a comprehensive work could be actualized.

But having reviewed the history and documents of SMAB, and interviewed some of those that work within it and work with it, then, what are the answers to the questions I asked earlier – what have I found out, specifically, about:

> 1) What institutional conditions allowed or enabled the creation and maintenance (political sustainability) of the food security programs in Belo Horizonte?
>
> 2) What are the institutional characteristics supporting the success and effectiveness of their municipal food security program, especially in terms of working with civil society in order to address hunger (food insecurity)?
>
> 3) How do institutional characteristics and choices encourage or inhibit local (agroecological) conservation?

The answers to these questions are, of course, linked. In my analysis, I relied heavily on the model of Kingdon with respect to policy process streams, a modified version of the "garbage can model of institutional choice" observable within organized anarchical institutions, as originated by Cohen-March-Olsen (1972). I also examined the linkages with civil society using Evans' (1996) definitions of synergy, the circumstances and factors that allow government and civil society to together produce more than the addition of their own separate efforts. Having already observed reasons to think synergy and policy entrepreneurs played key roles in SMAB's creation and maintenance, and to some degree are at work in the relationships between SMAB and local farmers, I presented the case that the outlined frameworks do seem to carry significant explanatory value for the case of SMAB and food policy in Belo Horizonte, and thus help address the three questions above, along with a perhaps implicit additional question: what has kept SMAB from being even more effective?

Using Kingdon's problems, policies and politics process streams, I found evidence suggestive of the operation of the dynamics Kingdon describes during the creation of SMAB. The institutional conditions that allowed its creation were, as we have seen, the interactions of these semi-independent streams, meaning that there were numerous different conditions evolving from many institutions that fostered its creation. However, it appears likely that, in terms of

problems, a history of at least decades of efforts to address food security nationwide and the societal and national institutional memory of these efforts was one key. As an issue, its widespread recognition was primed by this history, and a reformulation of the problem that redefined not just what the problems of food insecurity were (i.e. inequality and lack of access and agency rather than lack of availability) but how it was appropriate for the government to address it. That is, seeing the problem as going beyond the Malthusian "there's not enough food" allowed the development by the PT and Betinho's Citizens' Action Movement Against Hunger and Poverty and for Life of a definition of the problem calling for actions that improved the rights of citizens and changed the structures of inequality rather than emergency-oriented or merely assistentialist/welfare programs. Ananias and Nabuco's backgrounds prepared each of them to focus on the problem from this perspective and to treat food insecurity as one of their top agenda items.

Conversely, the movements of the problems stream act against the institutional sustainability of SMAB, and can be seen as part of the difficulties in its maintenance of an organizationally progressive and comprehensive approach. As problems are addressed and decline in magnitude, the pressure to keep addressing them diminishes. Examining its founding documents and interviewing the people who work there, one can see evidence that SMAB's objective is to completely address, in effect, the Five A's; yet there is much to be done still to accomplish this broader objective. By halving some of the problems in Belo Horizonte in relation to food security – infant mortality and malnutrition – and changing the structure of accessibility with visible and popular programs like School Meals, Popular Restaurant, and the Abastecers, the likelihood that SMAB's items reach the top of the City's administrative agenda, according to Kingdon's framework, goes down. The two questions this raises in regards to the problems are: should food security be kept at the top of the agenda? If so, how can food security be kept at the top of the agenda, even as indicators improve but remain problematic? Problems remain in Belo Horizonte, such as providing access to the very poorest citizens to both the assistentialist and the comprehensive programs when they cannot afford the minimal costs of some of them, like the Abastecers and Workers' Convoy. And the evidence implies that SMAB and the local community lack the conditions and the resources to fully provide and disseminate the assistentialist programs, like the Big Popular Basket, or what might be called the "self-assistance" programs like Urban Gardens. Do the decreases in infant mortality and malnutrition, important successes to be sure, mean that remaining problems such as these should be moved down in priority for city decision-makers' agendas? And housing, education, employment and poverty/inequality are all problems that are quite arguably urgent to some degree and in dire

straits of their own in Belo Horizonte at the moment. It is possible to reframe this question in the short-term as, "Is Mayor Pimentel's work on the housing/urban renovation projects of *Vila Viva*, perhaps one of the largest projects of its kind in South America, if not the world, simply more important right now?" This question could be refrained to correspond to any number of other priorities within the Mayor's office, that doubtlessly address real problems. And though SMAB's foundation rests on the idea that food security is multi-sectoral, that nonetheless does not mean that working on food security automatically addresses all other sectors, nor that other sectors will not at some times need more attention than food security. While the ultimate answer to this question will come likely about through the semi-anarchic process outlined here, the discussion among experts, the public, and the politicians will help determine the results of such a process – it will not be so conceptually simple as a simple popular vote or a consensus of technocrats, but it nonetheless is not random and can be definitively affected by democratic institutions.

The policies stream in Belo Horizonte and Brazil had seen years of innovations, trial balloons, uncoordinated and sometimes incoherent attempts to address food security by 1993. From this "policy primeval soup" came a flurry of policy ideas that had survived years of selection and recombination with the soup, and when the policy window opened, were enacted in a several-year flurry that has since tapered off. This period of apparently rapid and dramatic changes could be seen to challenge commonly held beliefs among experts and laypeople about the speed and magnitude of change.[33] Kingdon, responding to points on the dominance of incremental change as the mode of policy evolution, analyzed his 75 policy subjects within health care and transportation regulation in the United States and found no reason to favor incrementalism as a dominant mode: "It might be fair to describe some changes as incremental, but not all or even a majority of them." Simply stated, evidence reviewed here on the history of food security policy in Brazil and evidence from Kingdon's work implies that, although food security policy and SMAB saw very fast change in a short period and then relative policy stasis, there is no reason to think that such bipolar behavior is the only behavior possible for food security policy in this, or any other context.

However, beyond the evolution in the policy primeval soup, another factor is important in Kingdon's policy stream. The policy entrepreneur, as someone who takes advantage of a window for (rapid or gradual) change, is a key figure and seems to be present in the persons of the first SMAB Secretary Dr. Maria Regina Nabuco and the Mayor who created SMAB, Patrus Ananias de Souza, two people who were primed by their life experiences, knowledge, ambitions, and goals to advocate for food security in Belo Horizonte, and they both helped create the policy window through consensus building and took advantage of the window they helped open. They

were further aided by the fact that bringing the Secretariats of Education and Health into the design process also included, eventually, logistical and budget resources from those Secretariats, easing the way for food policies in Belo Horizonte even more.

Since the days of Ananias and Nabuco, evolution of policies continues apace inside Belo Horizonte and out, but the implementation of the policies at SMAB seems to be at a greatly reduced pace. The policies enacted right now appear to mainly respond to already-popular programs, like the flagship Popular Restaurant program, which has seen a number of increases in infrastructure and patronage in the past 15 years – meaning there should be a corresponding increase in expenses, absorbing resources away from other policies. Whether that is a good or bad thing is for those in the process to decide, but in terms of policy priority setting, its visibility and success do seem to have drawn the increased attention to it from Mayor Pimentel, a possible policy entrepreneur, and Secretary Colombini (1997 – 2006), who, in contrast to Nabuco, does not appear primed by experience or inclination to be a policy entrepreneur in the area of food security. Pimentel, meanwhile, is possibly an entrepreneur – but not, from the evidence, in food security.

Which brings us back again to Kingdon's politics stream. It may – and for some, has – be frustrating to see a program as innovative as SMAB struggling with organizational shifts, lack of physical and financial resources, and other difficulties in carrying its mission to the poorest to the wealthiest[34] in Belo Horizonte. But such a focus may be overlooking other important areas to sustainable development, like other human rights, as mentioned previously, and in any case, can be addressed in the politics stream. That is, Kingdon's model could foreseeably make one, at first reflection, feel rather discouraged about the possibility of addressing problems and instigating institutional change. If one is not, for example, a Mayor, a City Secretary, or the leader of a mass movement, one is rather less likely to be a policy entrepreneur in the Nabuco-Ananias mold. But the political stream represents the vagaries, and pressures of various groups in a society. Although some groups may oppose change as "pseudoadvocates," it is nonetheless true that genuine advocacy also affects the political stream. The Kingdon framework does not prohibit or deny the importance of individual action, but rather gives a model to those who seek action on their agenda to understand how it may work, and to emphasize the importance of both preparation (development and monitoring of indicators, development and recombination of pre-existing policies, political participation and agitation) and patience, as the process of ideas gaining and losing importance is in part cyclical rather than entirely random, but is nonetheless not easily predictable.

Having developed these ideas reflecting the creation of SMAB, and, to a lesser extent, its maintenance, I will briefly return to concluding comments in regards to synergy. Embeddedness, the personal relationships between public and private actors, and complementarity, the ability of public and private actors to efficiently work on different aspects of a problem or policy to co-produce public goods, are important in the case of Belo Horizonte in terms of the political process stream and in terms of SMAB's maintenance. Embeddedness, enabled by competent bureaucracies, competitive politics, "rules of the game" which are conformed to, egalitarian social structures, and complementarity, is itself an enabler for action and effective institutional change. We have seen how, in the case of links with local farmers, a lack of egalitarian social structures as well as political disarticulation between the farmers and the city of Belo Horizonte, and the uncertain status of Brazil's political left mean that egalitarianism and political competitiveness may not have been available as enablers in that case. If one adds the (self-reports of) limited resources for and, from my observations, inconsistent management of the Support for Basic Food Production section, the chance for embeddedness is further weakened. However, complementarity seems to be a strong presence in the mechanics of the Straight from the Countryside program, reflected in its relative level of success in seemingly bringing improved economic stability to partner small, family farmers, while bringing cost savings and increased fruit and vegetable consumption to the consumers of Belo Horizonte. A lack of greater embeddedness is a strong candidate for why the Support for Basic Food Production program is not more successful yet, and is not able to fully address the concerns of farmers within the program, nor maintain or increase the number of farmers participating each year.

In regards to the 3rd question, "how do institutional characteristics and choices encourage or inhibit local (agroecological) conservation", the lack of embeddedness between SMAB and local farmers also limits the degree to which SMAB can support sustainability in the local countryside and Atlantic Rainforest. There clearly is much institutional desire and the potential ability to more aggressively support organic and alternative agriculture within SMAB. However, SMAB may have already positively influenced conservation through providing greater security to its partnering local farmers. Additionally, the interviewed local farmers, whether or not they were partners of SMAB, evinced positive attitudes towards the environment, conservation, sustainability, and SMAB's mission of the right to food. This suggests further ground on which to build a sustainable city-to-country relationship, which is nonetheless faced with stiff obstacles in the forms of the lack of egalitarian social structures and direct political connection, much less competitiveness, between the farmers and SMAB – in addition to the problematic scaling-back of EMATER, which is already having negative consequences on SMAB's ability to outreach and

disseminate information and build relationships with local farmers, but also appears to threaten the farmers' abilities to maintain their farms, to a greater or lesser extent. As all farmers mentioned some degree of interaction with EMATER, from courses to on-farm technical help, there have been and will likely continue to be other negative impacts for them due to EMATER's scaling back, including a lack of access to educational resources to improve their farm operations, in regards to sustainability or anything else. Nevertheless, there is the possibility that the economic security provided by SMAB's programs to the farmers already in them has an effect on their practices and/or quality of their management. For example, it is suggestive but far from definitive that participation in SMAB encourages and allows farmers to diversify their crops, which should generally have a positive effect on biodiversity conservation more generally, and is one practice that is tied to a degree of higher sustainability on farms (see Chappell 2009, Chapters 2 and 4).

Final Remarks

SMAB represents an organization and innovative food security institutions unique, to my knowledge, in the world. Along with Mayor Pimentel's *Vila Viva* program, Belo Horizonte will potentially be a world model in sustainable development for a time to come, with only Cuba, perhaps, rivaling it in comprehensive food security programs (Rosset and Benjamin 1994, Rosset 1998). Is there something special, perhaps, in Belo Horizonte that allowed this program to come to be?

The answer, of course, is that it was a combination of chance and established factors for change. What I have attempted to show here is that, upon analysis, what we see is an example that hews closely to the existing framework of Kingdon/CMO. Within that framework, as I have discussed, there are a number of actions within each stream that make change more likely to come when a policy window opens. Embeddedness and complementarity further enable institutional change, as well as helping maintain momentum and helping to keep forward movement on positive institutional change going. Evans concluded in 1996 that embeddedness and complementarity are constructable. That is, they do not depend on pre-existing social capital, a system where intertwined relationships of friendship and trust between private and public actors are already present, where everyone is already mobilized and ready to work together to solve long-standing problems. Constructability comes from the fact that

> "social identities are constructed and reconstructed on a regular basis and can be reconstructed in ways that enhance prospects for synergy… In Mexico villagers who define their interests in terms of defending traditional land rights against infringements by neighbors in adjacent villages can also see themselves as peasants who need to cooperate

> with other communities in order to defend themselves against landowners and the impersonal forces of commodity markets. In Kerala, members of particular subcastes and religious communities can also see themselves as landless laborers who need to unite across caste and community boundaries in order to get out from underneath the indignities of feudal patron-client relations. New definitions of identity and interest have to be built on new experiences and interaction, but they can be constructed in years rather than decades or centuries."

One can see this type of redefinition at work as well, for example, in the Brazilian Landless Rural Workers' Movement, which drew significant inspiration from Brazilian educator Paulo Freire. Freire's work "The Pedagogy of the Oppressed" proposes learning and teaching through a method emphasizing dialogue and a discovery of oneself as an agent of history, your own history and history more generally. This emphasis on re-imaging the self is likely part of the foundations of the Movement's success, in terms of Evans' constructability. Beyond this reconstruction or re-imagining, construction of synergy can emerge from organizational design; in Evans' examples, synergy was enhanced by maintaining and building on local relationships with government workers, rather than social insulation of the bureaucracy which, while meant to prevent corruption, also prevented the relationships across the state-society divide that enables synergy and effectiveness. And lastly Evans lists problem redefinitions; we have already seen the power and importance of this within the examples of food security.

I raised Evans' constructability here because of the sometimes seeming-gulf that separates the ability of a city like Belo Horizonte to have made these reforms in food security and people's imaginations in terms of making the same reforms in, say, Detroit, Michigan. Which is not to downplay the difference, but rather to emphasize the true importance and potential of synergy and constructability; it seems unlikely that those during the military dictatorship in Brazil, who, say, helped develop or refine a popular restaurant program, could foresee the success of something like SMAB several decades later. The differences in institutions are not trivial, but the importance of understanding the framework of decision-making in organized anarchies and in building synergy should not be underestimated, either. Analyses that look at short-term failures of policy initiatives explicitly or implicitly often fall into the trap of the rational-comprehensive model Kingdon and CMO respond to. That is, although rational-comprehensive agenda setting no doubt sometimes occurs to some extent, without an examination of the history and evolution of the problems, policies, and politics, one may end up analyzing a proposed initiative's failure as a referendum on its design or quality – but this is only automatically true under the rational-comprehensive model. An analysis of the long term that looks at developments in the three streams of policy process offers a way to direct efforts into long-term problem, social identities, polices, and politics such that policy windows can be more effectively created, and more

effectively used by potential entrepreneurs when they occur; an entrepreneur's analysis should include this such that frustration does not lead to despair, when the elements of chance and independently evolving streams are so important.

Future research may look to details in the evolution of Kingdonian streams, in Belo Horizonte as well as elsewhere. Bentley's 2006 thesis says that

> "…the extent of cooperation between state and civil society that can be seen in Brazil's food and nutritional security councils and sustainable food and nutritional security commissions does not exist elsewhere, at least not to my knowledge. Whether and how such governance institutions might be applied outside, then, is certainly a topic that begs for investigation. Considering that the civil society participation in governance that these institutions facilitate is constitutionally mandated in Brazil—and that this mandate itself originated in civil society's lobbying efforts—I would suggest that their replicability outside the country will depend on the existence (or the ability to foster the existence) of a legal, cultural and/or political environment that supports them. Likewise, places which already have an established tradition of regional governance may be in a better a place to create institutions akin to Brazil's sustainable regional food and nutritional security commissions. The idea of using such commissions to facilitate a highly decentralized process to create a state food security plan that is responsive to the needs of local populations is certainly laudable... As is the case of São Paulo, strong leadership and impressive feats of organization and mobilization would be required for such a process to be successful.

Models such as that of Belo Horizonte and others hold hope of workable solutions to the problems of hunger and malnutrition. Redefining problems and identities takes place every day, and institutional change may be as often incremental as it is dramatic. SMAB's work rapidly started fulfilling and guaranteeing promises often repeated since the UN documents of 1948 and 1976: new approaches to food security, human rights, and development. With the potential created by linking this with the local countryside, Belo Horizonte has shown us a way to truly take revolutionary steps forward, to enact truly sustainable development – as long as we plan for it, are willing to wait for it, and are ready to go when a chance comes. It may not work the first time, or the second or third, as Belo Horizonte teaches us, and it will not be completed even after it makes quick progress the fourth time round. But if embeddedness can be constructed and problems and identities redefined, the potential to go forward each cycle is an exciting one, once it is understood.

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NOTES

[1] Supreme Court Justice Potter Stewart, Jacobellis v Ohio (1964)

[2] More purely economically targeted interpretations are possible, as are far more cynical views of sustainable development. For this paper, I assume a "good-faith" effort at development, meaning that development's goal is to increase human wellbeing. This is in contrast to the elements of imperialism in development most pointedly examined by Escobar (1995).

[3] See, for example, general comments by Julian Simon in Myers and Simon (1994). Technology in agriculture is touted by, among others, Cohen et al. (2003); Evenson and Gollin (2003); Fresco (2003); Pinstrup-Andersen (2001); Trewavas (2002).

[4] The rights listed are advanced by the United Nations in both its Declaration of Human Rights in 1948 and its Covenant on Economic, Social, and Cultural Rights in 1976, and also closely align with the goals of many civil reform movements.

[5] Equality as a Human Development Indicator is measured by the UNDP in the form of the GINI coefficient; GINI = 0 means perfect income equality; GINI = 100 means complete income inequality. In 2005, Brazil had the 8th highest measured GINI coefficient in the world (UNDP 2005). For discussions of Brazil's skewed income distribution, see Messias (2003); Wright and Wolford (2003).

[6] For example, Brazil has the sixth lowest access to improved sanitation in Latin America and the Caribbean (84%), the second lowest level of rural access to a sustainable, reasonable drinking water source (53%), the highest consumption of ozone-depleting chlorofluorocarbons, the fourth lowest ratio of protected land to surface area, and the 18th highest share of carbon emissions in the world (Fukuda-Parr et al. 2003).

[7] Availability refers to the sufficiency of a food supply to meet people's needs; accessibility refers to people's economic and physical ability to acquire food; acceptability addresses the cultural and nutritional suitability of the available food; appropriateness evaluates the ecological sustainability and the safety of a food supply; agency is "right to knowledge, and knowledge of rights," that is, access to accurate information on food supply, quality, and safety in order to make informed market choices,

rights to such information and to the other aspects of food security, and a competent sociopolitical system to guarantee these rights.

[8] An estimated 3,285 calories/person/day are available in the "Developed Countries". In comparison, 2,675 calories/person/day are available in the "Developing Countries" (Food and Agriculture Organization of the United Nations (FAO) 2003). The recommended daily intake of calories is approximately 2,200 (FAO 1985, Center for Nutrition Policy and Promotion (CNPP) 2000).

[9] A very crude measure of the gain in relative importance of more nuanced approaches in recent years can be seen in the number of citation hits for "hunger" relative to "food security" in the past century. Searching for the terms in Portuguese and English in the ISI citations database, it can be seen in Figure 3.2 that the number of citations for "hunger" rapidly increase starting in the 1970s-1980s, while "food security" sees rapid increases in cites starting in the early 1990s, such that today there are approximately twice as many citations for it over "hunger." (Drops in the citations of both terms are due to incomplete data for 2008.)

[10] According to the FAO, Brazil has increased its food consumption (that is, the estimated amount of food available for human consumption before wastage and losses of food in the household) from 2,430 kcal/person/day in 1970 to 3,110 kcal/person/day in 2003 (FAO 2007), while the estimated required daily *per capita* recommended caloric intake calculated for Brazil went from 1,840 kcal/person/day to 1,900 kcal/person/day in the same period (FAO 2005). Acute malnourishment has, however, been estimated to have declined from 23% to 7% of the population, but this unfortunately has also corresponded with a dramatic rise in obesity, nevertheless a possible symptom of food insecurity (Chappell 2009, Chapter 2; Tanumihardjo et al. 2007).

[11] Reportedly, "Betinho" was voted the most admired figure in Brazil in 1995, during the height of the movement he helped create and lead – more admired than Pelé, Brazil's world-famous soccer player (Rocha 2001).

[12] Although further statistics related to food security in Brazil and SMAB's programs in particular will be discussed in the remainder of this paper, it is important to note that, as observed by UNESCO Director in Brazil Vincent Defourny "Quotidian monitoring and the development of specific studies are relatively new procedures in Brazil; as a consequence, they have not yet been adequately established in government agencies..." (Defourny 2006). Thus, the coverage of the results for many of the pertinent areas of interest are less complete than one might one might hope.

[13] Cuba has arguably developed an equally or greater food security system on a country-wide scale, although detailed research into the Cuban system is still rather rare in the academic literature, for obvious reasons (see i.e., Rosset 1998, Funes et al. 2002, Pretty 2002, Koont 2004, FAO 2006.).

[14] Although Rocha (2007) does not explicitly mention or define "agency," she considers "the whole article to be in fact a justification of the importance of agency," and that "we cannot achieve the first 4 As of food security without *agency*." (*personal communication between M. J. Chappell and C. Rocha via email, dated 8/21/08*).

[15] Kingdon does further amplify in his later work that while "we will find our emphasis [within his study of the US federal government] being placed more on the 'organized' than on the 'anarchy'", his case studies revealed "properties of problematic preferences, unclear technology, and fluid participation." This will be further discussed in the context of SMAB in the next section.

[16] Perhaps to quickly summarize complementarity versus embeddedness, it would be wisest here to simply quote Evans:

"I argue that complementarity creates objective grounds on which cooperation between government and citizens can be built but that embeddedness generates the normative and interactional basis for realizing the potential joint gains." (Evans 1996a)

[17] The exact present status of a problem does, of course, depend to some extent on what policies and politics were in the past, leading us to the problem of "infinite regress," similar to that pointed out by Kingdon in reference to ideas or proposals. As he says of ideas, problems "[don't] start with the proximate source. [They] have a history." If you trace the history of a problem back through time, there often "is no logical place to stop the process" if one is looking for the ultimate cause temporally. That is not to say that the history of a problem (or idea) is irrelevant, but rather that its first origin in time is not easy to find or define, and not necessarily the most relevant element to study. For example, tracing the problem of food insecurity to its "ultimate origin" has led many to favor looking at total production, or bulk availability, rather than, say, inequality and poverty over time.

[18] A growing recognition of the broader "food security" approach as opposed to Neo-Malthusian hunger from lack of production can perhaps be seen implicitly in the growth in academic journals of the terminology "food security" versus simply "hunger." Hunger as an academic subject has a much older pedigree, and references including it as a keyword in ISI rapidly grew during the World Food Crisis of the 1970s. However, references to "food security" show rapid growth starting in the late 1980s, surpassing hunger in the late 90s-early 00s (see Note 9, and Figure 3.2).

[19] In the seminar, during a discussion of the founding of SMAB, Aranha – then a SMAB manager and presently a special administrative assistant to Ananias in the federal government – said of Ananias that he was "a devout Catholic" and saw "elimination of hunger as one of his fundamental goals." More generally, Catholicism in Brazil in the form of liberation theology has played an important role in the formation of many of its most prominent social justice movements of the 60s, 70s and 80s – see, i.e. Doimo (1995), Branford and Rocha (2002), French (2006).

[20] It has to be said that the Secretariats of Education and Health likely saw significant pressure, formally or informally, from the new PT Mayor Ananias to contribute to his new project. However, my interview subjects consistently described the relationships between Health and Education and SMAB positively, and there is no evidence that the consensus-building exercise of the series of seminars had any tone or implication of coercion from the Mayor's office. Nonetheless, such a dynamic cannot be ruled out. Additionally, the recruiting of nutritionists over other professionals from other disciplines, besides making some sense *prima facie*, also is consistent with Aranha's (2000) characterization of previous thinking in food security being inconsistent and contradictory: "The great challenge in this area and precisely in the moment when it was placed on the national food security agenda as a right was the search for an integrated national policy, [one that was] permanent, not [built around] emergencies, efficient, and effective." Indeed, at least in the United States, a vision of food security as being synonymous with hunger and an insufficient supply of food rather than situated in problems of access is still common in social work (Brown-Chappell, *pers. comm.*).

[21] For example, the two present and one former SMAB organic farmers I interacted with were a former financial trader, a former seminarian and his wife, both of whom had degrees in agronomy, and a university professor.

[22] Patrus Ananias, elected in 1993, was Mayor until 1996, leaving office with an 85% approval rating and going on to be the most voted-for *deputado* (congressional representative) in the history of Minas Gerais in 2002, then becoming National Minister of Social Development in the administration of President Lula in 2004. In Belo Horizonte, Ananias was succeeded by his former Vice Mayor and close friend Célio de Castro who served as Mayor until he resigned for health reasons in 2001. de Castro was succeeded by his Vice Mayor Fernando Pimentel, who had been Municipal Finance Secretary under Ananias, and who was re-elected in his own right in 2004. de Castro had been a member of the *Partido Socialista Brasileiro* (PSB), a coalition party of the PT, before he switched to the PT while in office. For his part, in a participant observation on April 4, 2005, Pimentel was characterized by some SMAB functionaries as being part of the ascendant "conservative wing" of the PT, unlike, for example, Ananias. There was no further evidence in my study supporting or disputing this characterization.

[23] For example, as de Araújo and Alessio said, "The Secretariat, however, doesn't possess sufficient capacity in order to attend to the demands of the population, due to scarcity in human resources and infrastructure." The list of concerns in the section under the main heading **SMAB: Progress and Problems** outlines many problems that seem solvable with varying levels of increased commitment to resources by the Mayor. In short, food security has been vastly improved in Belo Horizonte, but the feeling I got from "SMABistas" (SMAB functionaries) and that is backed up by my research more generally is that a number of aspects of food security still need serious attention that they are not currently receiving. Bettering services for the very poorest with little-to-no purchasing power, directly supporting community building and leadership development around food security, supporting urban gardening, increasing contact and recruitment for Straight from the Countryside, and enacting measures to directly support biodiversity conservation insofar as Belo Horizonte's administration can influence the farmers through its programs are just a few potential directions, as well as increasing the resources to education and information dissemination, a repeated concern or complaint that I received from practically all interviewees.

[24] "A corollary of addressing a problem is that growth inevitably levels off. Failure to solve or even address a problem, as well as success, may result in it its demise as a prominent agenda item. It takes time, effort, mobilization of many actors, and the expenditure of political resources to keep an item prominent on the agenda… a subject gets attention when it is novel. When it is no longer novel, people's attention may turn away from the subject even thought it may still be valid or important… 'The world of ideas is like the world of fashion. Ideas don't last for more than four or five years. They catch on, they become very popular, and because of that, they burn themselves out in a burst of growth and others take their place.'" (Kingdon 2003)

[25] Land reform, that is, breaking up the unequal concentrations of land possession present in most of the world and providing small and family farmers with secure tenure, is a significant issue in Brazil, with one of the world's largest social movements, the Landless Rural Workers' Movement, exerting considerable pressure on the Brazilian government in this area, with some significant amount of success. See, i.e. Branford and Rocha (2002), and Wright and Wolford (2003).

[26] One interviewed farm family, the "Santos", claimed that there was a 200% markup on their lettuce, saying that wholesalers bought it from them at R$4 and sold it at R$12; they did not specify how much was bought at R$4, but interviews with other farmers implies that it may be R$4 per box of 24 heads of lettuce.

[27] Davi answered as to who he sold his products, but his answer was unintelligible.

[28] Although the results are suggestive, even more caution is warranted in their interpretation than might otherwise be the case, as different farmers were interviewed in different years, so their perceptions of market conditions might be different due to differences between years rather than between farmers.

[29] Although data is only available for 2001-2003, numbers provided by SMAB shows that gross sales from Straight from the Countryside in terms of average monthly income had a standard deviation of ~R$310 for that time period, or around 10% of average monthly gross (R$3,360, R$3,050, and R$3,670 for 2001, 2002, and 2003, respectively).

[31] Although very few farmers were family with the concepts and context of food security, food citizenship, or the right to food, they all agreed that there was a right to food, and that guaranteeing it fell to the government when some of its ideas were briefly elaborated. Several were skeptical that the government would do anything or be effective at guaranteeing it, but nevertheless acknowledged that they considered it a right that can and should be guaranteed to all people.

[32] de Araújo and Alessio (2005) point out that there is sometimes nevertheless some competition between products sold by the Straight from the Countryside farmers and the Abastecers. In a way, they say, this advances the goals of the program, by providing competition and therefore perhaps even lower prices to consumers; obviously, this concerns the partnering farmers, who have asked that the Abastecers be prohibited from sales of certain products. They also are concerned, as I saw at the Association meeting, with larger producers or retailers intentionally undercutting their prices, and expressed some aggravation at SMAB's lack of action in this regard. I have insufficient information to determine how much retailers might be underselling the farmers, or if they are at all, and how much this hurts the farmers' profits; it is certainly an area for further explanation and potential future problems for SMAB.

[33] Kingdon, in his work, specifically names Lindblom (1959) and Wildavsky (1964) as two theorists of incrementalism that his analysis responds to.

[34] The wealthy are unlikely to be hungry, of course, but obesity is also a problem of food security, as I have defined it here, and a form of malnutrition. Obesity is rapidly becoming an urgent problem in Brazil (as throughout much of the world) (Menezes 2005, Tanumihardjo et al. 2007).

Figure 3.1. Organizational chart for the Belo Horizonte Secretariat of Food Supply, 2005. From de Araújo and Alessio (2005).

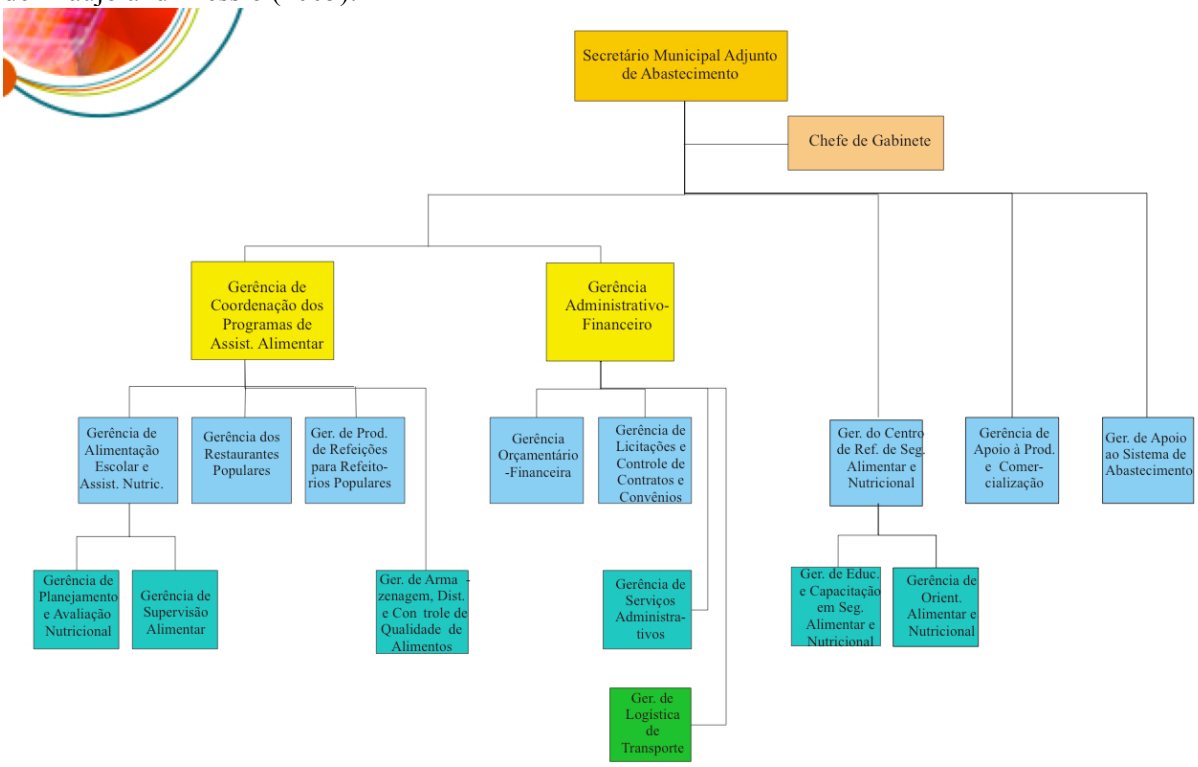

Figure 3.2. Numbers of citations by year related to hunger and food security in English and Portuguese. Citation hits found in an ISI keyword search for (a) "food security OR segurança alimentar" and (b) "hunger OR fome".

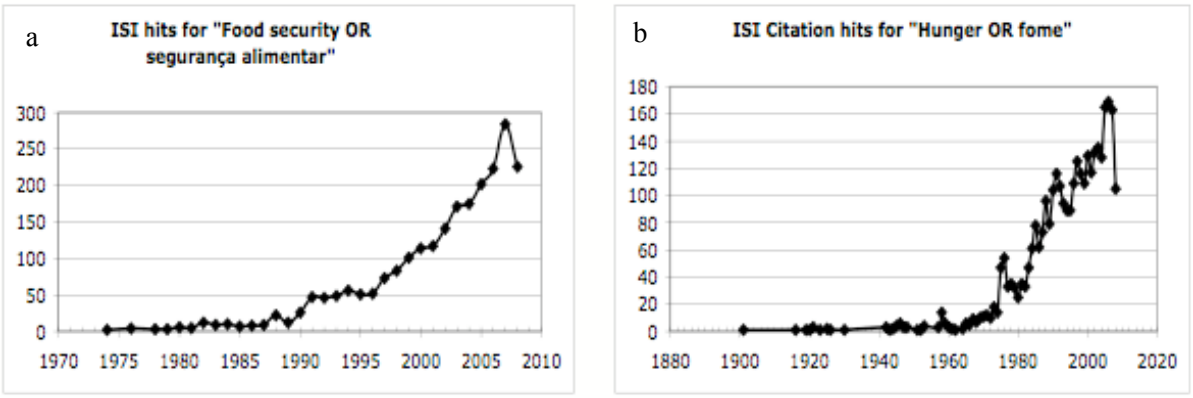

Table 3.1. Farmer demographics. Religion is not shown; all farmers who specified a religion identified as Catholic.

Farmer ID	Age	Sex M/F	Education Level	Race	Political Identification	Family Income (Net)*	SMAB Partner	Interview Date (mm/dd/yyyy)
001	52	M	4th grade	White	None/Leans PMDB†	US$ 184/mo.	No	07/01/2007; 10/14/2007
002	NS	M	NS	White	NS	US$ (100)/mo.	No	03/31/2006
003	43	M	3rd grade	Black	None	US$ 250/mo.	No	06/03/2007
012	29	M	4th grade	Black	None	NS	No	03/06/2007
059	NS	M	NS	NS	NS	NS	No	11/17/2007
064	NS	M	NS	NS	NS	NS	No	11/17/2007
066	61	M	4th grade	NS	None	US$ 230/mo.	No	11/17/2007
075	NS	M	NS	NS	NS	NS	No	Summer 2008
078	NS	M	NS	NS	NS	NS	No	11/17/2007
093	42	F	High school grad.	White	Left (formerly PT¶)	US$ 920/mo. ††	No	03/24/2006; 04/21/2006
136	46	F	4th grade	White	None	US$ 460/mo.	Yes	03/16/2005; 03/15/2006; 05/31/2008
159	NS		College grad.	White	NS	US$ 470/mo.‡	Yes	03/11/2006
175	NS	M	NS	NS	NS	US$ 6360/mo.§	Yes	11/17/2006

NS = Not specified.

(*): Converted from reais, at R$ 1 = US$ 0.46 (as of November 7, 2008); numbers in parentheses are negative (i.e., net loss).

(†): *Partido do Movimento Democrático Brasileiro* (Party of the Brazilian Democratic Movement), a center/center-left national political party.

(¶): *Partido dos Trabalhadores* (Workers' Party), a Leftist party and the party of the current President of Brazil.

(††): Average total net income for farm: 2 married couples and their children, plus one adult sibling, and their mother all live together on the farm (total of 6 adults and an unspecified number of children).

(‡): Estimated average gross monthly income from 2003; net income information not available.

(§): Estimated average gross monthly income from 2001-2004; net income information not available.

Table 3.2. Farm descriptions.

Farmer ID	Dist. from BH (km)	Farm status	Farm area	%area in production	Pesticides used*	Fertilizers used	Crops	Animals	Ants collected?	Employees
001	36	Owns outright	29 ha	70%	None	LF, GM, ChkM, CowM, NPK 25-0-20	2007: L, CY, SC, CB, BR (5) 2008: Y, CB, BE (3)	Cow, horses	Yes	15
002	36	Owns outright	NS	NS	Cuaé 40, Veciso, Cal 40, Karaté, Monsat, Atraqual, others	OV	L(1)	NS	Yes	NS
003	~36	NS	9	50%	None	None	L (Bst, LL, Ib), CY, EN, BE, BR, CR, CO, CF, M, W, S (11)	None	No	Yes (number NS)
012	112	Rents	12	80%	Veciso, Monsat	OV	L, BR, CY, A, K, R, M, others (~7)	Pigs, turkey, chicken	No	1
059	~34	NS	5	100%	Roundup	Peat substrate	L, A, K, BR, CF, T (seedlings) (6)	No	No	NS
064	~36	NS	0.01 ha	NS (100%?)	Yes (NS)	CowM	CO, P (2)	NS (none?)	No	NS
066	40	Interviewee is a share-cropper	4 ha	90%	Rarely used: Monsat, Orthocide, Folisuper (methyl parathion)	OV, ChkM, CowM	L, BR, W, S, M, A, R (7)	1 horse	No	1

Farmer ID	Dist. from BH (km)	Farm status	Farm area	%area in production	Pesticides used*	Fertilizers used	Crops	Animals	Ants collected?	Employees
075	~34	NS	1 ha	NS	Monsat, others	ChkM (only)	S, W (2)	NS	No	NS
078	~36	NS	9 ha	44%	Almost none: Mussarem, Fusilastes	GM, ChkM	L, CY, K, BR (4)	NS	No	NS
093	34	Owns outright	21	24%	As needed	ChkM, NPK 12-6-12, LF	L (Ib, Bst, LL, R), CY, BR (3)	Chickens	Yes	1 (share-cropper)
136 (2 sites owned)	34 / 36	Owns outright/Rents	0.5 ha/ 1 ha	~98%/ NS	Almost none (Roundup when necessary)	ChkM, CowM, HM, NPK 25-0-20	GO, P, CO, K, MT, BA, CH (7) / L (1)	None	Yes	3 share-croppers at each site
159	34	Owns outright	NS	NS	None (organic farm)	Manure (origin NS), compost	~15 (NS)	Chickens	Yes	2
175	34	Owns outright	(3.70 ha†)	NS	Monsat	OV, NPK, others	L, K, W, others (3+ total)	NS	Yes	Share-croppers (number NS)

NS = Not Specified. **Fertilizers:** CowM = Cow manure. LF = Leaf fertilizer. ChkM = Chicken manure. GM = Green Manure. HM = Horse manure. OV = Ouro Verde (brand). **Crops:** A = Arugula. BA = Basil. BE = Beets. BR = Broccoli. CB = Cabbage. CR = Carrots. CF = Cauliflower. CH = Chayote. CY = Chicory. CO = Cilantro. EN= Endives. GO = Green onions. K = Kale. L = Lettuce. (Bst, LL, Ib, R are Boston, Looseleaf, Iceberg and Red leaf lettuce varieties, respectively.) M = Mustard. P = Parsley. R = Radishes. S = Spinach. SC = Swiss Chard. T = Tomato. W = Watercress. Y = Yams.

(*): Names, based on interviews, may be inaccurately transcribed, colloquial or casual names rather than formal product names.

(†): Total farm area not specified. Area reported is area under production.

Table 3.3. Demographics of interviewed SMAB functionaries.

SMABista ID	Age	Sex M/F	Education Level	Race	Political Identification	Time with SMAB (yrs)	Salary*	Interview Date (mm/dd/yyyy)
602	42	M	Master's degree	Mixed	PT[†]	12	US$ 1,610/mo.	03/18/2005; Spring 2006
682	30	F	College grad.	NS	None/Centrist	1/2	NS	Spring 2006
693	37	F	College grad.	Black	PT	11	US$ 600/mo.	03/08/2005
697	36	F	College grad.	Parda (Mixed)	PT	~3	US$ 920/mo.	Spring 2005
699	32	F	Post-baccalaureate	NS	Leftist; no specific party	13	NS	04/21/2006

(*): Converted from reais, at R$ 1 = US$ 0.46 (as of November 7, 2008).

Table 3.4. List of SMAB programs under the office of Support for Basic Food Production. Number of service points, number of beneficiaries, and program start dates are shown. From Machado (2003).

Programas do Eixo da Produção

	Incentivo à Produção	
	Iniciado em	**Resultados em 2002**
Direto da Roça	ago/94	
Pontos de Atendimento		34
Beneficiários		250000 consumidores/ano
Armazem da Roça	out/96	
Pontos de Atendimento		1
Beneficiários		25000 consumidores/ano
Feira Orgânica	set/01	
Pontos de Atendimento		2
Beneficiários		5000 consumidores/ano
Hortas Escolares/Comunitárias	out/93	
Pontos de Atendimento		63
Beneficiários		25000 beneficiários/ano
Oficinas de Plantio em Espaços Alternativos	out/93	
Pontos de Atendimento		Vários
Beneficiários		
Pró-Pomar	mai/94	
Pontos de Atendimento		
Beneficiários		7000 beneficários/ano
CAM	mai/94	
Pontos de Atendimento		1
Beneficiários		8000 consumidores/ano

Table 3.5. List of SMAB programs under the office of Management and Regulation of the Market. Number of service points, number of beneficiaries, and program start dates are shown. From Machado (2003).

Programas do Eixo da Regulação

	Regulação do Mercado	
	Iniciado em	**Resultados em 2002**
Abastecer	1988*, foi reformulado em 1993.	
Pontos de Atendimento		23
Beneficiários		100000 famílas beneciadas/mês
Comboio do Trabalhador	1993	
Pontos de Atendimento		12
Beneficiários		35000 beneficiadas/mês
Cestão Popular	1995	
Pontos de Atendimento		22
Beneficiários		18708 famílias cadastradas
Feiras Livres	Desde a fundação da capital	
Pontos de Atendimento		52
Beneficiários		16000 famílias beneficiadas/mês
Feiras Modelo	jul/93	
Pontos de Atendimento		3
Beneficiários		3200 beneficiadas/mês
Mercado Distritais	Meados da década de 70	
Pontos de Atendimento		4
Beneficiários		9000/ famílias beneficiadas
Padaria Escola e	2000	
Cozinha Pedagógica		400 alunos/média mensal
Cesta Básica-SMAB	jan/95	Pesquisa semanal

Table 3.6. List of SMAB programs under the office of Promotion of Food Consumption and Nutrition. Number of service points, number of beneficiaries, and program start dates are shown. From Machado (2003)

Programas do Eixo do Consumo

	Incentivo ao Consumo	
	Iniciado em	**Resultados em 2002**
Alimentação Escolar	jan/94*	
Pontos de Atendimento		181
Beneficiários		159460 alunos do ensino infantil e fundamental
Restaurante Popular	jul/94	
Pontos de Atendimento		1
Beneficiários		4768 usuários/dia
Aliment.Entidades Infantojuvenis	set/95	
Pontos de Atendimento		232
Beneficiários		31672 crianças de 0 a 14 anos
Aliment. Abrigos e Albergues	mar/96	
Pontos de Atendimento		26
Beneficiários		962 beneficiários
Aliment. Portadores de Deficiências	mai/96	
Pontos de Atendimento		13
Beneficiários		1728 beneficiários
Agente Jovem	jul/00	
Pontos de Atendimento		18
Beneficiários		658 adolescentess
Prevenção e Combate à Desnutrição	jun/93	
Pontos de Atendimento		129
Beneficiários		7640 crianças, 2282 nutrizes e gestantes. Outros 1.102
Alimetação em Cac's	jun/93	
Pontos de Atendimento		9
Beneficiários		619 crianças e adolescentes
Assitência Alimentar à 3ª Idade	jun/95	
Pontos de Atendimento		29
Beneficiários		1135 idosos
Cestas Básicas	nov.1993	
Pontos de Atendimento		
Beneficiários		600 famílias carentes e 200 famílias desabrigadas (mê
Distribuição de Marmitex	nov.1993	
Pontos de Atendimento		
Beneficiários		300 pessoas/mês no período chuvoso (out. a mar.)
Educação para o Consumo	mai/93	
Pontos de Atendimento		1
Beneficiários		370 pessoas/mês

* Transferido da SMED para SMAB em 1994

APPENDIX A

Interview Guide

Script for Greater Belo Horizonte Area Farmers (English Version)

To the interviewee: Once again, thank you for your help in agreeing to this interview. Please remember that you can stop the interview at any time, and you don't have to answer any questions that you don't feel comfortable with. All information in this interview will be kept confidential, and you won't be identified in any public material without your specific prior consent.

Section 1 – Interview Background
Interviewee Study Number/Name: Sex:
Interview Date: Location:
Status of Farm: Own Title Outright / Own with Partner(s) / Bank Title / Without Title / Farm Worker Only / Other
Location of Farm (Municipality):
Size of farm:
Amount in active production (on average, % or area):
Distance from Belo Horizonte:
Time working as a Partner of SMAB (if applicable):
Age:
Formal Education Level:
Family Income/Wages:
Race:
Political Affiliation:

Seção 2 – Detailed Background

1. Where were you raised? (I.e. locale, and type: farm, city, rural town, etc.)

2. How did you come to be a farmer? How did you come to own / lease your farmland? (If the answer is not obvious, follow-up questions:)
How did you learn how to farm effectively? (Did you grow up on a farm? Did you learn to farm from your parents?)
Do you have other close friends or family who farm?

3. How long have you farmed?

4. How many employees/workers (if any) do you have?
And by activity:
_____planting _____harvesting _____handling _____selling

5. How many and which crops do you raise on your farm?
How long have you raised each of these?
Do you raise any animals? (If so, which?)
Have you grown any other crops in the past? If so, why did you stop?

Do you have any new crops you plan for the future?
Are there any plants you grow for special personal use or tradition – such as medicinal herbs, traditional remedies, cultural heritage, etc?

5. Do you use agro-ecological and/or organic farming methods? Would you say you are very, somewhat, a little, or not at all familiar with agro-ecological and organic farming? (*If answer indicates some degree of familiarity:) How did you come to learn about agro-ecology and organic farming?*
(If applicable:) What made you decide to use more agro-ecological and/or organic methods?
What agro-ecological/organic practices do you use? (I.e. Green manure, animal manure, homeopathy, "artificial" selection, special cultivars, agro-forestry, structural diversity, species diversity, integration of life cycle (i.e. waste recycling), integrated pest management)
Have you ever had problems with weeds, pests, infestations etc?
If so, how have you treated them? That is have you used pesticides, natural predators, agroecological/organic treatments, homeopathy or other methods, conventional (agro-toxic) or alternative methods?
(If not already clear): Do you use, or have you ever used chemical pesticides (agrotóxicos)? Chemical fertilizers?
If you've changed use of these (started/stopped), why?

6. Are you familiar with the topic of "biodiversity"? What do you think of it? (I.e. do you think it's useful on the farm, inherently valuable, difficult or easy to use, worth the trouble, helpful for conservation, etc.)

7. What is your opinion of the Brasilian law requiring you to set aside property for preservation of the Mata Atlantica? Is it worth it? Do you think other farmers view it as worthwhile?
That is, what do you think of the environment and native Atlantic Rainforest? Is it important to protect it? Is it useful to you as a farmer?
Do you have (or have you seen) any native animals or plants on your farm? Did you used to see more native animals and plants on your farm in the past?
Has there been a big change in the amount or quality of Atlantic Rainforest in your lifetime?

8. If you wouldn't mind sharing this information, what is your budget like? I.e. how much do you spend on inputs, labor, land, preparation, transportation, and sale?

_____Inputs _____Labor _____Land(payments?)

_____preparation and transport of products _____sales

How much of your income is based on the sale of your farm products?
Does food from your own farm compose a large part of your diet at home?

9. Do you have other work you or family members do to earn income?

10. (*If not already explained*): What inputs do you use on your farm? (Manure, green manure, other animal waste, fertilizers, homeopathic formulations, pesticides, biotechnology, natural predators, nitrogen-fixing bacteria?)
How have you changed any of your practices (types of crops, types of agriculture in terms of conventional/organic, types of inputs) during the time you've farmed, if at all?
What influenced these changes?

11. Are there any important influences on how you farm that I haven't asked about? Advice from relatives, friends?

Most especially, what is your relationship with local, state and federal government – that is, extension agents? State farm programs? Fome Zero?
Do you find the local, state, or federal governments helpful? Should they be doing more? If so, what?

16. Have you heard of Fome Zero? What do you think of the program? Has it had any affect on you (if not already clear)? What should be changed (if anything) to make it more effective?

Questions Regarding SMAB Partnership (when applicable)

1. Where did you first hear of the programs of SMAB?

2. What do you think its main purpose is?
Do you think it's fulfilling that purpose?

3. Is there any program or accomplishment of SMAB that stands out in particular to you as useful, valuable, or important? Why?
Is there something you think has not been very successful in regards to SMAB's programs?

4. Are you familiar with how SMAB started? (*If so*) What do you think the most important factor in getting it running was?
Is there anything right now you see as particularly important in making/keeping SMAB successful?

5. (*If a SMAB partner*) How long have you worked with SMAB?
Why did you decide to join? (*Prompt: Did involvement with any other groups lead you to the programs?*)
Has this partnership been successful, in your opinion? (I.e. good for you, good for the consumer, and good for society?)
What has helped make it successful?
What has kept it from being more successful?
Do you know anyone else who has a partnership with SMAB? If so, do you think it's been beneficial for them? Why/why not?
Are many local farmers aware of SMAB? How do you think they, in general, view SMAB and its programs?

6. Have you started doing anything differently as a result of working with SMAB?

7. Are you a member of any other organizations? (I.e. rural unions, farmers' associations, co-operatives, agricultural technology/extension programs, academic programs?) More broadly, political organizations, community groups, church, local government?
Do you interact much with other local farmers (method/idea/experience exchanges, mutirãos, cooperatives, communal transportation for sale, etc.)?

8. What would you do if the partnership programs with SMAB stopped? (*I.e. would you try to join a farmer association or find a way to continue selling direct in BH?*)

9. Is there anything in SMAB in general you would like to see change in the future? Why?

10. Is there anything specifically in your partnership with SMAB that you would like to change?

11. Have you ever felt SMAB has treated you unfairly or dishonestly? Have you heard of them behaving inappropriately with anyone else?

12. Have you heard of the concept of *cidadania alimentar*?
If so, what do you think of it? (i.e. is it a good concept, is it a useful idea, has it helped make SMAB more effective?)

13. How would you describe your relationship, on a person-to-person level, with SMAB?
Prompt: Do you regularly see members of SMAB? Do you feel there is a lot of trust in your relationship with SMAB? Would you say you consider any of them your personal friends? Do you see them outside of SMAB partnership-related work?
How does this compare to your relationships in other organizations (if applicable; i.e. rural unions)?

14. How important have these personal relationships been in making the partnership work, and in helping SMAB's programs work?

APPENDIX B

Interview Guide

Script for SMAB Food Policy Administrator/Staffer

To the interviewee:
Once again, thank you for agreeing to this interview. Please remember that you can stop at any time, and you may refuse to answer any questions you are not comfortable with. Some questions ask your personal evaluations of co-workers and of SMAB; all information will be kept confidential and you will not be identified in any material without your specific prior consent.

Section 1 – Interview Background
Interview Name:
Interview Date: Location:
Interviewee Title: Organization:
Time with Organization: Age:
Political Affiliation/Identification (Party/Left-Right Spectrum):
Education Level:

Section 2 – Private/Public Synergy, Policy Entrepreneurs and Associative Networks

1. What do you consider to be the primary purpose(s) of SMAB?
Do you think it is fulfilling that purpose?

2. In general, what would you consider SMAB's greatest accomplishment? Please explain why.
Area where it has had the least success? Please explain why.

3. What do you consider to have been the most important part contributing to SMAB's creation and success(es)? Can you explain why?
Prompt: Is there one specific person or resource that stands out as having been most crucial to SMAB's creation and success? Can you explain why?

4. Considering SMAB's partnerships in general, who would you say has been most important to making SMAB function?
Specifically, as far as other government agencies, who is/are SMAB's most important partner(s) (past or present)?
In agricultural production, who is/are SMAB's most important partners (past or present)?
In the area of nutrition?
In the area of distribution of food?

5. Specifically, what do you consider to be the main goal of SMAB's partnerships?

6. How would you describe SMAB's partnerships in terms of how and why they have been effective or failed to be effective? (Do any (2-3) partnerships stand out in particular for their success or lack of success?)
What would you change to make a difficult or unsuccessful partnership improve? (What would you have done differently, if anything?)

7. Thinking of what you consider to be the most successful partnership(s) SMAB has had, how did these partnerships develop?
How have they contributed to SMAB's success?

8. What new partnerships would you like to see in the future? (*Why?*)

9. In comparison to your views, how do you think the public sees SMAB? Clarification, if needed: How well known do you think SMAB's activities are?
How do you think the average citizen feels about SMAB?

10. Are you a member of any Associations, Sindicatos, ONGs, etc? Which and how active are you (i.e. holding office and/or # of hours per week)?
How would you say this relates to your work at SMAB, if at all? (That is, has participation in an organization changed your views or how you do your job at SMAB?)

11. Describe *cidadania alimentar*.
Do you think the idea of *cidadania alimentar* is useful?
Do you think the idea is "catching on" in Belo Horizonte? If so, has it helped increase SMAB's effectiveness? How? If not, why not?

12. How have other governmental entities affected SMAB? (I.e. the state and federal governments)? Have they been helpful? Neutral? Hindering?

13. How have international organizations and agencies affected SMAB and food security in BH? Not at all? Positively, neutral, negatively?

14. What factors do you think made the formation of SMAB possible?
Prompts: What role did the analysis of food security experts play at the time?
What role did government administrators have?
What role did the public awareness/sentiment around food security have?
How are these factors affecting BH and SMAB now?

15. How would you describe the personal relationships SMAB staff and administration has with its partners (farmers, distributors, and citizens)?
Prompt: Is there a lot of trust between SMAB and its partners? Respect? Would you say there are strong "informal" ties between partners and SMAB, such as close working relationships, friendships, and/or association outside of official business?

16. How important do you think these personal relationships and their strength are to SMAB accomplishing its goals?

17. Have you ever felt one of the SMAB partners was not behaving completely honestly or appropriately with SMAB? Has SMAB ever behaved inappropriately with a partner?

18. What kind of relationship do you see between food security and the environment?
Were you aware that the Atlantic Rainforest makes up (or made up) much of this region?
(If not already clear) Do you think that food policies can affect the environment in a positive way? Why or why not?

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CHAPTER 4

FOOD SECURITY POLICY AND THE MATRIX: ANT DIVERSITY AS A BIOINDICATOR ON LOCAL FARMS INVOLVED IN A COMPREHENSIVE CITY FOOD SECURITY PROGRAM IN SOUTHEAST BRAZIL

ABSTRACT

The effects of the agricultural matrix on native habitat fragments immersed in it have been well-established in the literature. The specific character of human activities can help or hinder biodiversity conservation in the larger landscape. The present work examines such effects on biodiversity through a case study of food policy and biodiversity in Belo Horizonte, Brazil and the surrounding landscape. Belo Horizonte, a populous city in Brazil's Atlantic Rainforest region, created a Secretariat of [Food] Supply in 1993 in order to guarantee the right to food. The Secretariat's comprehensive programs have had an unprecedented level of success in enhancing food security (access by all people to sufficient and appropriate food for a healthy and active lifestyle). The city's programs also connect it with local, small family farmers, implicating the role local food may play in landscape biodiversity conservation. I examined the Secretariat's possible effects on ant biodiversity on local farm fields and their adjacent forest fragments, using this as a response variable to test for a difference in matrix quality between four "SMAB" and three "non-SMAB" farms. Ant sampling on these farms between February-April of 2005 and 2006 indicated that participation in SMAB corresponds to higher ant species richness and abundance within farm fields, and higher species evenness within forest fragments, after taking fragmentation and matrix characteristics into account. These results were individually significant only before a conservative correction for multiple testing. Beta diversity, however, was significantly higher within SMAB fields, implying greater gamma (regional) diversity within SMAB fields than non-SMAB. Directionally, though not statistically, a number of other results also indicated greater diversity on SMAB sites. Taken together, the overall results of this study indicate there is a clear, if subtle, positive effect of participation in SMAB on biodiversity on partner farms. This study may be the first to so directly link food policy decisions with local benefits to biodiversity – showing the fundamental role that human activities within the matrix

and within a sociopolitical system at large have in affecting elementary ecological characteristics. Additionally, these results imply the possibility that appropriate action can simultaneously provide food security and biodiversity conservation.

KEY WORDS

Agriculture, agroecology, ants, Atlantic Rainforest, Belo Horizonte, biodiversity, bioindicators, Brazil, food security, matrix, political ecology

INTRODUCTION

Agriculture, biodiversity, sustainability and sustainable development

Even a cursory examination of the state of the world makes it quite apparent that food systems and agriculture have huge impacts on ecosystems, inextricably linking two of the most pressing current problems – global biodiversity loss and widespread food insecurity.[1] This is unsurprising, being that consumption of food is one of the most basic elements of all life, despite the 850 million people in the world who are nevertheless malnourished (Food and Agriculture Organization of the United Nations (FAO) 2006). Our (humans') copious use of space in the form of land area devoted to agriculture – approximately 40% of the earth's land surface – similarly affects the rest of the world's ecosystems, in large part by fragmenting "natural" landscapes (Ferraz et al. 2003, Stouffer et al. 2006, FAO 2007, Chappell and LaValle, in revision). Agricultural expansion into "natural" areas, and intensive practices within agricultural lands inimical to biodiversity (monocultures, heavy applications of pesticides and fertilizers, compaction from mechanization, tilling, and agriculturally-driven erosion) have made agriculture a major driver in the worldwide biodiversity crisis, characterized by rates of species loss estimated to be anywhere from hundreds to thousands of times greater than the normal "background rate" (Hanski et al. 1995, Pimm et al. 1995, Benton et al. 2003, Tscharntke et al. 2005, but see Ibáñez et al. 2006).

At this point, to understand the stakes and present situation in terms of biodiversity loss and food security, it is necessary to point out several relatively recent realizations in ecology and food systems that fundamentally change the conception of the relationships between food, agriculture and conservation. That is to say, the modern understanding of food security and agricultural expansion beyond Malthusianism and Neo-Malthusianism, the surprisingly high rates of biodiversity loss within reserve systems and their lack of species coverage, the role of land outside of reserves in conserving biodiversity, and the production and conservation potential of alternative agriculture.

In terms of food and agriculture, perhaps the most important thing to note is the relatively conclusive refutations of widespread or simple Malthusian mechanisms within the food system and human-caused environmental degradation. The basic Malthusian/Neo-Malthusian hypothesis that populations inexorably outgrow their food resources (and thus undermine or destroy their environment) has been shown again and again to be at best a quite dramatically oversimplified relationship, and far more often has been empirically incorrect. The widespread hunger seen in the world – 850 million malnourished people, and a total of two billion people with micronutrient deficiencies – is not a simple consequence of population growth worldwide or even within countries (Sen 1994, United Nations Millennium Project (UNMP) 2005, FAO 2006). Indeed, there are more than enough calories available on an average per capita basis – 2,800 calories/person/day in 2003, according to the most recent available FAO statistics (FAO 2007). Overwhelmingly, widespread hunger has been linked to poverty, political or structural problems, and other exigencies, and seems to only rarely occur due to an actual acute lack of food availability (Drèze and Sen 1989, Patnaik 1991, FAO 2006, Chappell and LaValle, in revision).[2] Conversely, agricultural expansion often, if not usually, occurs due to economic forces that have no necessary relationship with overall population growth, but rather depend on within-landscape migration of agricultural laborers, profit motive, and agricultural intensification (Angelsen and Kaimowitz 1999, 2001, Sloan 2007, Perfecto and Vandermeer 2008). The two classic studies by Angelsen and Kaimowitz led to the conclusion that agricultural intensification – increasing yields per unit labor or unit capital – is strongly correlated to greater deforestation, one of the most significant threats to biodiversity stemming from agriculture. Without regards to Malthusian mechanisms of population growth or local food demand, such intensification was found in most cases to encourage in-migration of new farmers and workers and expansion of pre-existing farms due to the increased economic incentive to clear more forestland in order to take advantage of successful high-yielding practices. An extreme form of this phenomenon can be seen in the unfortunately far-from-unique *New York Times* headline from 2002: "Poor in India starve as surplus wheat rots," (Waldman 2002). In this context, analyses of the food security needs of the growing human population must be seen in a different light, especially the so-called "sparing land for nature" (or "saving land for biodiversity") approach (see i.e., Balmford et al. 2005, Matson and Vitousek 2006). Given the present (and projected – see i.e. Alexandratos et al. 2006, Badgley et al. 2007) bulk availability of sufficient food for the world population and the side-effects of certain approaches to intensification, agricultural expansion and related biodiversity loss would appear not to be an inevitable result of increasing demand, which has long been unmoored from population and hunger by profit motive and poverty, but rather the counter-

intuitive and inimical result of the conventional intensification approach called for by the "sparing land" argument. This is not to say that human population has no relationship to biodiversity loss, but considering the data presented, the widely varying amounts of total per capita resource use throughout the world, and the truly complex dynamics underlying population size and agricultural methods it is clear that population per se, especially as mediated through food security, hunger, and agriculture, has a tenuous and inconsistent relationship with biodiversity (Harvey 1974, Vandermeer 2008, Chappell 2009, Chapter 2).

The second point comes from studies of the past 10-20 years showing that even very large contiguous reserves may show startlingly high rates of extinction (at least within avian and mammal groups) (Newmark 1995, Brashares et al. 2001, Ferraz et al. 2003, Perfecto and Vandermeer 2008). In accordance with pre-existing theory, smaller reserve size has generally been correlated with higher extinction rates and decreased species richness, though quite likely not for the reasons classic island biogeography predicts (Fahrig 2003, Laurance 2008). But the implication of these studies nevertheless remains that even a successful strategy of large reserves may not accomplish the underlying goal of conserving biodiversity in the long, or perhaps even medium-term. Depending on how one looks at it, the further realization that even extremely large reserves capture a very limited portion of overall biodiversity in a landscape implicates either further problems yet, or the need (and possible viability and potential of) alternative approaches. To whit, recent studies show that the majority of the world's organisms exist outside of protected areas. Studies estimate that the 7% of Kenyan land in its National Parks still leaves 75% of the wildlife outside the parks (Western 1989, Baskin 1994); Rodrigues et al. (2004) estimate that although ~12% of the earth's land surface was nominally in protected areas, 13% of the almost 12,000 vertebrate species they studied were not contained in any of them, while the coverage for 74% of the species did not meet its targets and approximately 90% of threatened and endangered species had no or insufficient coverage. Ferrier et al. (2004) further extrapolated that 43% of all terrestrial plant and invertebrate species existed outside of protected areas. And regardless of the coverage, or lack thereof, for these taxa, Vandermeer et al. (2008) argue that if one is concerned with the majority of the world's species, the coverage of large reserves by their very design will miss a larger portion of species than the same total area spread out in a series of smaller reserves. This is because most of the world's animal species (and its millions of species of plants) are not in the hallowed group of so-called "charismatic megafauna", who (uncharitably) could be called conservation's poster children. Rather, the great majority of animals belong to less charismatic groups such as invertebrates – hence the classic quote of Robert May to the effect that to a first approximation, all animals are insects. In contrast to the so-called charismatic megafauna, the

estimated 1 to 30 million species of insects in the world tend to have much smaller ranges, and may thus be more amenable to such a "small reserve" approach than the 4,000 or so species of mammals, with more effective publicity and larger ranges.

However, as we are additionally reminded by Vandermeer et al., it is very important to not divide the world so simply into protected areas to conserve biodiversity versus everything else, where anything goes. For one thing, what happens in each area affects the other – quite tellingly in the case of agriculture, where intensive practices can lead to off-farm effects that damage the surrounding environment and human health. Perhaps the best known examples here would be the infamous secondary reductions in biodiversity represented by eutrophication and "Dead Zones" where the capability of an entire ecosystem to support life has been undermined (Pimentel et al. 1992, Steingraber 1997, Tilman et al. 2002, Devine and Furlong 2007, Scavia and Nassauer 2007, Tonitto et al. 2007). Secondly, it has been well established that what happens in the matrix – the areas surrounding "natural" habitat fragments, such as farms and pastures situated around fragmented forest areas – strongly influences the ecology within such fragments, in a large number of potential direct and indirect ways (including, but not limited to, changing microclimates, edge effects, migration through the matrix, population subdivision and access to resources – see i.e. Hansen and Rotella 2002, Dunford and Freemark 2004, Kupfer et al. 2006, Stouffer et al. 2006, Hansen and DeFries 2007, Perfecto and Vandermeer 2008, Vandermeer et al. 2008). This is perhaps most dramatically shown in the study of Brashares et al. (2001), where the classic species-area models predicted extinction rates in six reserves in West Africa 14-307 times below the empirically calculated rates. However, by taking human demography and land/resource use into account along with reserve size, 98% of the variation in extinction rates between reserves could be explained. On the other hand, a high quality matrix – i.e., agricultural land managed such that it is more similar to the native ecosystem – may very well function in the way that corridors were expected to function, decreasing patch isolation and potentially leading to higher levels of biodiversity in both the desirable "pristine" habitat fragments and in the agricultural system itself (Hanski 1999, Fahrig 2001, Ricketts 2001, Vandermeer and Carvajal 2001, Kaiser et al. 2008, Perfecto and Vandermeer 2008). Additionally, the biodiversity of more "traditional/alternative" (as opposed to conventional/industrial) agricultural systems has been shown to be similar to that of intact fragments in agroecosystems with jungle rubber, coffee and cacao plantations, and other ecosystems (Andow 1991a, 1991b, Gouyon et al. 1993, de Jong 1997, Matson et al. 1997, Perfecto et al. 1997, Moguel and Toledo 1999, Griffith 2000, Joshi et al. 2002, Armbrecht and Perfecto 2003, Gouyon 2003, Donald 2004, Schroth et al. 2004). Interestingly, a number of recent studies have shown that, at least for some taxa, the total

percentage of the landscape under organic agriculture and other characteristics of the overall surrounding matrix may matter as much or more than land use directly adjacent to native fragments, or even the size and separation of individual patches (see i.e., Conti Nunes and Galetti 2007, Billeter et al. 2008, see i.e., Holzschuh et al. 2008, Rundlöf et al. 2008). The finding that landscape characteristics at the level of hundreds of meters or even many kilometers has such strong effects on local patches of biodiversity is a perhaps surprising one, but it also further highlights the importance of regional planning and support for more broad-scale efforts to address biodiversity in agroecological matrices. The landscape containing endangered and/or biodiversity-rich areas must be treated as a coherent system, and not as pockets of biological interest or natural purity surrounded by ecologically uninteresting or inconsequential human activities.

On the other side of this coin are the effects of natural systems and biodiversity on agricultural areas. Briefly, natural areas and native biodiversity offer a variety of what is now commonly called "ecosystem services," natural processes and products that provide helpful or necessary functions to humans (Costanza et al. 1997, Daily 1997), although natural systems can also pose challenges to agricultural systems in the form of potential sources for pests and disease organisms. Nevertheless, one possible ecosystem service that biodiverse and natural systems may provide agriculture is "insurance" – additional temporal and spatial sustainability from redundancies and resiliencies in the ecological responses and functions of a biodiverse system (see i.e., Holt-Giménez 2002, Hooper et al. 2005, see i.e., Pimentel et al. 2005, Tscharntke et al. 2005, Kibblewhite et al. 2008). Lacking "insurance", systems that are intensified and simplified may be much more dependent for yield and profit on an "optimized" environment – that is, dependent on high-input, irrigated, fertile zones free from disease, rather than adaptable or adapted to local or changing conditions in any given agricultural area (Ceccarelli et al. 1996, Witcombe et al. 1996, Tilman et al. 2002). An extensive consensus review by Hooper et al. (2005) concluded that, despite certain caveats and systemic idiosyncrasies, "more species are needed to insure a stable supply of ecosystem goods and services" over larger areas and time periods. They had "high confidence" that certain species combinations were complementary (meaning that they could increase productivity and nutrient retention as compared to a less diverse system), that under similar conditions, susceptibility to invasion by exotic species was generally lower with higher diversity, and that having a range of species with different responses to disturbance can help increase stability, despite their conclusion that the exact relationships between biodiversity and different ecosystem properties required significantly more research. However, in addition to possible "insurance" from biodiversity, natural and biodiverse systems

offer a number of other ecosystem services, including but far from limited to erosion control, groundwater and nutrient retention, carbon sequestration, pollination, pest control, nutrient recycling, climate regulation, flood and drought mitigation, air and water remediation, and recreation and leisure (Costanza et al. 1997, Fraizer et al. 2001, Loreau et al. 2002, Vandermeer et al. 2002b, Tonitto et al. 2006, Tscharntke et al. 2007, Pretty 2008, Ricketts et al. 2008, Veddeler et al. 2008). In other words, careful planning of agroecological landscapes can potentially generate the always elusive "win-win scenario," benefiting biodiversity conservation while providing and serving a number of human needs. The potential of such a scenario is shown in recent literature, such as Badgley et al. (2007), where an extensive literature review found that alternative agriculture (a diverse set of practices that tend to incorporate and support higher biodiversity) may provide enough food on a caloric basis to feed the present and projected human population, and Chappell and LaValle (in revision), which details how such alternative systems may provide sufficient food, secure livelihood for farmers, and support higher biodiversity.

Putting Biodiversity and Food Together

Knowing that certain agricultural systems may be better for biodiversity than others, one question that immediately arises is what the characteristics of such systems are. Although this question has been amply explored from the perspective of specific practices, schemes, certifications, countries, regions, etc., what has not often been asked in the academic literature is whether or how systems supporting higher diversity may directly fit into local questions of food security. That is, much of the work by, say, agroecologists and conservation biologists in this area deals with sustainability of the systems in terms of empirical studies of the ecology of biodiversity-friendly practices (see i.e. Philpott 2004, Bengtsson et al. 2005, Billeter et al. 2008, Holzschuh et al. 2008, and the extensive review by Perfecto and Vandermeer 2008), with many social scientists, agronomists, and some agroecologists focusing on production potential in order to address poverty and bulk food availability (Tilman et al. 2002, Trewavas 2002, Fresco 2003, Balmford et al. 2005, Herring 2007, Zilberman et al. 2007, Veddeler et al. 2008). Typically, a much different literature analyzes the problems of food security where, for example, it has long been concluded that bulk food availability has little direct relationship to individual food security, especially among the poor (Sen 1984, Drèze and Sen 1989, Patnaik 1991, Rocha 2001, Badgley et al. 2007, Rocha 2007, Chappell and LaValle, in revision). The focus of this literature tends to be on policy instruments, social barriers and enabling factors of food security, looking not at production but the politics and principles of efficient distribution and healthful consumption. While work in this area spans scales (or even critiques the idea of scale itself – Born and Purcell

2006, Breitbach 2007), sub-regional analyses of food security and the problems individuals may face in obtaining food include important details missed in much of the yield- or profit-focused agroecological and agronomic works, where typically the production of more food marks success. Thus, although each of these focuses have provided important insights and innovations, I am unaware of any work to date that has put these bodies of work together, especially from an empirical standpoint. That is, to look at a local food system and its policy structures around food security, while examining practices and comparing biodiversity in the very same agroecological matrix that provides food for the local system. The present work attempts just such an integrative approach, through a case study of a system where a seemingly effective array of food security policies have been enacted that connect the food security of a city directly with the production of local farmers, who themselves are situated in a "biodiversity hotspot," the Atlantic Rainforest of Brazil.

Brief Site Background and Experimental Approach

The present work targets the interconnections between food security policy and biodiversity through a case study of Belo Horizonte, Brazil, a city of 2.5 million residents, and its local food system, situated in the "mega-biodiverse" Atlantic Rainforest-Cerrado (prairie) transition zone of southeastern Brazil. Belo Horizonte's government made access to food a right of citizenship, and in 1993 created the *Secretaria Municipal de Abastecimento* (SMAB) – the "Secretariat of [Food] Supply" – in order to guarantee this right. The Secretariat's programs have had an unprecedented level of success in enhancing food security – that is, access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle (FAO 1996, Aranha 2000, Rocha 2001, Chappell 2009, Chapter 3). One measure of their success has been the reduction of infant mortality and infant malnutrition by more than 50% since the Secretariat's start (Prefeitura Municipal de Belo Horizonte (PMBH) 2006, Alves et al. 2008). The city's programs also connect it with local, small family farmers situated in the city's periphery within the Atlantic Rainforest region, implicating the important role local food may play in biodiversity conservation. The uniqueness and relative recentness of these programs therefore provide a singular opportunity for a case study of a food system and its effects on biodiversity within an agroecological matrix and adjacent forest fragments.

In order to measure potential effects of the city program on local farms, and through them, the local agroecological matrix, I assessed the diversity (richness and abundance) of ant species on local farm fields and in their adjacent forest fragments, using this as a response variable to test a difference in matrix quality between farms that work with the Secretariat and

those that do not. Interviews with farmers both on farms partnering with the city and neighboring non-partner farms indicated that working with the city may have increased their income and financial security (Chappell 2009, Chapter 3). This, along with cultural/historical motivations and direct encouragement from the city government, seems to have led to a pattern wherein Secretariat partner farms either maintained pre-existing low pesticide use, cut down, or stopped pesticide use altogether, while in some cases increasing the diversity of crops grown – implying biodiversity/environmental quality should be higher on these farms. To test this, samples of ant biodiversity were collected using tuna baits on seven farms and their adjacent forest fragments.

METHODS

Site description and experimental overview

I collected samples of ground-foraging ant communities using tuna baits in 11 sites within seven farms located in the Mata Atlântica (Atlantic Rainforest) region located ~20-30 km to the Southwest (in six cases) and ~30 km Northwest (in one case) of the major Brazilian city Belo Horizonte, capital of the state of Minas Gerais. Samples were collected between February 22 and April 1 of 2005 and between March 9 and April 22 of 2006, corresponding to the end of the "Rainy" season in the region. The seven farms were owned by: 1) Dona Marta (two farms, DM at 20° 03' 53" S, 44° 09' 49" W, and another, DM2/DM-Citrolândia, at 20° 02' 26" S, 44° 12' 36" W); 2) Seu Ricardo (SR: 20° 03' 14" S, 44° 09' 10" W); 3) Seu Edmar and Dona Diana (SEDD; 19° 33' 57" S, 44° 07' 56" W); 4) Seu Henri (SH; 20° 03' 60" S, 44° 10' 12" W); 5) Os Santos (OS; 20° 02' 59" S, 44° 02' 51" W); and 6) Seu Herbert (SHB; 20° 03' 50" S, 44° 10' 37" W). Because the farmers were also interviewed about potentially sensitive information, their names have been changed to preserve confidentiality. All farms lie between 730 – 840 m in elevation and receive approximately 1500 mm of rainfall a year (Instituto Nacional de Metereologia (INMET) 2008). All farmers in the Atlantic Rainforest region are required by Brazilian law to keep 20% of their land set aside for preservation of any extant Rainforest fragments (Congresso Nacional do Brasil 1965); nevertheless, there were no fragments at two locations, it is possible that the forest in those sites had been cleared several decades earlier, before the law was passed. Farm production area ranged from 1 to 5 hectares. Samples were all taken during the Rainy season for consistency, with no sampling of diversity during the Dry season. However, ants are a perennial species, and at least one study in the Neotropics has found that there is little variation in ant abundance between rainy and dry seasons (Adis et al. 1987); seasonal effects on abundance and richness were not empirically tested per se in the present work.

At each farm, ground-foraging ants were sampled within an 8 m X 18 m plot in the farm

field not under active cultivation and, where present, in the interior of an adjacent forest fragment, using a grid of 50 tuna baits to attract ants (5 rows X 10 columns, 2 m separation between each bait). Ants were collected because of their common use as an indicator of biodiversity, the relative ease of quickly surveying ground-foraging ant communities, their ubiquity, and their sensitivity to environmental changes. Any given taxa cannot truly stand in for all others – the diversity between different taxa will inevitably not be completely correlated – but this is an unavoidable problem with biodiversity studies, where complete surveys of diversity require daunting resources in terms of time and labor (see the section "Ants as bioindicators", below). Tuna baiting was selected as it is a common method for quick surveying of ground-foraging ant communities (see i.e., Bestelmeyer et al. 2000, Delabie et al. 2000, Perfecto and Vandermeer 2002, Philpott 2004, Philpott et al. 2004). Each bait of 1-5 g of canned tuna was placed directly on the soil after clearing leaf litter or other debris. After waiting approximately 15 – 20 min, each bait was surveyed for the presence of ants, and 1-5 specimens of each species present was aspirated and placed into a vial containing 75% ethanol for later identification. (In some cases, the tuna bait itself was gone and no ants were seen; these samples were not counted since it was not possible to ascertain what ants, if any, had been present. Thus, some sites have a total of slightly less than 50 baits sampled.) In 2005, only four farms were sampled, two participating in SMAB (hereafter, "SMAB farms"), and two non-participants ("non-SMAB farms") – Sites DM & SR (SMAB), and SH & OS (non-SMAB). In 2006, two more SMAB farms were sampled in addition to DM & SR, DM2 and SEDD, and one additional non-SMAB farm was sampled, SHB. Sites DM and SEDD had no on-site forest fragments, and thus only have field samples.

All collections were identified to species or morphospecies in laboratory. Initial morphospecies identifications were conducted using guidance from Longino (2008); further identifications and corrections were made by Dr. Jacques Delabie at the Center for Cacao Research of the Executive Planning Commission for Cacao Farming (CEPEC/CEPLAC), Itabuna, Brazil. Although tuna baiting will only recover a portion of the total ground-foraging ant community, such baiting has been found to be effective for comparisons between farms in a number of studies, and directly recovered approximately 30% of the total diversity in one study on a rustic coffee farm in Mexico (Perfecto and Vandermeer 2002, J. Vandermeer, pers. comm.). When paired with rarefaction or other incidence- or abundance-based methods of extrapolating total community richness, baiting was shown to account for approximately 50% of the extant species in the sampled community (Delabie et al. 2000, although sardine, not tuna, was used by Delabie et al.). This is especially notable as many of the other methods outlined by Delabie et al. are much more labor and time-intensive than tuna baiting.

In this study, EstimateS (Colwell 2005) was used to produce resampling-based incidence rarefaction curves. Using EstimateS, a number of species richness and diversity measures were computed and used for analysis. After identification, vouchers of all species and morphospecies were deposited at the Laboratory of Myrmecology at CEPEC/CEPLAC.

The SMAB programs started in 1994, and the studied farmers affiliated with it have spent 14 years working with the program (since its start) in two cases (Seu Ricardo and Dona Marta), and something less than 10 years in the other case (Seu Edmar). Two non-SMAB farmers (Seu Henri and Seu Herbert) had little interest in joining the program, while one had applied but has thus far been turned down due to a lack of space for new members in the programs. Sites were chosen primarily by the willingness of farmers to participate, but all farms were similar in area, and except one of the sites, all were located in the same area southeast of Belo Horizonte (one SMAB partner farm, an organic farm, was located 30 km north of the city, still within the same transition region between Atlantic Rainforest and the Cerrado/Brazilian savannah region). All were primarily vegetable farms, growing mostly lettuce varieties, though some variously grew other vegetables such as spinach, broccoli, endives, arugula, beets, and carrots.

Social characteristics among the studied SMAB and non-SMAB farmers were broadly similar – all were small family farmers, meaning that at least 80% of their income came from farming or forestry-related activities, labor is primarily family-provided, and total property size is not greater than 30 hectares. One SMAB-affiliated farm was certified organic; one non-SMAB farm was experimenting with organic methods for health reasons and a possible future transition to becoming a certified organic farm; all other surveyed farms have no formal designation or certification as "organic" or related labels, and indeed seem to each base their farm practices on idiosyncratic perceptions of market conditions (what the consumers want, and what they will pay for it), family background, and personal ideals. (For a more complete discussion and analysis of the social characteristics, motivations, and differences between the farmers, see Chappell 2009, Chapter 3.)

Fragments of the Atlantic Rainforest on farmers' properties can be generally characterized as established secondary, closed-canopy forest, such that understory growth and light gaps are relatively rare in the interior of the fragments. Overall, the Atlantic Rainforest is widely described as being 90% deforested (Dean 1995, Critical Ecosystem Partnership Fund (CEPF) 2001, Saatchi et al. 2001), though it is possible that this is an overestimated as very small fragments that nevertheless may be ecologically significant may have been overlooked (J. Vandermeer, pers. comm., M. J. Chappell, pers. obs., Vandermeer and Perfecto 2007) (Figure 4.1).

The purpose of studying these sites was to examine whether or not participation in the SMAB programs by local farmers would produce a significant difference in the levels of ant biodiversity in their fields and the adjoining forests on the farmers' properties. It is reasonable to expect differences in biodiversity due to the fact that SMAB's programs are specifically aimed to supporting local small, family, and traditional farms. Such farms tend to use practices (such as low or no levels of synthetic inputs) that have been shown to provide a number of benefits to biodiversity as compared to larger farms using more intensive methods (Rosset 1999b, 1999a, Chappell and LaValle, in revision). In this way, "SMAB" vs. "Non-SMAB" farms may stand in as rough proxies for what has been referred to as "syndromes of production" (after Vandermeer (1997), and Andow and Hidaka (1989)). That is, sets of practices that may act together to optimize productivity – and may additionally support higher or lower levels of biodiversity – where different optimums may be reached using different sets. Thus, the pre-existing sets of "SMAB" and "Non-SMAB" farms of similar sizes and backgrounds, in same region, forms a sort of "natural experiment" or case study to examine whether providing greater local food security may have also led to differences in biodiversity within the local agroecological matrix.

Ants as bioindicators

The diversity and richness of arthropod groups has in the past been shown to be a reasonable indicator for general biodiversity and changes in agroecological habitat (Andow 1991a, Alonso and Agosti 2000, Vandermeer et al. 2002a, Armbrecht and Perfecto 2003, Buchs 2003b, 2003a, Butts et al. 2003, Duelli and Obrist 2003, Perner 2003), and in at least one example, ants alone constituted up to 15% of total of a rainforest's animal biomass (Fittkau and Klinge 1973, see also Figure 4.2). Ants also play a number of different ecological roles, are ubiquitous, extremely diverse (allowing the possibility of greater resolution of differences between sites than less diverse taxa), highly studied, and basic identification skills can be quickly acquired (Table 4.1). Additionally, ants in particular are of interest because of the extensive study of the ecologically interesting trophic interactions resulting from ants' predation on agricultural pests conducted in fragmented agroecological landscapes in Mexican rainforest/coffee systems (see i.e., Vandermeer et al. 2002b, Armbrecht and Perfecto 2003). More generally, ants are a classic bioindicator due to their sensitivity to changes in their environment, their ubiquity, and ease of catching and identification, as well as their successful correlation in some systems with broader biodiversity and/or ecosystem condition (Majer 1983, Allen et al. 1998, Peck et al. 1998, Allen et al. 2001, Andersen et al. 2002, Philpott 2004).

A number of studies broadly reinforce the use of biodiversity indicators, finding that correlations or models may provide reasonable estimates of species richness across taxonomic groups (see references at the beginning of this section, as well as Andersen 2000, Kaspari and Majer 2000, Mac Nally and Fleishman 2004, Schulze et al. 2004, Fleishman et al. 2005), in some cases based on as little as occurrence data of three indicator species. However, a number of critiques (see i.e., Lawton et al. 1998, Larsen et al. 2007, Billeter et al. 2008) as well as a review by Alonso (2000) provide a compelling case that the usefulness or robustness of indicator taxa in providing a picture of overall biodiversity is inconsistent and limited. Nevertheless, they may be useful for predicting levels of species richness in taxa with similar habitat or microclimate needs, taxa in disturbed habitats that share similar dispersal or colonizing abilities, and species in tight mutualisms. For example, diversity of certain plant species may correlate with ant biodiversity, as a number of ant species serve as seed dispersers and may influence plant diversity that way (Schultz and McGlynn 2000), and in one study, diversity of twig types strongly affected the diversity of twig-nesting ants, providing a significant correlation between species diversity in those two taxa (Armbrecht et al. 2004). The long history of ants as indicator species also provides ease-of-comparability with such studies, notably including a number of studies of diversity in agroecological matrices (Room 1971, Perfecto and Snelling 1995, Alonso and Agosti 2000, Delabie et al. 2000, Kaspari and Majer 2000, Armbrecht and Perfecto 2003, Philpott 2004, Clough et al. 2007, Silva et al. 2007), and when paired with the information recovered about land use and practices in the Belo Horizonte-area farms, the general predictive power of indicator species may also be increased (Billeter et al. 2008). The caveats discussed here mean that any results from this study must be considered as provisional and of limited value in predicting overall biodiversity in SMAB and non-SMAB farms, and would need to be confirmed by an expansion of the number of sites as well as measurement of other indicator taxa.

Data analysis

Fragmentation and Biodiversity

Species richness – the total number of species in a given area -- is only one measure of biodiversity. Although there are many ways to unpack biodiversity concepts, several other basic measures besides species richness includes evenness, the equality of numerical abundances between species in a community; functional group diversity; and functional group evenness, as well as a number of indexes designed to summarize site diversity, such as the Shannon-Weaver index, Fisher's α, and the Simpson diversity index.

In addition to these measures, which indicate species richness at any given site and time (alpha diversity), another measure of diversity is the turnover from site to site or time period to time period, or the differences in species identities between two sites or times (beta diversity). Beta diversity is often overlooked in applied ecological studies, despite the fact that it has been found to be the major component of biodiversity in some studies of agricultural systems (Clough et al. 2007). For example, one might study several sites and find 8 species in each one. However, at one extreme (high beta diversity), there may be no overlap in the 8 species of any site, meaning the total regional species richness is some multiple of 8; at the other extreme (low beta diversity) the exact 8 species are present at each site, meaning the regional diversity is also 8 species exactly (total regional biodiversity itself, dependent on both alpha and beta diversity, is traditionally called gamma diversity). Often, beta diversity is measured using similarity indexes, such that sites that are more similar represent lower beta diversity. One such similarity measure is Sorensen's index, which I will use here, that measures the amount of overlap between species at two sites, scaled by the total number of species at both sites:

$$(1) \qquad \frac{2c}{S_1 + S_2}$$

where c is the number of species shared in common between sites 1 and 2, and S_1 and S_2 are the number of species at site 1 and site 2, respectively. Sorensen ranges from 0 to 1, with 0 indicating no species in common – 0 similarity – and 1 indicating complete overlap, or 100% of the species in common. The dissimilarity of the sites can be found simply by subtracting Sorensen's similarity from 1.

There are, of course, pluses and minuses for each measure as well critiques of each within the literature (see i.e., Vellend 2005, Chao et al. 2006). In regards to alpha diversity, in order to minimize redundancy and unnecessary replication of analysis, Fisher's α and Simpson's index are reported, but not statistically compared between sites (see Table 4.2). To test the selected measures' differences between farms – the Shannon-Weaver index (H; Equation 2), species evenness (Equation 3), functional group diversity (using a modified Shannon-Weaver index, Equation 2) and functional group evenness (Equation 3) were regressed against a number of landscape characteristics reflecting the effects of fragmentation.

$$(2) \qquad H = -\sum_i^s p_i \ln p_i$$

where H is the Shannon-Weaver index, p_i is the proportion of species (or functional group) relative to the total number of species (or functional groups) S.

(3) $$E_H = H / \ln S$$

where E_H is the species or functional group evenness, H is the Shannon-Weaver index, and S is the total number of species in the community, i.e., the species richness.

Additionally, the total number of species incidences – how often all ant species were found on all the baits in a given site – was normalized to the total number of sample baits at each site, and this normalized incidence data was used as an approximation of ant abundance and compared between sites. (The data was normalized because of a small number of lost baits at several sites, and in one case collection was limited to 25 baits due to logistical limitations. Incidence data was used in place of individual abundance data, as foraging ants are effectively only a part of a full functional organism as represented by an entire ant colony; individual abundance and species incidence are thus both systematically indirect measures of the local effective population.) Evenness was derived from the Shannon-Weaver index calculated by EstimateS for each site, as was functional group evenness after manually computing the Shannon-Weaver index of the functional groups of the collected specimens (Equation 2). Functional group assignments of genera were based on Andersen (2000), and Brown (2000).[3] Although Shannon's H and evenness were calculated, such indices are likely unreliable as reflections of true diversity, as they are based exclusively on the actual species recovered by sampling, yet any one sampling method inevitably will miss some extant local species. As such, results from a single-method sampling effort of 50 baits as was used in my experimental design is highly unlikely to be represent complete census (Delabie et al. 2000). The program EstimateS calculates the classic measure of Shannon's H, but other measures, such as the species richness estimators Chao2 and ICE, use non-parametric methods to estimate total species richness at a site, or at least, the total richness of all species recoverable at that site using a given method such as tuna baiting (Chazdon et al. 1998, Longino et al. 2002, Perfecto and Vandermeer 2002, Petersen et al. 2003). Using EstimateS, rarefaction curves can be calculated showing the rate of accumulation of species versus number of samples collected, averaged among data sets representing randomizations of the original data (resampling). The shape of a curve representing the actual species collected can show how close the sampling effort has come to sampling all recoverable species; rarefaction curves of Chao2 and ICE show whether or not the predicted species richnesses have stabilized (in

Chazdon et al. 1998, ICE and Chao2 stabilized around 48 samples). Whether Chao2 or ICE reach an asymptote or not reflects the stability of the estimates, but their values nevertheless represent the best approximation of total species richness at any given point, and as such they were used preferentially over Shannon's H and other measures. The values used for comparisons were the values at the maximum sampling effort for a given site (i.e. usually 50 samples, but less in some cases such as the site with 25 baits as mentioned above).

Relationships between alpha diversity and abundance measures and collection and matrix characteristics (including participation in SMAB) were probed using linear mixed effects (LME) models in R (R Development Core Team 2008). LME models can account for variation through time or by group, making the method appropriate for the present study, where several sites were sampled over two different years (Garson 2008). Stepwise regression by backward elimination was used to compare goodness-of-fit and significance among models. Goodness-of-fit was determined by seeking the minimum values Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC), Log Likelihood (logLik), deviance, and Restricted Maximum Likelihood deviance (REMLdev), all calculated using the function *lmer* in R, part of the R package lme4 (Bates et al. 2008).

To begin each analysis, images of each site was recovered using Google Earth (Google, Inc. 2008) and coordinates recovered from each field site via GPS. These images were processed using the program ImageJ (Rasband 1997-2008), where the shade and similarity of the image pixels were used to detect and approximate the extant forest fragments in the landscape (see Figure 4.3). After re-rendering the pictures with a thresholding function (as shown by the second image in each of Figures 4.3, a-n), distances between fragments and field sites were recorded, and ImageJ's "Analyze Particles" function was used to recover area and perimeter data on all fragments greater than 1 ha in size. This last step was done in order to decrease the "noise" in the images, where unforested darker spots appeared as fragments after thresholding – most were well under 1 ha in size. Classic island biogeography theory would also rate these smaller fragments as being of minimal importance, though work since then has shown that is not necessarily the case (Hubbell 2001, Ricklefs 2004, Dick et al. 2008).

Following image analysis, a full linear mixed effects model was created based on the inclusion of the following measured fragment and collection characteristics: Collection Day (collday); Farm Site (farmlabel); nearest fragment distance (nearfrag; field only); nearest fragment size, for field sites, or size of sampled fragment, for forest sites (nefraarea); shape index – the ratio of the actual perimeter to the minimum possible perimeter for the same amount of area, i.e. a circle – of the nearest fragment for field sites, or of the sampled fragment for forest sites

(shapeind); total area of forest cover within a 2 km radius (loclforarea); total of all the fragment perimeters – i.e. total fragment "edge" – within a 2 km radius (localedge); number of fragments within 2km (numfrag); and number of tuna baits found with army ants (*Labidus coecus*) foraging on them (numarmy). (*L. coecus* can be a ravenous predator of other ant species, and can quite dramatically reduce local ground-nesting ant fauna as they spread through a landscape (Perfecto 1992, pers. obs.) Local ant communities may quickly recover, though the species present at the site and their relative abundances may be different versus the species and abundance levels previously seen at the same site (Kaspari and Majer 2000).

Linear mixed effects models take the form of

$$(4) \qquad y_{ij} = \beta_1 x_{1ij} + \beta_2 x_{2ij} + \ldots + \beta_p x_{pij} + \gamma_{i1} z_{1ij+\ldots+} \gamma_{iq} z_{qij} + \varepsilon_{ij}$$

where y_{ij} is the dependent or response variable for the *jth* observation in the *ith* year or group, $x_{1ij} \ldots x_{pij}$ are fixed-effect independent variables – variables that are consistent for an entire population or repeatable levels of an experimental variable, independent of the year of data collection, such as SMAB participation or fragment area, $\beta_1 \ldots \beta_p$ are the coefficients for the fixed-effects, expressing these consistent relationships between fixed-effect independent variables and the response variable, $z_{1ij} \ldots z_{pij}$ are the random-effect independent variables, or the variables representing idiosyncratic effects of individual experimental units drawn at random from a multivariately normal distribution – such as year or farm site, $\gamma_{i1} \ldots \gamma_{iq}$ are the coefficients for the random-effects independent variables, and ε_{ij} is the error term for the regression. For the variables analyzed, an example of this regression might be

$$(5) \qquad sppeven = \beta_1 * collday + \beta_2 * smab + \beta_3 * nearfrag + \gamma_1 * year + \gamma_2 * farmlabel + \varepsilon$$

where *sppeven* is species evenness, as explained previously, *collday* is the day of the year (i.e. number of days since January 1, essentially measuring the effects of the change in season from Rainy to Dry as it gets later in the year), *smab* is participation in the SMAB program (expressed as 0, non-SMAB, or 1, SMAB), *nearfrag* is the distance to the nearest fragment, *year* is the year (0 for 2005, and 1 for 2006), and *farmlabel* is the site identification, going from 1 (DM) to 7 (SHB).

Using stepwise regression, a model is fit and generated based on a mixed effects equation including all of the independent variables mentioned above, and then variables are removed one by one. For example, in Equation (5) – p-values are calculated for each coefficient (β and γ), and

then the likelihood that the coefficient is significantly different than 0 is calculated– that is, assessing whether or not a given variable has a statistically significant effect on the response, in this case, species evenness. To conduct the stepwise reduction, I removed the least significant term (i.e., the term with the highest p-value) and then reran the reduced model. This model's goodness-of-fit was then compared to the goodness-of-fit measures of the previous model; if removing the term increased the goodness-of-fit, the process was repeated. If all terms registered as significant at $p = 0.05$, terms were then examined for their practical significance – that is, whether the random-effects terms contribute notably to overall variance, and whether remaining fixed-effects' coefficients meant that the contributed realistically to the response variable. For example, if γ_1 in Equation (5) was equal to $6.0 * 10^{-1}$ while γ_2 was equal to $6.0 * 10^{-17}$, γ_2 was set to 0 (i.e., the *farmlabel* term was removed), and the model reran and compared to previous models. This process was repeated to determine the model with the best fit and most statistically and practically significant terms. In some cases, models were constrained such that SMAB participation remained in the model, even when it had lower statistical significance than other terms. In those cases and a few others, terms showing extreme significance were nonetheless removed, to compare goodness-of-fit measures among the models. (See Discussion for elaboration.)

Stepwise regression does raise the problem of multiple comparisons and the increased likelihood of Type I (false positive) errors; statistical corrections (i.e., Bonferroni) were made where noted. However, while it is true that such a correction must be made if the significance level of all tests being simultaneously true is to remain at $p = 0.05$, significance at 0.05 of individuals tests from "data mining" such as this can be useful to look for future and promising areas of inquiry.

RESULTS

Species Richness

A total of 72 species and morphospecies in 22 genera and 5 sub-families were collected from 11 sites across 7 farms and 4 forest fragments (see Appendix A). The sub-family accounting for the most species was by far Myrmecinae (40), followed by Formecinae (19), Poneromorphs (10), Dolichoderinae (6), and Ecitoninae (1). Using EstimateS (Colwell 2005), species rarefaction curves were calculated for each site for each test year, showing the accumulation of observed species versus individuals (Figure 4.4, Graphs A-F). From the figure, one can see that in 2005, the number of observed species calculated from resampling (Sobs) is leveling off only on the DM farm site (which had only a field sampling site, as there were no on-

site forest fragments), and in 2006 on the SEDD (another site with no fragments). The fact that the rarefaction curves do not level out at an asymptote means that the ant community detectable from tuna baiting was not completely sampled – meaning that further sampling would likely somewhat alter the results of these sites. However, nonparametric species richness estimators from EstimateS such as ICE and Chao2 can nonetheless be used to predict total richness of each site, and have been shown to be relatively robust measures in the prediction of species richness from this type of field study (Chazdon et al. 1998, Longino et al. 2002, Perfecto and Vandermeer 2002, Petersen et al. 2003) – though the large range for the Chao2 95% confidence intervals (shown as error bars) shows that the precision of the estimates does nonetheless suffer as a result (Figure 4.5, A-F). Pairwise comparison of final Chao2 values shows very few significant differences in that measure at the 0.05 significance measure (i.e. non-overlapping error bars). Neither 2005 nor 2006 data show significant differences between the estimated Chao2 species richness at any of the forest sites, with the mean Chao2 values predicting slightly greater richness in Non-SMAB forest sites in 2005 (OS > SH > SR) and extensive overlap between SMAB and Non-SMAB forest sites in 2006 (SR > SH > SHB > DM2 > OS) (Figure 4.5, C and F). In the field sites, 2005 shows overlap among SMAB and Non-SMAB species richness as well (OS > SR> DM > SH), with OS and SR having significantly higher richness than DM, while SH was not significantly different from any of the other three sites (Figure 4.5, B and E). In 2006, however, the three field sites with the highest diversity were all SMAB farms, followed in richness by the three non-SMAB farms, with a fourth SMAB field site having the lowest richness (DM > SR > DM2 > SH > OS > SHB > SEDD). The two richest sites, SMAB farms DM and SR, were significantly higher in richness than OS, a non-SMAB site, and SEDD, a SMAB site. DM2, SH, and SHB had significantly greater Chao2 richness than SEDD, but were otherwise statistically indistinguishable from the other sites.

Examining differences in species richness in sites using the ICE measure, permutation tests (resampling) using the Resampling Stats package for Matlab (Kaplan 2003, The MathWorks 2008) showed no significant difference between mean ICE species richness on the fields of SMAB farms and non-SMAB farms in 2005 (11.93 and 11.69, $p > 0.5$ for the difference between the means) or in 2006 (12.47 and 6.79, $p = 0.22$ for the difference between means). In forest sites, there were similarly no significant differences between the SMAB and non-SMAB means in 2005 (16.79 and 17.54, $p > 0.5$) or 2006 (21.80 and 20.07, $p > 0.5$). Pooling the data across years, neither the mean ICE species richnesses for the fields or for the forest fragments of SMAB and non-SMAB farms are significantly different (12.29 and 8.75, $p = 0.26$ for SMAB vs. non-SMAB field sites; 20.14 and 19.06, $p > 0.5$ for forest sites). Briefly examining other measures, in

regards to abundance (normalized species incidence) and functional group evenness, significant differences were found via resampling only in abundance data pooled across years for SMAB and non-SMAB sites (64.17 and 41.6, $p = 0.025$). Functional group evenness, pooled or tested separately by year, showed no significant differences.

In terms of functional groups, ants classified as Tropical Climate Specialists were by far the most numerous of any group. This is in large part due to the ubiquity of the fire ant *Solenopsis saevissima*, which was found at almost every site, usually in both the field and forest areas (see Appendix A and Figure 4.7).

Beta diversity

Given the arrangement of sites and sampling, several comparisons of beta diversity were made in order to evaluate the effects of partnerships with SMAB. (Beta diversity may vary depending on a gradient of environmental factors as well as from the factors of matrix and land-use discussed earlier – see Clough et al. 2007.) Beta diversity was compared in terms of the similarity within all SMAB farm fields versus similarity within all non-SMAB farm fields; similarity of ant species in farm fields and forests within SMAB and within non-SMAB farms; and temporal species similarity (species similarity at the same site in different years) for SMAB and non-SMAB.

Sorensen's indexes for comparisons of farm fields to farm forests are shown in Tables 4.4 and 4.5, and in Figure 4.6. The average species similarity in 2006 between SMAB farm fields was 0.207; between non-SMAB fields it was 0.496. Testing the significance of the difference between the two means (0.289) via resampling indicates that SMAB farm fields are significantly less similar to each other than non-SMAB fields are to each other ($p = 0.016$). The opposite was true in 2005: two SMAB farms sampled, DM and SR, showed a similarity of 0.526; the two non-SMAB farms sampled in 2005, SH and OS, gave a similarity of 0.316. However, since there was only one data point per category in 2005, no statistical testing was possible for the Sorensen similarity. Species similarity between fields and forests within SMAB farms averaged 0.237, and 0.125 within non-SMAB farms; the difference of 0.111 was not significant after testing with resampling ($p = 0.155$). Temporally, SMAB fields were more similar year-to-year than non-SMAB fields, but the difference was not significant (0.539 vs. 0.384, difference of 0.171, $p = 0.183$). Within forest sites, the temporal similarity as measured by Sorensen was slightly less within SMAB sites than non-SMAB sites (0.471 vs. 0.475), although the difference was not submitted to statistical testing either with only one data point for SMAB sites.

Regression models

Fragmentation and collection variables (independent variables) were fit against the five diversity measures: ICE, normalized species incidence (NSI), functional group Shannon-Weaver diversity index (F. grp. H), functional group evenness (F. grp. E), species Shannon-Weaver diversity index (Spp. H), and species evenness (Spp. E.). The fixed-effect independent variables for the number of fragments within 2 km, distance to nearest fragment, and number of incidences of army ants (*L. coecus*) were not found to be significant factors, i.e. $\beta_{numfrags}$ in Equation 4 is not significantly different than 0 (see Tables 4.6 and 4.7). Of the remaining factors – collection day, SMAB participation, nearest fragment area, shape index, local forest area, local edge, year, and farm site all showed significant or near-significant effects on a number of the diversity measures. No factor was significant or near-significant for at least one regression in one land type (farm or forest) but not in any regression in the other. However, fixed-effects independent variables significant for a dependent variable in one land tape were **not** necessarily significant for another – in fact, in no case did the best fit model in for field sites contain fixed-effects independent variables matching the best fit model for the same dependent variable in forest sites.

For farm fields, the coefficient for collection day was found to be significantly different than 0 (-0.217, $p = 0.049$) in regression of ICE, though neither of the two reported linear regressions in Table 4.7 were significant as a whole. When local forest area is included ($\beta_{lclforarea} = 2.31$, $p = 0.19$), collection day has a statistically significant effect on ICE, though the equation as a whole is not significant ($p = 0.11$). Removing the non-significant local forest area term, collection day's β decreases in magnitude from -0.217 to -0.177, but $\beta_{collday}$ also then becomes non-significant ($p = 0.091$); the overall p of the equation decreases to 0.092, but is still not significant. In both cases, a linear regression without random effects (year and farm site) best fit the data, despite their non-significance. The equation including local forest area and collection day could account for 28% of the variation in the data ($r^2 = 0.28$); eliminating local forest area, $r^2 = 0.20$. (Bonferroni correction for multiple sampling eliminates significance in these equations; with 13 models compared, the corrected significance level becomes $p = 0.0039$.) ICE for forest sites, however, shows no dependence on collection day. Instead, terms in the best-fit model included SMAB participation ($\beta = -13.37$, $p = 0.017$), shape index ($\beta = -0.689$, $p = 0.28$), local forest area ($\beta = -0.341$, $p = 0.0011$). As can be seen, only SMAB participation and local forest area had significant effects on forest ICE, and only local forest area was significant at the Bonferroni-corrected level. Examining the random effects from year and farm site, their reported values for variance (2.38 and 17.33, respectively) means, practically speaking, that once the

above fixed-effects are accounted for, there is a 12% intraclass correlation between ICE values taken the same year, and an 87% intraclass correlation between ICE values taken at the same site.

For field sites, NSI was only significantly influenced by SMAB participation ($\beta = 22.54$, $p = 0.021$), and was better fit by a model without random effects. The adjusted r^2 for the regression as a whole was 0.41, with $p = 0.02$ – meeting normal significance, but not reaching the corrected value of $p = 0.0028$. For forest sites, the best-fit model included six terms, achieving a high level of significance. However, like other regressions found with very high significance in the stepwise process, the number of terms is very close to the degrees of freedom and number of data points, meaning that the correlation is likely spurious. Examples of this can be found in Tables 4.7, but such results are almost certainly a statistical artifact, or at least, their significance is not confirmable without far more data than present here. Thus the specific values of β and other factors for forest NSI are not reported in Table 4.8, and will not be further discussed here.

Functional group diversity in the farm fields, as measured by the Shannon-Weaver Index (H), showed a significant relationship with shape index only ($\beta = 0.176$, $p < 0.001$), excluding all other fixed and random effects. Adjusted $r^2 = 0.73$, meaning that shape index accounted for almost three-quarters of the variation in functional group H. The overall p value for the relationship was also < 0.001, achieving Bonferroni-corrected significance ($p = 0.0028$). Functional group H in forest sites was significantly related to collection day ($\beta = -0.0076$, $p = 0.037$), with the random effect of year showing a 70% correlation between samples the same year, after shape index has been taken into account. At 0.037, the p-value for $\beta_{FxlGrpH}$ is significant at the traditional 0.05, but not after correction.

Functional group evenness (E) in farm field sites had highly significant terms for shape index of the nearest fragment ($\beta = 0.094$, $p < 0.001$) and local edge length ($\beta = -0.0037$, $p = 0.00561$), with an almost 50% of correlation between evenness and sample year after considering the fixed-effects. The shape index term is significant even after correction; local edge length marginally misses corrected significance ($p = 0.00556$). Forest functional group E is negatively correlated with collection day ($\beta = -0.0042$, $p = 0.013$) with the random effects from year showing a 75% intraclass correlation. At a corrected significance level of $p = 0.0046$, the fit regression of functional group E meets normal significance, but not the corrected value.

H for overall species biodiversity was correlated to collection day ($\beta = -0.013$, $p = 0.0026$) and shape index ($\beta = 0.221$, $p = 0.0057$) in field sites, with both year (~14% intraclass correlation) and farm site (~76% intraclass correlation) remaining in the best-fit model. Collection day was significant after correction; shape index was close to corrected significance ($p = 0.0050$). In forest sites, the regression with species H was significantly related to SMAB

participation ($\beta = 0.394$, $p = 0.043$), with local forest area remaining the in best-fit model, but not constituting a statistically significant term ($\beta = 0.268$, $p = 0.073$); year generated a 27% intraclass correlation. Neither fixed term was significant after correction.

Lastly, species evenness E in field sites was significantly related to shape index ($\beta = 0.0723$, $p = 0.012$) with year effects accounting a 20% of intraclass correlation. The fixed term for shape index was not significant after correction. In forest sites, species E was related to collection day ($\beta = -0.00193$, $p = 0.012$), SMAB participation ($\beta = 0.085$, $p = 0.013$), and shape index ($\beta = 0.0728$, $p = 0.013$), with year generating a 41% correlation after accounting for fixed effects. None of the fixed terms were significant after correction.

DISCUSSION

The number of species found (72) and their sub-familial makeup generally follows results from more intensive studies conducted elsewhere in the Cerrado and Atlantic Rainforest regions of the states of Minas Gerais and Bahia (Delabie et al. 2000, Ribas and Schoereder 2004, Ribas et al. 2005, Silva et al. 2007), though Delabie et al. point out in their assessment of sampling methods that using one method inevitably misses a significant percentage (on the order of 10-40%) of extant species. In the same edited volume, however, Bestelmeyer et al. (2000) observe that baiting is a good method for comparability. They note, though, the baits are most likely to attract trophic generalists, which constitute a significant portion of ant faunas worldwide, and are less likely to attract species with dietary preferences. Thus they may be useful tools for comparison, but can give very skewed data in regards to overall community composition.

However, despite the adequacy of 50 baits in collecting community data in some studies (see i.e. Chazdon et al. 1998, Perfecto and Vandermeer 2002), the fact that the site rarefaction curves reached an asymptote in only a couple of examples shows that the intensity of sampling was insufficient at most sites in order to reasonably estimate total ant species diversity. This is unsurprising in a region with such diversity, where intensive sampling of one site found over one hundred species (Delabie et al. 2000), and large-scale sampling found almost 200 (Schoereder et al. 2004). Nevertheless, while sampling intensity was insufficient to stabilize the rarefaction curves, ICE and Chao2, as total species richness estimators, represent the "best guess" at total diversity for a given intensity. As such, they can reasonably be used to compare diversity across sites, even if they do not represent an incomplete estimate of total diversity. Further sampling would be able to reduce the confidence intervals, and adding more farm sites (data points) would perhaps allow a stronger conclusion about effects from the SMAB program. But it is important to indicate that an evaluation of the present data in total points to a distinct, subtle "signal" of higher

biodiversity among SMAB sites, including what might be called "suggestive" signals from the non-statistically significant results among the initial results of the four data subsets (farm field and forest sites in 2005, and field and forest sites in 2006). Three of the SMAB sites showed higher average ICE, though if Chao2 is averaged, SMAB farms' average is higher in two cases (fields and forests 2005) and the non-SMAB farms' is higher in the other two (fields and forests 2006). More evidence of this "signal" of higher biodiversity on SMAB farms, including statistically significant results, is discussed below in the context of the linear mixed effects statistical model used to evaluate them.

Between the three independent variables that were not found to have significant effects on any response variable (number of fragments within 2 km, distance to nearest fragment, and number of incidences of army ants), perhaps most surprising on a superficial level is the lack of influence of *L. coecus* incidence. As mentioned previously, *L. coecus* is a very aggressive predator, and (like any disturbance) can significantly and differentially affect ant and other arthropod communities and species composition (Perfecto 1992, Andersen 2000, Kaspari and Majer 2000, Kaspari and O'Donnell 2003, M. J. Chappell, pers. obs.). In at least one case, an informal survey found a high degree of species turnover one day before and one week after a wave of them swept through a forest site (M. J. Chappell, unpublished data), though it is known that it can take a substantial amount of time for communities to recover richness and evenness after severe disturbance, and that ant species vary in their abilities to defend against or escape attacks from *L. coecus* (Perfecto 1992, Kaspari and O'Donnell 2003). All the more reason the lack of significant effects from *L. coecus* is surprising, though it is possible, if not likely that its presence at only three sites limited the signal recoverable from the data. The fact that it was only found at three sites may simply reflect the fact that it usually is reported as foraging underground, and that many army ant species forage at night, meaning that army ants may have been present or recently present at more sites but were simply not recruited to the tuna baits during collection.[4] (Kaspari and O'Donnell 2003 found that every square meter of tropical rainforest may see an average of 1.22 ± 1.11 army ant raids per day, including all species of army ants, not just *L. coecus*.) A larger and more systematic study of the effects of this and other army ant species in the Belo Horizonte region of the Atlantic Rainforest would be illuminating.

The lack of significance of distance to fragments in my results is possibly because of the limited data here as well, in that ten of eleven sampled sites were between 25 and 80 meters from the nearest fragment, with the remaining site located 280 meters from the nearest one. Although distance to fragments has been shown to effect diversity, Perfecto and Vandermeer (2002) found the most significant drop in species richness was within the first 20 m from a forest for a low-

quality matrix. Their results for a high-quality matrix showed that its species richness was statistically indistinguishable from that of the nearby forest, although a regression for species richness vs. distance from the forest did give a significant result such that distance appeared to account for almost 30% of the variation in number of species. However, their high-quality matrix system was agriculture in the form of rustic coffee, entailing organic production with 200 species of cover trees; agriculture in the low-quality matrix produced moderate-shaded to full-fledged sun coffee. My sites could possibly be classified as falling in a range of medium-to-low quality matrix, given that none of the sites had any tree cover whatsoever within the actively managed fields and in all cases, there was heavy disturbance (recent agricultural tilling) between the fragment and the sampled farm field site. However, most of my sites also saw little or no use of the biocides that were described as "routinely used" in the low-quality matrix in Perfecto and Vandermeer. Thus, as all of my field sampling was done at greater than 20 m from the forest edge, where a low or moderate-quality matrix might be expected to see the largest drop in species richness, the finding that distance from the forest fragment was not a significant factor may be consistent with these earlier findings (in a different agricultural system and country, it must be noted) by Perfecto and Vandermeer.

In terms of other independent variables tested by my statistical model, the number of fragments in a landscape has been seen to have an impact in several studies of fragmentation and matrix characteristics. However, it has been pointed out that several of the factors studied here – number of fragments, fragment size, distance between fragments, shape index, local forest area, and local forest edge length are all inherently correlated to one another, and thus effects seen from one in any study are likely to also be influenced by the others, directly or indirectly, whether or not they were found to be significant for the particular data set (Fahrig 2003, is an excellent review and critique of the fragmentation literature). This is doubly problematic in the present study, as linear mixed effects models assume independence among the terms; a high degree of correlation violates part of the foundations of the models. In the regressions, an effort was made to eliminate highly correlated independent variables early in the stepwise process, but besides the obvious relationships mentioned above, SMAB and collection day often showed surprisingly high correlations with the factors describing the physical matrix. It is possible that participation in SMAB is confounded with number of local fragments, for instance – that farmers working with the city program are more often located in a more (or less) fragmented area. However, there is no particular reason to think this is so, and it is, in the absence of further data, more likely that this is another artifact of small sample size.

Of the independent variables that did show significant effects on biodiversity measures, the most commonly seen were collection day and shape index. When significant or near-significant, collection day showed a consistently negative relationship with diversity measures, including ICE species richness, Shannon species diversity H, incidence/abundance, and evenness for both functional groups and species. It seems likely, then, that the transition from the rainy to the dry season indeed had a negative effect on ant activity – that is, it is highly unlikely species were going extinct as the season wore on but rather that the frequency and/or time of day of their foraging changed, such that the community of species responding to tuna baits between 9am and noon gradually shifted. Notably, however, significant effects of collection day were seen only in species richness measures in the field – H and ICE – while in forest sites evenness in functional groups and species decreased as well. On average, field sites showed lower species and functional group evenness and richness, meaning that they were more likely to be numerically dominated by a smaller number of species and functional groups. (Practically speaking, this tended to mean dominance by *S. saevissima*, in terms of species, and their functional group, Tropical Climate Specialists. Although such species in this functional group do tend to dominate sampling methods like tuna baiting, they would not necessarily differentially dominate in forests and fields if they were equally present.) Nevertheless, collection day presents another potential confound, and even though it may be partially compensated by taking account for it in the regression model, the sampling order of farm sites should be randomized in future study. It could also be compensated for by varying collection method and bait, following suggestions by Delabie et al. (2000), such as sampling at night, using mini-Winklers or pitfall trapping, and adding other food items such as seeds, honey, or peanut butter. Ideally, the efficacy of different methods would be tested, such that a compromise between the quite time and labor intensive Winkler and pitfall methods, and the incomplete sampling with tuna baiting used here could be found to optimize efficiency and broader or more consistent sampling of the extant community.

Shape index is an interesting factor; it had strong and statistically significant positive effects on functional group diversity and evenness in farm fields, even after Bonferroni correction, while it showed positive effects on species diversity and evenness in farm fields, which were significant at $p = 0.05$ but not after correction. Shape index has no apparent correlation with membership in SMAB, so its effect on these diversity measures should not be confounded with regards to the factor of SMAB. The fact that shape index had such a significant effect on functional group diversity and evenness perhaps implies that greater irregularities in the forest edge border, which would decrease circularity/increase shape index, may have created more microclimates between forest and field and thus more niches for ant functional groups to

occupy. If that were true, it would follow that more types (functional groups) of ant species would be capable of colonizing the matrix near the forest borders for some length of time, possibly long enough for the colony to reproduce and send out progeny to re-colonize inside the forest fragment, within the matrix, or in other forest fragments, leading to a dynamic like that described for higher-quality matrices in Perfecto and Vandermeer (2002) that sustains greater species richness in the landscape. A greater number of niches for functional groups would imply there also should be a greater number of species, which is weakly supported by the (uncorrected) significance of shape index's influence on Shannon's H and species evenness. These proposed mechanisms, however, are contradicted by the statistically significant, if smaller in magnitude, **negative** effect of local edge length on functional group evenness (though not functional group diversity). This is because edge length and deviance from circularity are correlated; as shape index increases, the amount of perimeter (edge length) for a given amount of area increases by definition. An explanation could be advanced – for example, that the edge microclimates create more habitat for a subset of the functional groups, decreasing evenness by increasing the environmental conditions favoring one or a few functional groups over the others – but the fact that this runs counters to the influence of shape index does not seem so easy to reconcile. It is possible that, as Fahrig (2003) warns, the underlying mechanisms in this study are tied up in both habitat loss and habitat fragmentation, although if the farmer interviews are to be believed, none of them have cut down any of the forest on their land (which would be illegal in any case). Perhaps the explanation does not lie in contradictory effects of fragmentation and habitat loss, then, but in contradictory effects of edge itself – Fahrig points to edge's possible positive effects on biodiversity like the higher interdigitation of habitats and thus an increase in "landscape complementation" where it becomes easier for organisms to move between different habitat types, as well as possible negative effects on biodiversity, which, besides disturbance, includes possible increases in predation on habitat edges as was seen on forest birds in a study by Chalfoun et al. (2002, in Fahrig 2003). Shape index, which is dependent on area and perimeter, may reflect different aspects of edge influence therefore than edge length itself, which instead reflected the negative effects of increased edge *per se*.

At a broader scale, other possible confounding factors in this study include tilling and other farmer practices, as the time since the last till, fertilizer and pesticide application wasn't known; such disturbances, especially tilling, can have profound effects on ant communities (Kaspari and Majer 2000, Clough et al. 2007). Indeed, observations of the farm sites during interviews and farm visits make it appear as if mechanical tilling is used at all sites, SMAB or non-SMAB, several times a season as most areas are continuously cropped and harvested several

times within one year. Pesticides are, with one exception, used sparingly according to farmer interviews at all of the sampled sites, and indeed, the organic farm which used neither synthetic pesticides nor fertilizers had the lowest ant diversity (4 species), although there are a number of possible reasons for the low diversity at that particularly site – i.e., it was the farthest from any forest fragments, it was possibly more aggressively tilled to compensate for the inability to use synthetic herbicides, and it was the only studied farm managed by someone who had not grown up a farmer. Despite these factors, SMAB participation was shown to have a (possibly) statistically significant positive effect on abundance (species incidence) within farm fields.[5] Within forest fragments, SMAB also had effects on species richness as measured by Shannon's H, and on species evenness, significant at $p = 0.05$ but failing significance after Bonferroni correction.

Even keeping the previous caveats in mind, however, beta diversity measures showed some clear results consistent with such positive effects of SMAB on alpha diversity (beta diversity measures were compared using resampling, obviating the need for statistical corrections like Bonferroni). The lower average Sorensen's similarity in SMAB fields vs. non-SMAB fields in 2006 means there is higher beta diversity between SMAB sites than between non-SMAB sites. The lower similarity within SMAB fields implies a greater gamma diversity (regional/overall diversity) within SMAB fields than non-SMAB, which translates to a broad-scale benefit of SMAB programs for biodiversity that is not detectable on the basis of a single individual site. And indeed, the raw numbers for gamma diversity bear this out: a total of 28 distinct species and morphospecies were recovered from SMAB farm fields, compared to 21 from non-SMAB farm fields.

As in the example given in the **Data Analysis** section, a region with multiple sites hosting 8 species and high beta diversity will by definition have greater total diversity than a region with the same number of sites hosting 8 species, but with the same 8 species present at every site. Said another way, if the practices on SMAB farms are indeed better for biodiversity, the results for beta diversity may reflect that a larger number of ant species are capable of establishing and maintaining colonies within the matrix represented by SMAB fields, for at least a short period of time (as opposed to a matrix of zero equality, such as a body of water in the original island biogeography model, where survival outside of habitat patches was 0; and as opposed to a matrix equal in quality to the habitat, where species can survive, theoretically, in perpetuity). Thus even if the same total number of species (alpha diversity) inhabit a SMAB and non-SMAB field at any given time, SMAB fields may be "better" temporary habitats, meaning that the species that are present are more abundant, and that the species in the matrix of two

different SMAB farms are likely to share less similarity than species in the matrix of two non-SMAB farms. Effectively, the SMAB farms may have a greater number of niches available. However, because none or few of these species can survive in the matrix indefinitely, there is constant turnover as different species capable of colonizing the matrix emerge from the forest and temporarily establish in a farm field. As a given colony of Species A dies out due to the unsuitability of the matrix for long-term habitation, the larger pool of species capable of replacing it means a higher probability a different species, Species B (or C, D, E or F), will come into the matrix to temporarily fill the niche vacated by Species A. Conversely, in a lower quality matrix as might be represented by non-SMAB farms, there may be a smaller pool of species, perhaps one made up in larger part by a smaller number of hardy or generalist species able to colonize non-SMAB fields, such that if Species A dies out in a non-SMAB field, the pool of species able to replace A only includes B and C, such that the species identities in non-SMAB areas shifts between A, B, and C while in non-SMAB farms it switches between Species A-F. That is, as each colony in the farm field dies out, a smaller possible pool of species to replace it means that each non-SMAB field will have a more similar complement of species than SMAB fields. This hypothesis is somewhat reinforced by the correlation between SMAB fields and higher ant incidence (abundance). The higher temporal similarity within SMAB fields may also support this, in that if species are able to survive for longer in SMAB fields, the year-to-year similarity within a given SMAB field may be higher than that within a given non-SMAB field. Of course, the converse mechanism would also be expected to be present, as it was in the measures of spatial beta diversity – a larger pool of possible species to colonize the field matrix would also imply lower temporal similarity within SMAB fields. However, as the results for temporal similarity were not significantly different, little can be gained by further speculation, although further study along new lines – such as sampling sites several times a season, or following specified colonies and noting their establishment, growth, and survival or death in order to test these hypotheses mechanistically and determine which of the two possible temporal dynamics is at work.

The field-to-forest similarity in terms of Sorensen's index implies a similar picture, though again the results are not statistically significant and therefore the fact that it follows an expected pattern for SMAB sites as a higher-quality matrix is suggestive but completely inconclusive. The higher level of similarity between forest species and field species in SMAB farms – 0.237 vs. 0.125 – is what we might expect to see if a larger pool of forest species was capable of colonizing SMAB field sites. If non-SMAB field sites are inhabited by a smaller number of species that are particularly hardy, generalist, or adapted to matrix conditions, the composition of non-SMAB fields may represent an assemblage more depauperate in terms of

representation from species from the local forest fragment. If forest specialists, for example, can survive for a short time in SMAB fields but not at all in non-SMAB fields, we would expect to see lower similarity between non-SMAB fields and forests than between SMAB fields and forests. This higher beta diversity – lower similarity – between non-SMAB fields and forests, if it were significant, could also simply represent lower alpha diversity in non-SMAB fields, as if it has a lower number of species, it by definition cannot share as many species with the more species rich forest sites. However, as alpha diversity in the fields was not found to be significantly affected in the regression analysis by SMAB participation, little specific can be determined in regards to this mechanism.

Species richness and evenness within the forest were found to (possibly) be affected by SMAB. This again implies that SMAB fields may be higher-quality matrices, allowing greater passage of ant species through them into the forest fragments, maintaining greater diversity and, possibly, greater evenness due to the persistence of less common, more specialist and more rare species supported by new immigrants from other fragments through the SMAB fields. These results are broadly consistent with what one would expect to see in higher quality matrices, as outlined, for example in Perfecto and Vandermeer (2002).

So, we have seen several suggestive, though not conclusive, lines of evidence that SMAB farms are better for biodiversity than non-SMAB farms. What, however, are the possible reasons for this? What practices are different on SMAB farms?

Farmer practices, SMAB, and matrix quality

We have already examined how the matrix can affect biodiversity in the introduction and in the results reviewed thus far. But what factors may be making SMAB farms a higher quality matrix?

In Chapter 3, I found that SMAB farmers may feel a greater sense of socioeconomic security due to their partnership with SMAB, and expectations and experiences of a stable market for their produce. Such security has been tied to the degree of care and the emphasis a small farmer may place on sustainability as opposed to farmers with less security who may "mine the land" agriculturally because of an unsure future. It is possible, therefore, that the better outlook and positive attitudes from SMAB farmers may be reflected in how they conduct their practices and the amount of care they take in cultivating their land, encouraging biodiversity in subtle and direct ways. For example, from the case of Dona Marta, not only did she diversify his crops,[6] but in her interview she said that she also cut down on pesticide use after she entered the program, "because we wanted to sell a much fresher, healthier product, so we are avoiding using pesticides

as much as we can. We hardly ever use it now." Some non-SMAB farmers also avoided pesticides, such as Seu Henri, who said he used hardly any pesticides and fertilized his plants with both animal manure and synthetic fertilizers, and who also diversified his crops in an attempt to entice consumers in direct sales and because he felt that lettuce farming had become too unprofitable. However, in this case, Seu Henri had stated his interest in direct sales, and one of the tentative findings of Chappell 2009, Chapter 3 was that not just SMAB farmers, but any farmers able to sell directly to consumers seemed to indicate a more positive outlook on their financial situation and their economic future. The one SMAB farmer with ready financial information also indicated an income that was above the average of five non-SMAB farmers, and within the median income for farmers in the state of Minas Gerais.

Strictly in terms of practices, overall synthetic pesticide and fertilizer use varied, with several non-SMAB farmers worried about their health and environmental effects or expressing aspirations to be organic, while the prominent SMAB farmer Ricardo seemingly used pesticides slightly more often than a number of the other farmers, who said they "hardly ever used it." (On the other hand, one non-SMAB farmer, Seu Herbert, said that he essentially used whatever pesticide he could get his hands on.) From on-site observations, it appears that all of the farmers tilled their soil, and occasional heavy rain contributed greatly to erosion. Only one farm used green manure; most used chicken manure, with cow manure being used by some as well. Also commonly used was "leaf fertilizer," that is, a synthetic fertilizer applied directly to the leaves in a spray, with the brand name *Ouro Verde* ("Green Gold"). However, both the former manager of SMAB's Incentives for Basic Production programs and the EMATER extensionist working with SMAB often quite clearly encouraged farmers to reduce synthetic inputs and move towards organic production.[7] An examination of the goals of SMAB makes it clear that addressing appropriateness in terms of sustainable/organic production is a key part of their approach to food security, although it is clearly also an area of difficulty for them, as they have neither jurisdiction nor staff in the rural areas around Belo Horizonte. SMAB relies primarily on Valdir Guimarães, an EMATER extensionist assigned to work with SMAB full-time, and he often drives the one car dedicated to the Secretariat's use to contact and encourage farmers to engage in sustainable practices. Guimarães does enthusiastically endorse alternative/organic agriculture in his interactions with the farmers, possibly contributing to the biodiversity-friendliness of their practices in ways that were not ascertainable during my interviews.

Given my observations, participation in SMAB has some aspects that support the possibility that it is an influence encouraging sustainable practices and therefore higher biodiversity in the agroecological matrix around Belo Horizonte. On the other hand, there are not

clearly or consistently defined differences between the two farm groups (SMAB and non-SMAB): all till, some use chemical inputs on both sides and some don't, some grow many varieties of vegetables, some sell fewer, and though it does seem that SMAB encourages diversification, some independent farmers have diversified for their own reasons. Limited staff and financial resources do not allow those within SMAB to encourage sustainable practices as much as they would like, or even disseminate information on such practices within SMAB itself such that functionaries in other sections and program areas can understand and buy into this thrust as well. A lack of effective dissemination of information to local farmers was indeed an incredibly consistent complaint within farmers, SMAB and non-SMAB, as well as several functionaries within SMAB. This fact notwithstanding, the attitude even among some non-SMAB farmers that pesticides are to be avoided or minimized is not terribly surprising when put into a larger context. Every farmer interviewed supported the Brazilian law requiring them to keep 20% of their land in Atlantic Rainforest, although interestingly, many felt that other farmers did not share their views or understand the importance of forest conservation. Almost all of them mentioned the essential nature of the forest fragments in maintaining their sources of water, with Dona Marta, and the non-SMAB Santos, pointing out that they had observed some streams drying up as development encroached into the rural areas and residential neighborhoods were built where forests used to be. The Santos were concerned that rapid development of their area into residential zones would affect the amount and quality of water they were going to be able to obtain, especially considering that pumping water for irrigation was, apparently, the largest expense in their budget (~R$1,400/month). The reasons the farmers supported the preservation of the Atlantic Rainforest usually started with its vital role in maintaining sources of water, but their concerns also extended beyond the ecosystem services it provided to them. Several expressed appreciation of the Rainforest as the patrimony of Brazil, or even explaining that it was simply necessary to conserve it, to protect the natural areas. For example, Seu Henri stated it rather simply: "It's a future, to leave it here… You have to preserve it, because of our children. So, we keep letting it be, we keep working, and we'll be leaving it for them." These general attitudes of the interviewed farmers align well with the findings of a survey of the Brazilian population in 2001 (Simões 2001). Simões found that Brazilians, in general, support preserving the environment and to varying degrees value it for its own existence and feel that it's worth an individual cost (i.e. higher taxes) to do so.

Given this backdrop of general support for conservation, and within this study, near-universal consciousness of the negative effects of chemical inputs, there seems to be a solid base to spread alternative and organic agricultural measures. All farmers cited guidance and

interactions from EMATER as being fundamental in both their understanding of how to use pesticides effectively and safely, from both courses offered by EMATER and site visits by extension agents, and often in how to reduce pesticide use or use agroecological methods. And it is this last item that could tentatively go farthest in explaining possible differences in SMAB and non-SMAB farms in terms of practices and biodiversity: participation in SMAB programs requires regular inspections of their farms by SMAB staff (usually Guimarães) to confirm that they are still meeting various SMAB production standards (these seem chiefly to do with proper food safety, storage and sanitary standards). However, a recurring comment in farmer interviews had to do with the increasing difficulties in engaging with EMATER –comments that it had become harder and harder to find and take EMATER classes, and that it was difficult to get extensionists to the farm promptly. Several observed that you can call EMATER if you have a problem, but you're not sure when they'll get there, and that until recently they were "everywhere" in the farmers' local areas. Now, one non-SMAB farmer said, he has no idea where to find them, that they're slower to come, that they will come eventually, but that there's a delay (this farmer's land was not sampled for ant biodiversity). This dovetails with the observation that EMATER itself appears to be going through a financial and staffing crunch; there was a perception among the Santos that the state was devolving responsibilities for EMATER to the local governments, such that it now depended on whether local mayors paid attention to the issues of the small farmers and dedicated resources to supporting EMATER agents for that region. The farmers' impression were that coverage was much more spotty now, and Nabuco and Souki (2004) confirm that "The Straight from the Countryside Program, after an expansion between the years 1994 and 1999, suffered a contraction between 2000 and 2003. This fact can be explained as a function of the decrease in the number of technicians [agronomists] contracted with EMATER." Although this contraction may have made things more difficult for SMAB, it also implicates a possible mechanism for better practices on SMAB farms: if EMATER is indeed pulling back, and it has become harder to get a hold of EMATER staff, it is possible that the fact that SMAB farms will nonetheless see an EMATER agent with some regularity, even though it's for regulatory purposes, serves as an additional support or opportunity to learn, implement, or maintain sustainable practices, as in my personal observations, not only is Guimarães passionate and knowledgeable about sustainable agriculture, but he also seemed willing to spend extensive time with the farmers discussing technical matters when he was there, to the point where he may miss later appointments. In contrast, organic agriculture is not an explicit priority of EMATER extensionists at large, but rather "a political strategy to fill a vague niche" (R. Matta Machado, pers. comm.). Thus, SMAB farmers' regular contact with Guimarães

in particular, who advocates for sustainable methods and seems willing to spend extra time socializing and advising farmers on an impromptu basis during his normal trips may be the mechanism for enhanced SMAB practices at a level that is not immediately apparent within their own descriptions of how they farm, nor to the casual or not-so-casual collector of ant biodiversity at their farm.

CONCLUSIONS

Taken together, the overall results of this study indicate that there is a clear, if subtle, positive effect of participation in SMAB on the biodiversity of farms in the Greater Belo Horizonte area. Although the results from the study are not necessarily completely consistent and may benefit from further study both in terms of intensity of sampling per site and in the number and scheduling of sites, the evidence relatively strongly supports the hypothesis of an effect from SMAB participation on the biodiversity in the matrix of the farms themselves, and within the forests adjoining the farms as well. Considering the regional proximity and observed similarities in agricultural practice among SMAB and non-SMAB farms, with little difference observed in factors like number of crops, tilling or pesticide use, it was actually quite surprising to see a signal of higher biodiversity on SMAB farms at all. That is, direct observation of the sites and casual conversations with farmers at each would lead to very little reason to suspect, *a priori*, that they would differ in biodiversity in any measure. As there were none of "usual suspects" in terms of major ecological drivers of biodiversity differences such as the agricultural practices listed above and discussed in Chappell and LaValle (in revision), nor enough regional separation that the fragmentation characteristics among SMAB and non-SMAB farms could be considered to be very different, it was indeed surprising to find as strong a signal as I did, even if it was a subtle one. In the meantime, this study may be the first to directly link upstream food policy decisions with local effects on biodiversity – showing the absolutely vital role a recognition of human activities not just within the matrix, but within a sociopolitical system at large has in understanding what could be considered straightforward and elementary ecological measures. Indeed, if the effect seen here is due to participation in SMAB, through SMAB's influence on economic security, the increased likelihood and regularity of seeing an EMATER extensionist, or both, a conventional ecological approach might miss the mechanisms at work if it focused only on factors within the landscape itself. But beyond this revelation, there is the intriguing and invigorating possibility that the SMAB programs, which have had some immense successes in development in terms of providing the basic human right to safe, adequate and nutritious food within the city of Belo Horizonte, has simultaneously led to enhanced biodiversity in the nearby

rainforest with a relatively small amount of explicit effort towards this goal. This is not to downplay the expertise or passion of some in EMATER and within SMAB for sustainable agriculture and conservation of the Atlantic Rainforest and its biodiversity, but rather the simple fact that those within SMAB have told me that they have not been able to concentrate on sustainability to the degree they would like, due to a lack of resources for this mission from the city, the contraction of EMATER's work in the countryside, the necessity for SMAB to emphasize food price and quality over environmental effects *per se*, and the lack of direct legal or statutory authority of the city on the surrounding countryside where the farmers are located. If it is possible to have even a small positive effect on biodiversity via a program that has been more explicitly targeted at providing food for the entire population of a city of 2.5 million people, the possibilities for truly sustainable development based on a more explicit approach and greater resources devoted to agroecological measures in the matrix are, to engage in the mildest of hyperbole, practically breathtaking. Despite the political problems rooted in elementary factors of governmental decision making (i.e. decision making in an "organized anarchy" where attention to problems and solutions varies without a simple, direct relation to the problems' importance or the solutions' feasibility – see Chappell 2009, Chapter 3), the possibility of providing food security and biodiversity conservation simultaneously contradicts the well-established common wisdom and widely accepted belief that human welfare and environmental conservation are, to some degree, inimical to each other. Along with important studies by Rosset (1999a), Vandermeer et al. (2008), Badgley et al. (2007), Ravnborg (2003), Breitbach (2007), and Sen (1984) to name a few, we are increasingly faced with the possibility that development that addresses the urgent needs of the many in terms of food and economic solvency, at least, can be addressed in ways good for the environment and good for social justice if some simple, though not easy, steps are taken. There is a responsibility, then, among ecologists and others who care about the environment to ally with concerned advocates for social justice and development to effectively study these possibilities and address barriers to implementing them. Embracing this responsibility is necessary for ecologists not only because we must do it if we are to effectively act to protect the ecosystems and organisms that we have devoted our lives to, but also because embracing the larger ecosystem, the "political ecosystem", is the scientifically honest thing to do.

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[1] In brief, food insecurity is used here to mean the lack of physical and/or economic access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle. See, i.e. the Rome Declaration on World Food Security and Plan of Action (FAO 1996). Under this definition, obesity should be equally considered a food security problem as hunger; it has joined malnutrition as an acute, widespread global problem (Tanumihardjo et al. 2007).

[2] Similarly, population growth itself is usually insufficient to explain hunger, generate acute food scarcity, and cause environmental degradation. I am in agreement with the conclusion of de Sherbinin et al. (2007) and propose that what they say applies not only to environmental degradation but to food security issues: "[M]onocausal explanations of environmental change that give a preeminent place to population size and growth suffer from three major deficiencies: they oversimplify a complex reality, they often raise more questions than they answer, and they may in some instances even provide the wrong answers."

[3] Functional groups as used here are defined by Anderson (2000) and Brown (2000) as "collections of species based on an amalgam of phylogeny, habitat, and microclimate." Further, according to Anderson:

> "Global community ecology requires the identification of functional groups that transcend taxonomic and biogeographic boundaries and vary predictably in response to stress and disturbance. Such groups have been identified for ants based on Australian studies (Greenslade 1978; Andersen 1995, 1997). There are seven such ant functional groups, and their major representatives in Australia and the New World are listed in Table [4.3]."

[4] In the early afternoon of a day in early October of 2004, I witnessed a column of what appeared to be *L. coecus* advancing from one forest fragment across a trail to another. Although this species has been described as nocturnal and subterranean, Longino (2007) observed that "Columns will also surface to cross hard-packed footpaths," a good description of my own observation. Tuna baiting the following week saw very, very low recruitment to the baits; two weeks later, there was a greater degree of recruitment, but the number of species observed was still a fraction of what was observed before the presumed raid by the army ants I saw that afternoon in the beginning of October.

[5] I call the effect "possible" because the result did not pass Bonferroni correction – meaning that the likelihood of this result, and all of the other significant results, being simultaneously true by chance is greater than 5% (i.e. $p > 0.05$). The result's failure after Bonferroni correction does not mean, however, that the chance of this particular result happening by chance is greater than 0.05; rather, due to Bonferroni's conservative nature, there is a greater likelihood of a Type III error (rejecting a true hypothesis) in order to minimize Type I errors (confirming a false hypothesis). Correcting the confound from multiple testing means that *some* of the hypotheses that pass traditional $p = 0.05$ significance but fail Bonferroni may be true, but it is not possible to determine which of the hypotheses, if any, are incorrectly rejected.

[6] "Planned biodiversity," or the number of different crops and animals a farmer rears, has been shown to be strongly linked to "associated biodiversity," – that is, all of the unplanned, "natural" flora and fauna on a farm and in nearby habitats. For most taxa, there is strong evidence that increased planned biodiversity correlates to increased associated biodiversity; see i.e., Vandermeer et al. (2002a), and Kibblewhite et al. (2008).

[7] EMATER is the *Empresa de Assistência Técnica e Extensão Rural*, or the State Company for Technical Assistance and Rural Extension.

Figure 4.1. The Atlantic Rainforest region and its remnants. From Critical Ecosystem Partnership Fund (CEPF) (2001). Original data sources: SNE, CI & Fundação Biodiversitas (1993), Fundação SOS Mata Atlântica, INPE & ISA (1998), and Fundação SOS Mata Atlântica & INPE (2002).

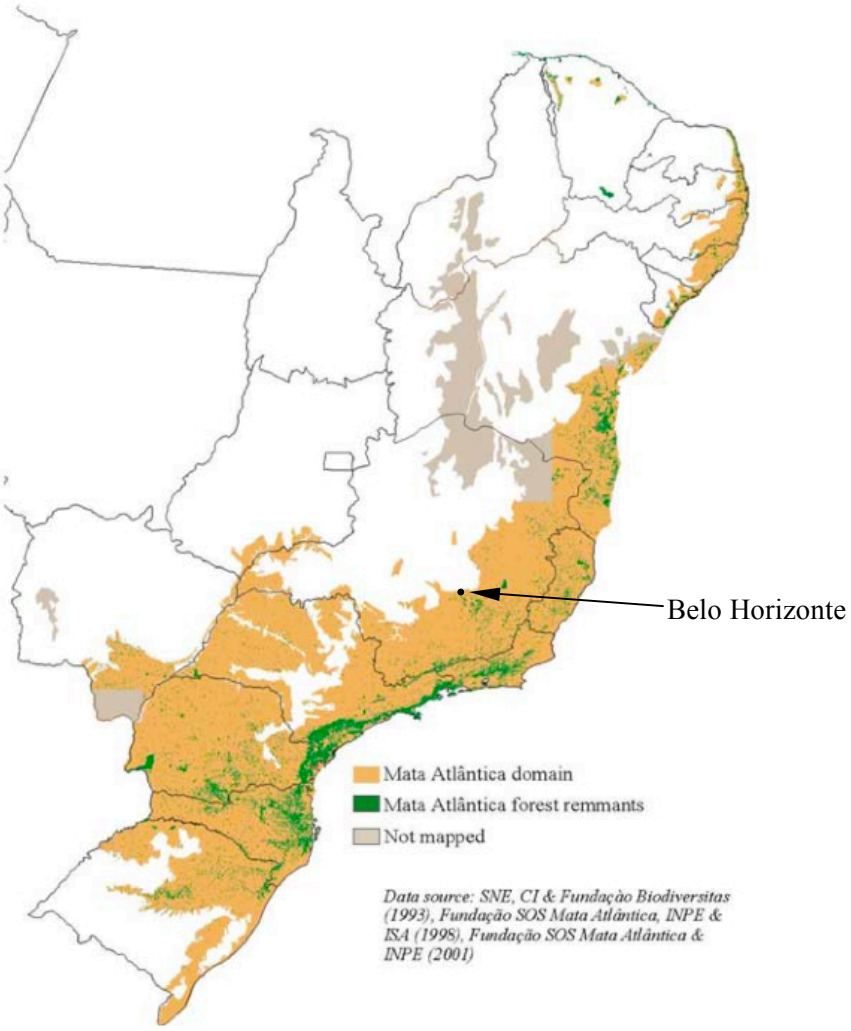


Figure 4.2. Biomass and species composition near Manaus, Brazil. (a) shows the composition of total animal biomass and (b) shows composition of insect fauna species. From Fittkau and Klinge (1973).

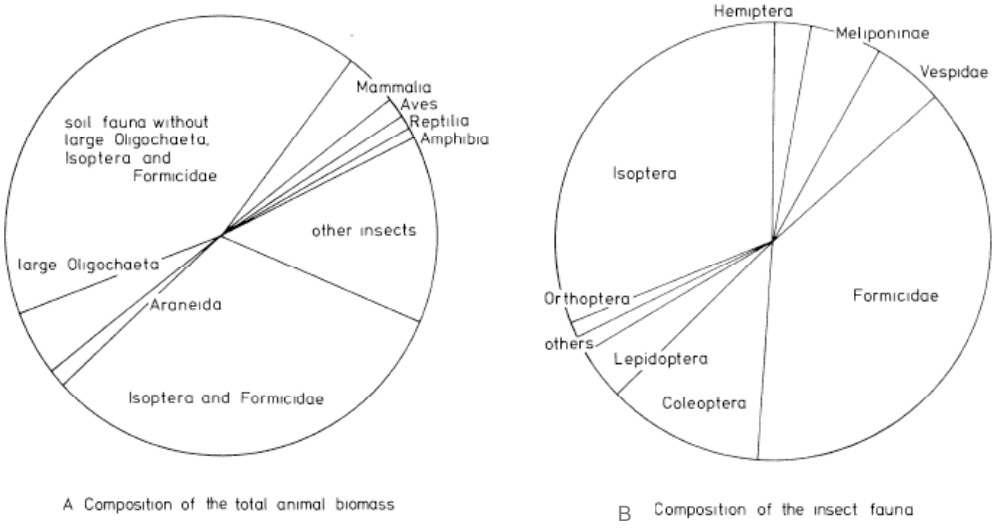
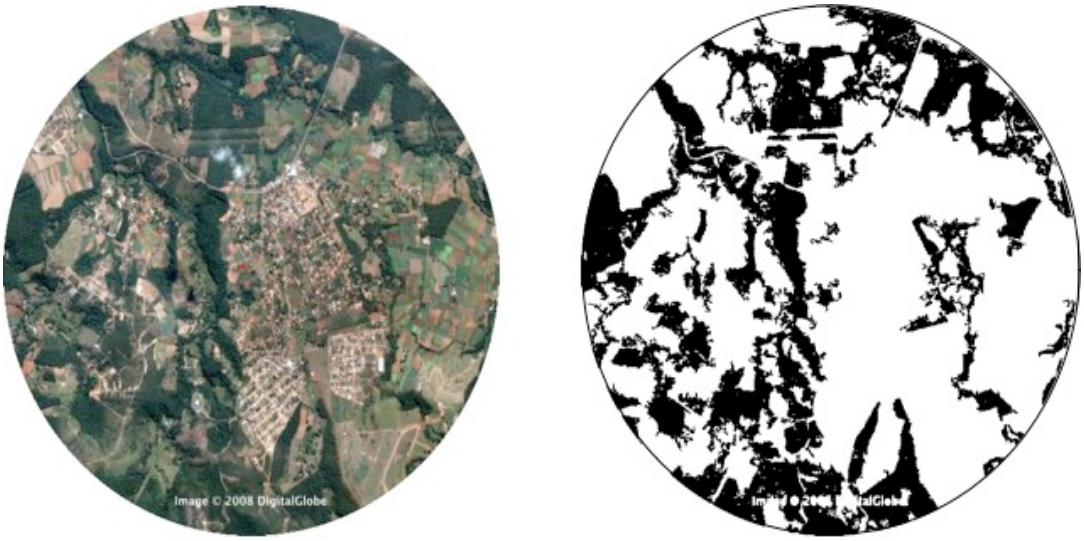
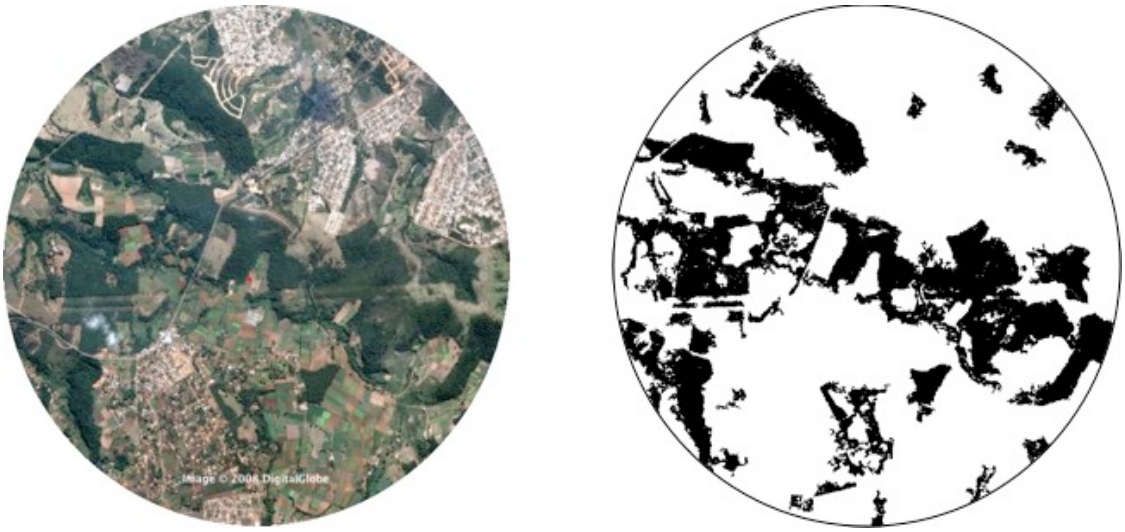


Figure 4.3. Satellite images of studied farms and the surrounding landscapes within a 2 km radius, before and after image transformations. Original satellite images are © 2008 Digital Globe.

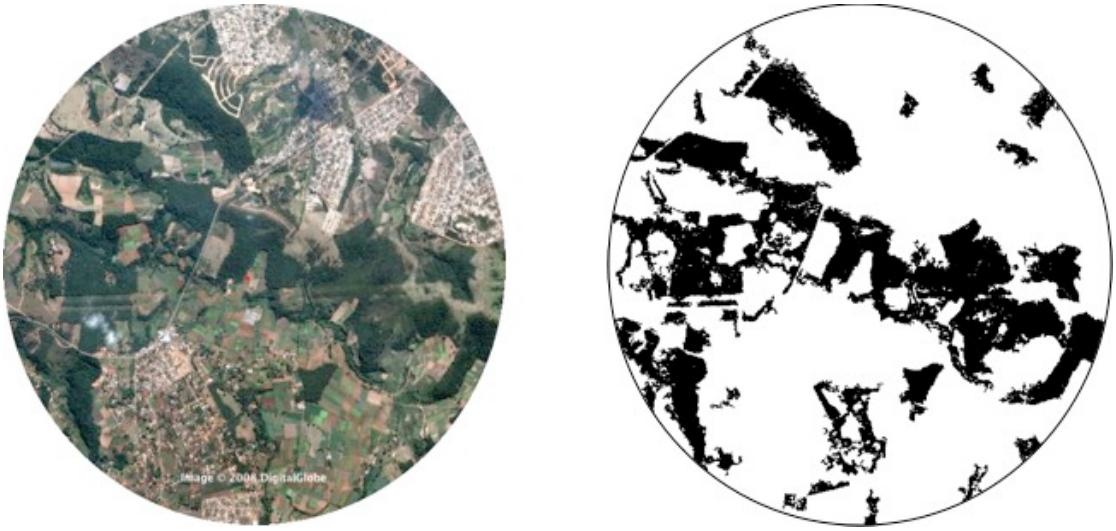
(a) SMAB Participant Dona Marta's farm and **(b)** the surrounding area.



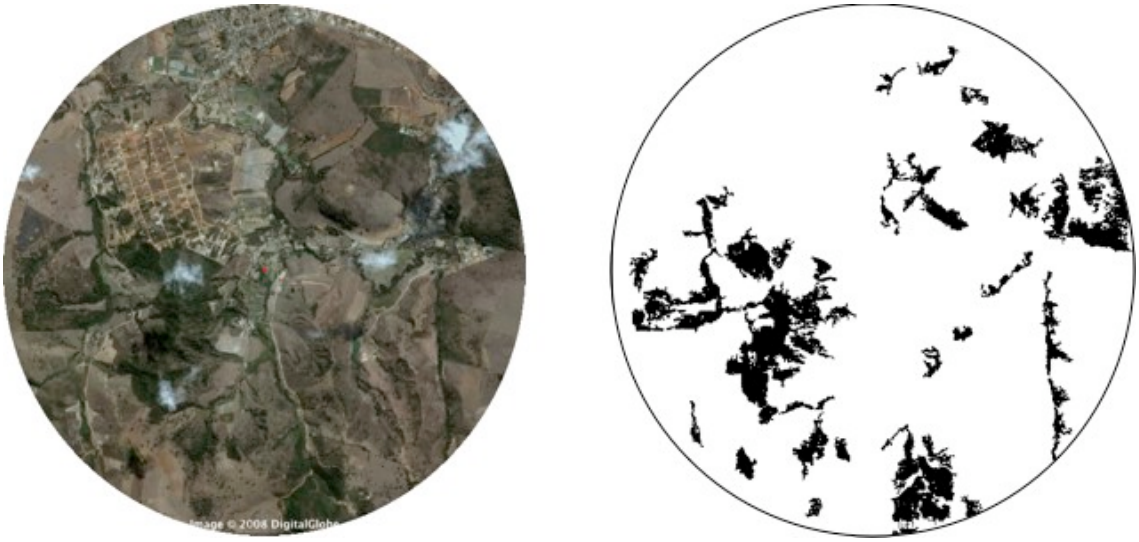
(c) SMAB Participant Dona Marta's second farm site (Citrolândia) and **(d)** the surrounding area.



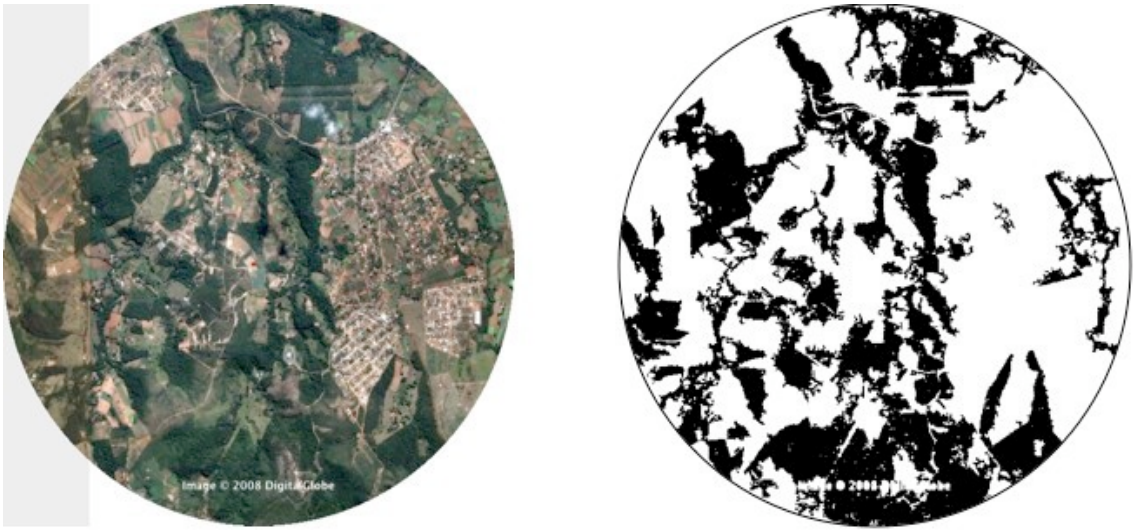
(e) SMAB Participant Seu Ricardo's farm and **(f)** the surrounding area.



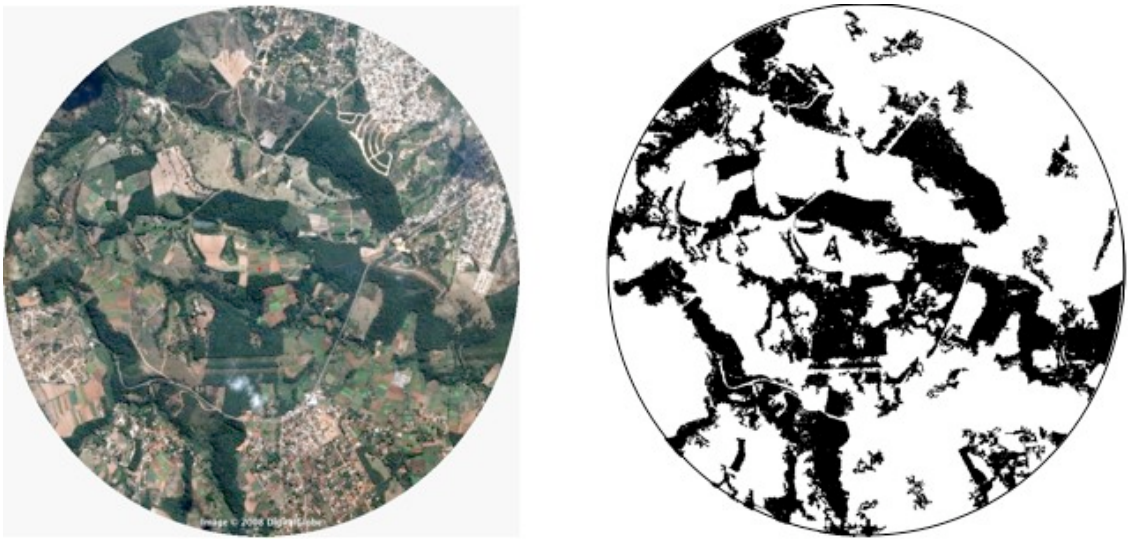
(g) SMAB Participants Seu Edmar and Dona Diane's farm and **(h)** the surrounding area.



(i) Non-SMAB Participant Seu Henri's farm and **(j)** the surrounding area.



(k) Non-SMAB Participant Os Santos' farm and **(l)** the surrounding area.



(m) Non-SMAB Participant Seu Herbert's farm and **(n)** the surrounding area.

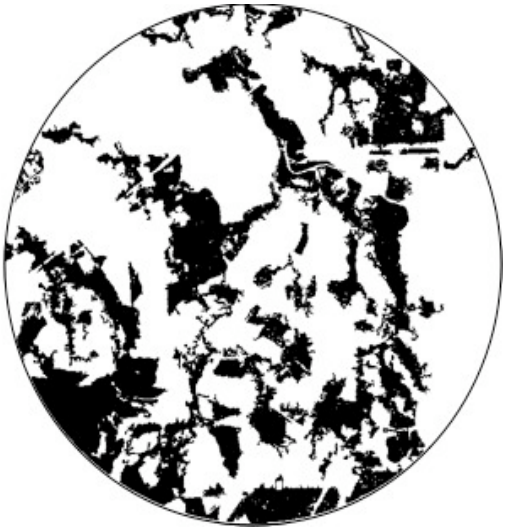


Figure 4.4. Rarefaction curves, resampled observed species (Sobs) vs. Individuals. Graphs A – C: 2005 data. D-F: 2006 data. The first pair of graphs (A and D) display all sites for each year. B and E are field sites only, and C and F are forest sites. (All SMAB sites are displayed as diamond outlines; non-SMAB sites are displayed as solid circles.)

2005 **2006**

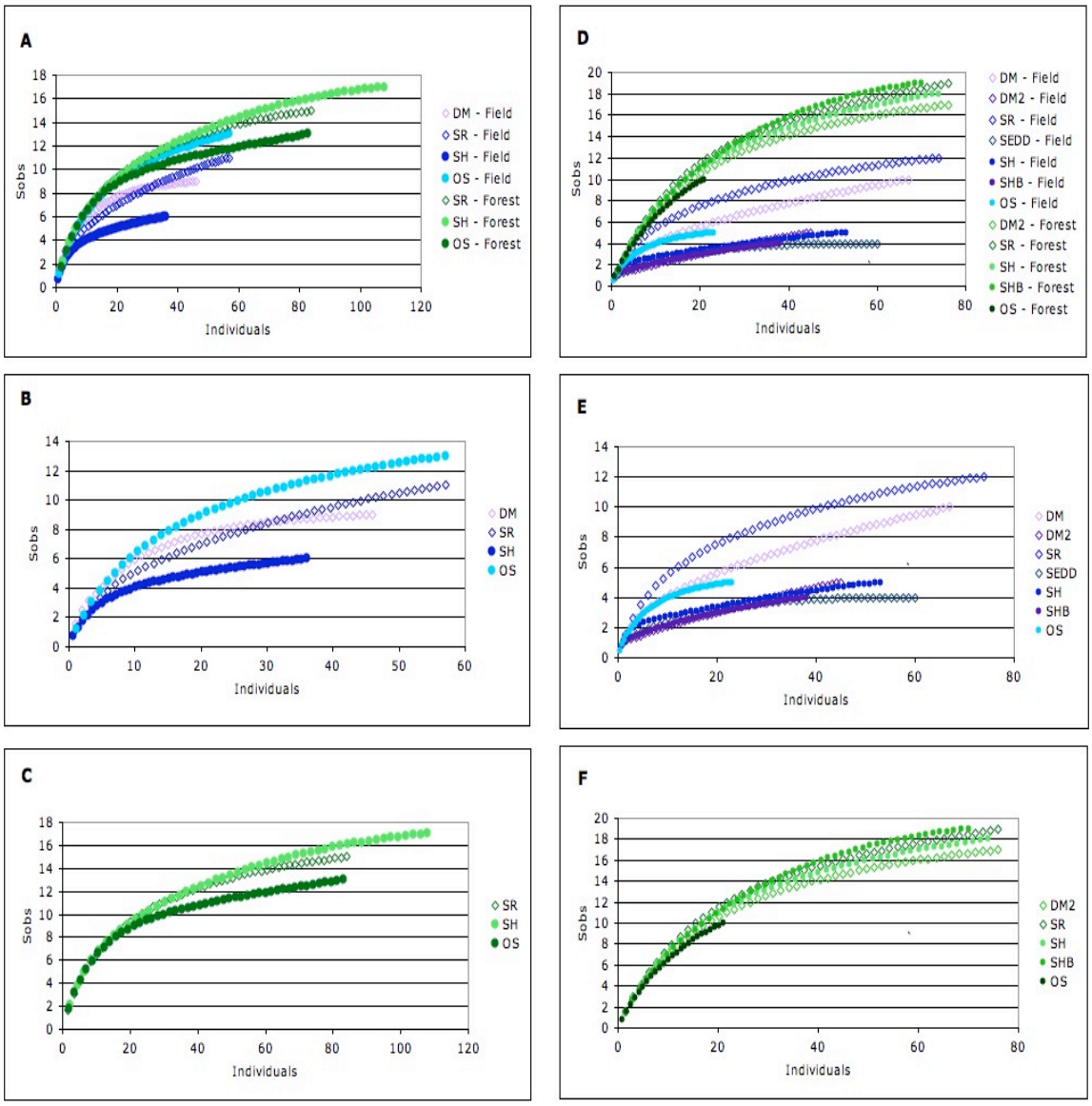


Figure 4.5. Final Chao2 values of Estimated Species Richness. Graphs A – C: 2005 data. D-F: 2006 data. The first pair of graphs (A and B) display all sites for each year. Graphs B and E are field sites; C and F are forest sites. Error bars show 95% confidence intervals; different letters connote statistically significant differences at p = 0.05.

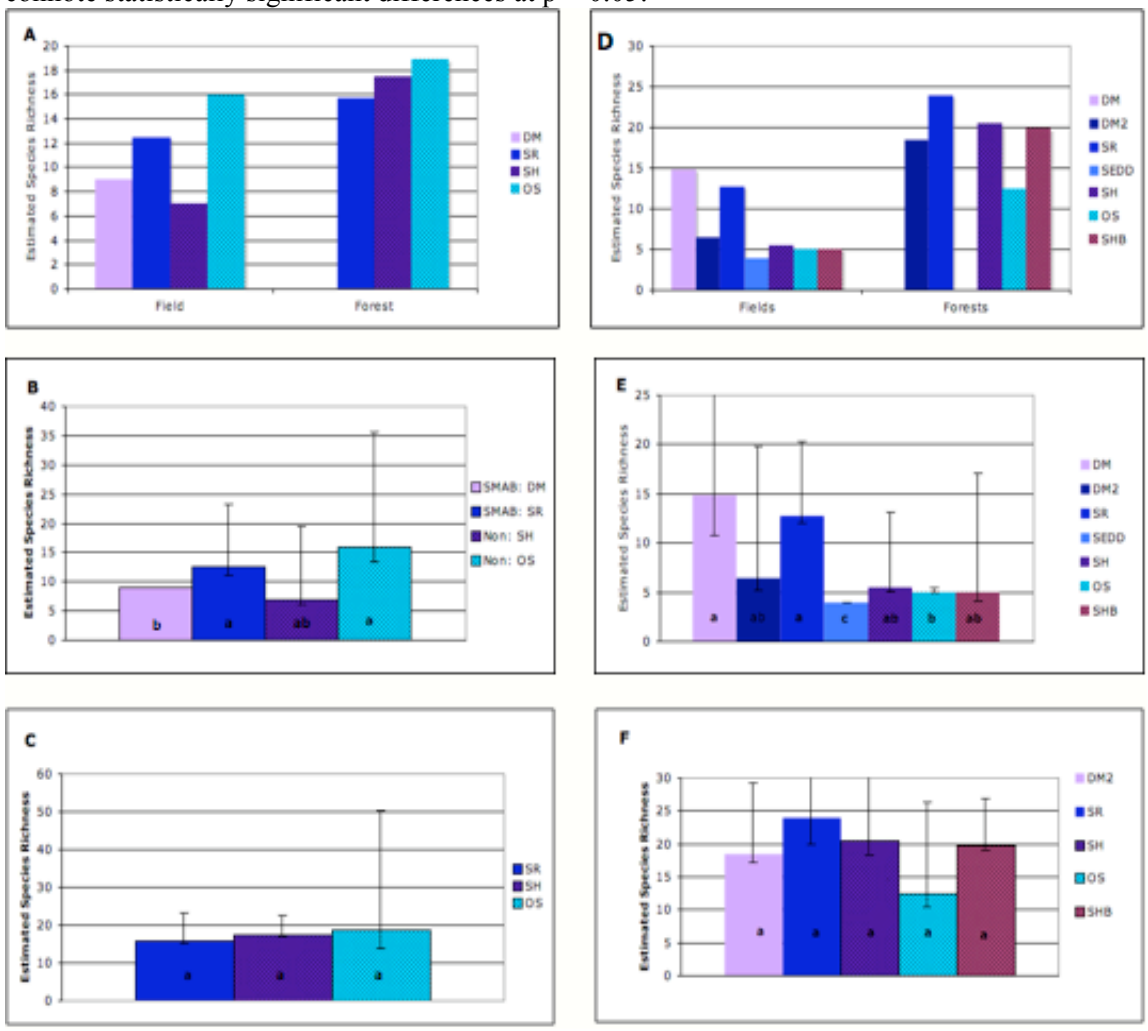
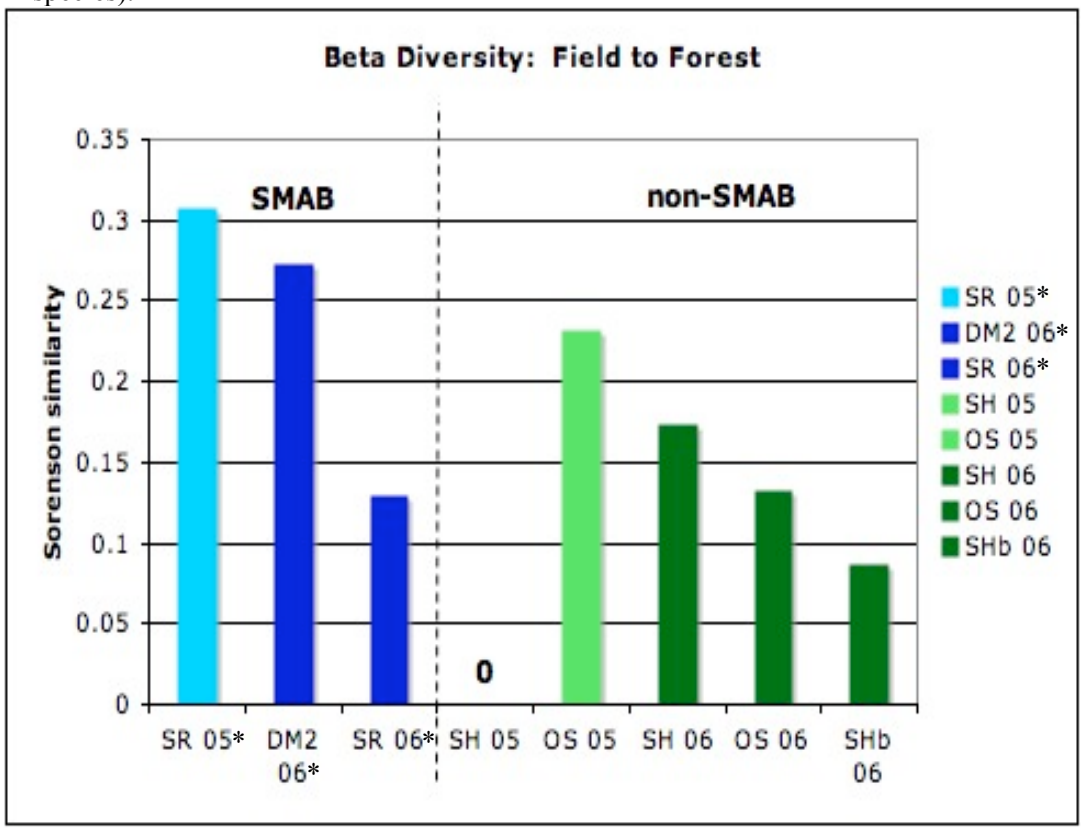
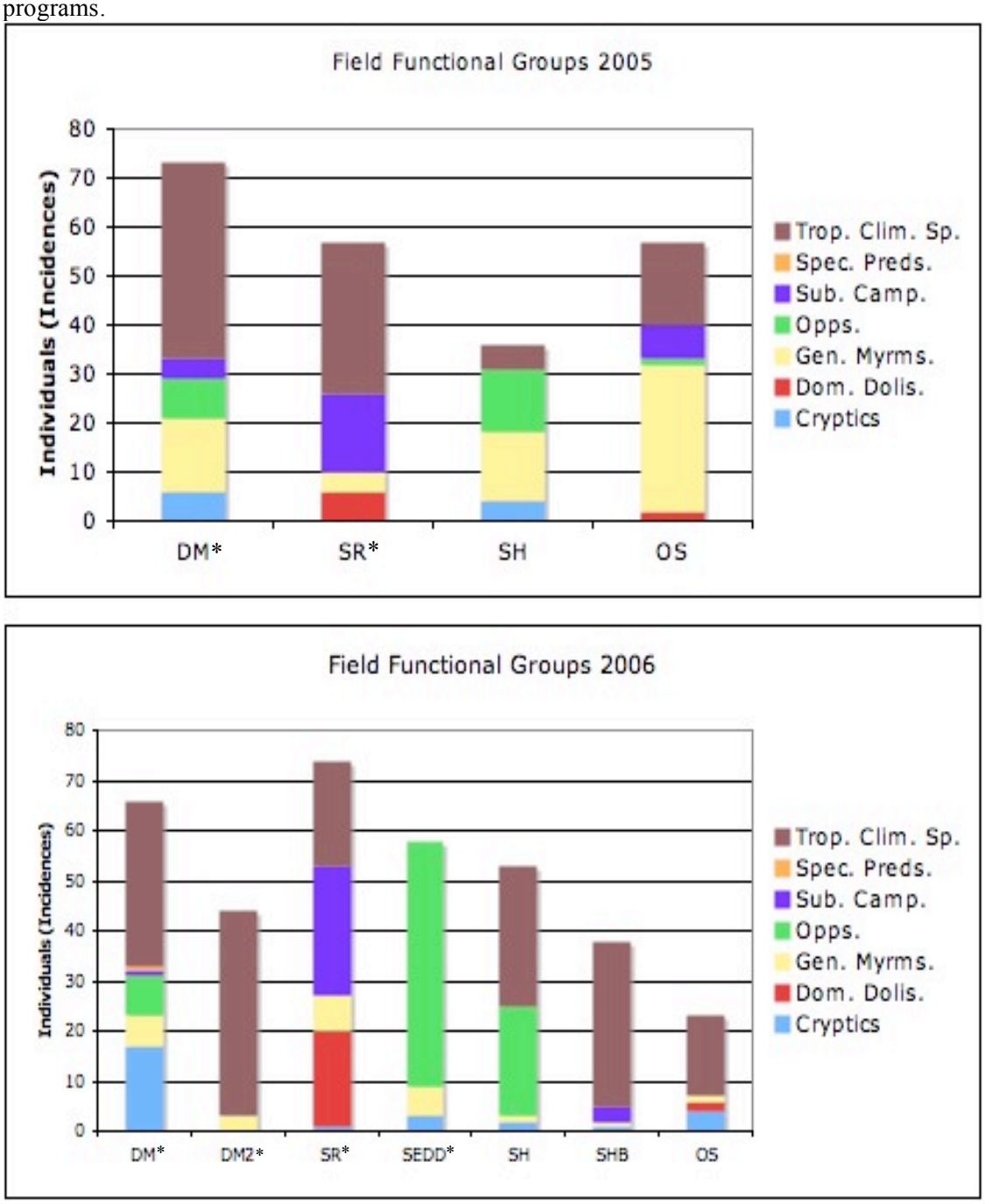


Figure 4.6. Within farm Sorensen Similarity. (0 = no overlap in species, 1.0 = complete overlap in species).



(*) denotes a farm that is a partner of SMAB.

Figure 4.7. Functional groups by species incidences for each farm site. Farms DM, DM2, SR, and SEDD are SMAB participants. Farms SH, OS, and SHB do not participate in the SMAB programs.



(*) denotes a farm that is a partner of SMAB.

Table 4.1 The Importance of Ants[†]

Biomass

- Ants constitute up to 15% of the total animal biomass in a Central Amazonian rainforest (Fittkau and Klinge 1973).
- Of the more than 750,000 described species of insects, some 9500 are ants (Arnett 1985).
- Of all insect specimens collected in the celebrated forest canopy fogging samples in Peru, 69% are ants (Erwin 1989).
- Some 5300 individual ants were enumerated in 1 m^2 of tropical lowland forest soil near Manaus, Brazil (Adis et al. 1987).

Diversity

- In 20 m^2 of leaf litter and rotting logs in Malaysia, 104 ant species representing 41 ant genera were collected (Agosti et al. 1994).
- A single tree in Peruvian tropical lowland forest yielded 26 genera and 43 species of ants (Wilson 1987).
- In 250 m^2 on a cocoa farm in Ghana, 128 species and 48 genera of ants were reported (Room 1971).
- In approximately 5 ha of Peruvian tropical lowland forest, 365 species from 68 genera of ants were found (Tobin 1994).
- In 18 km^2 of semiarid South Australia, 248 species from 32 genera of ants were documented (Andersen and Clay 1996).
- In 5.6 km^2 in temperate Michigan, 87 species from 23 genera of ants were observed (Talbot 1975).

Biology

- All ants are social. Their nests are perennial and thus can be collected all year round.
- There is little variation in ant abundance between rainy and dry seasons (Adis et al. 1987).
- Fragmentation affects ground-dwelling ants (Fisher et al. 2000).
- Together they turn more of the soil than do earthworms in New England (Lyford 1963).
- The density of leaf cutter ant *(Atta sexdens)* nests is up to 20 times greater in secondary forest than in primary forest (Nepstad et al. 1995).
- Leaf cutter ants are the dominant herbivores in tropical forests: the ground volume occupied by a single 6-year-old nest of *A. sexdens* weighed approximately 40,000 kg, and this young colony was estimated to have gathered 5892 kg of leaves (Wilson 1971).
- The seeds of 35% of all herbaceous plants are estimated to be dispersed by ants (Beattie 1985).
- Ants rank among the principal granivores in the southeastern United States (Davidson et al. 1980).

Systematics

- A catalogue of all described ant taxa exists and lists 9538 species (Bolton 1995).
- An illustrated key to the ant genera of the world is available (Bolton 1994).
- The taxonomy of ants is based on the ubiquitous worker cast.

Leaf litter ant surveys are cost [and time] efficient

- A statistically representative sample of the ant diversity of a given area can be completed in

one week.

- In comparison, other taxonomic groups require:

  Sampling and identification of tree species in 1 ha in the Atlantic Forest, Brazil: 4 person-years (Thomas, pers. comm.).

  The number of new tree species (DBH > 10 cm) in an Amazonian rainforest still readily increases after 4 ha have been sampled (Ferreira and Prance 1998).

  Representative sample of snakes in the Brazilian Amazon: >l000 km walked (Zimmerman and Rodriguez 1990).

  Representative sample of frogs near Manaus, Brazil: >350 person-hours (Zimmerman and Rodriguez 1990).

  Representative sample of birds in Western Amazonia: >800 catches; 1.2-8 catches per day using mist nets (Robinson and Terborgh 1990).

  Representative sample of butterflies in Ecuadorian rainforest: >1000 catches (specimens) over one year (De Vries et al. 1997).

  Representative sample of ithomiine butterflies in Cartago, Costa Rica: 4 days (Beccaloni and Gaston 1995).

Table 4.2. Study sites and diversity results.

Coll. Day	SMAB/Non	Site	Year	Field/Forest	Nrmzd SppIn	FG Shannon Diver.	FG Even.	ICE	Alpha	Shannon	Simpson	Spp Even.
74	SMAB	DM	2005	Field	79	1.26	0.78	9.31	2.70	1.65	3.60	0.74
82	SMAB	SR	2005	Field	58	1.11	0.80	14.54	4.06	1.85	5.25	0.69
90	Non	SH	2005	Field	36	1.25	0.90	7.62	2.06	1.42	3.75	0.70
51	Non	OS	2005	Field	58	1.14	0.71	15.75	5.26	2.22	8.23	0.81
73	SMAB	DM	2006	Field	67	1.29	0.72	20.67	3.26	1.49	3.21	0.49
79	SMAB	DM2	2006	Field	45	0.24	0.35	11.00	1.44	0.50	1.27	0.21
67	SMAB	SR	2006	Field	76	1.36	0.84	14.22	4.06	1.99	6.06	0.75
69	SMAB	SEDD	2006	Field	60	0.56	0.51	4.00	0.96	0.63	1.43	0.45
86	Non	SH	2006	Field	53	0.90	0.65	8.00	1.35	0.98	2.36	0.47
89	Non	SHB	2006	Field	38	0.51	0.37	6.99	1.13	0.51	1.32	0.26
110	Non	OS	2006	Field	23	0.91	0.65	5.40	1.97	1.30	3.20	0.77
82	SMAB	SR	2005	Forest	84	1.02	0.63	16.79	5.32	2.33	8.74	0.83
90	Non	SH	2005	Forest	108	1.29	0.72	18.96	5.67	2.35	8.55	0.80
51	Non	OS	2005	Forest	88	1.27	0.92	16.11	4.33	2.24	8.64	0.81
79	SMAB	DM2	2006	Forest	78	1.50	0.83	20.31	6.80	2.53	11.83	0.84
67	SMAB	SR	2006	Forest	78	1.70	0.95	23.31	8.13	2.68	14.39	0.85
86	Non	SH	2006	Forest	77	1.59	0.89	21.67	7.57	2.58	12.11	0.84
89	Non	SHB	2006	Forest	70	1.38	0.86	20.82	8.58	2.57	10.41	0.85
110	Non	OS	2006	Forest	42	1.12	0.81	17.73	7.48	2.04	7.78	0.71

Coll. Day = Collection day, counted from January 1 of the collection year. **Nrmzd SppIn** = Species Incidence, normalized by number of samples taken at a given site. **FG Shannon Diver.** = Functional Group Shannon Diversity (Functional Group H). **FG Even.** = Functional Group Evenness (Functional Group E). **ICE** = Incidence-based Coverage Estimate (see text for explanation). **Alpha** = Fisher's α. **Shannon** = Shannon Diversity Index (Species H). **Simpson** = Simpson's diversity index. **Spp. Even.** = Species evenness (Spp. E.).

Table 4.3. Ant functional groups in relation to stress and disturbance, with major representatives in Australia and the New World.[†]

Functional Group	Australia	New World
1. Dominant Dolichoderinae	*Anonychomyrma, Froggattella, Iridomyrmex, Papyrius, Philidris*	*Azteca, Forelius, Linepithema, Liometopum*
2. Subordinate Camponotini	*Calomyrmex, Camponotus, Opisthopsis, Polyrhachis*	*Camponotus*
3. Climate specialists		
a. Hot	*Melophorus, Meranoplus, Monomorium* (part)	*Pogonomyrmex, Solenopsis s.s, Myrmecocystus*
b. Cold	*Monomorium* (part), *Notoncus, Prolasius, Stigmacros*	*Formica* (part), *Lasius, Leptothorax, Stenamma, Lasiophanes*
c. Tropical	Many taxa	Many taxa
4. Cryptic species	Very many small myrmicines and ponerines, including *Hypoponera*, most Dacetonini, and *Solenopsis* (*Diplorhoptrum*)	Very many small myrmicines and ponerines, including *Hypoponera*, most Dacetonini, and *Solenopsis* (*Diplorhoptrum*)
5. Opportunists	*Paratrechina, Rhytidoponera, Tetramorium*	*Dorymyrmex, Formica* (*fusca* gp.), *Myrmica, Paratrechina*
6. Generalized Myrmicinae	*Crematogaster, Monomorium, Pheidole*	*Crematogaster, Monomorium, Pheidole*
7. Specialist Predators	*Bothroponera, Cerapachys, Leptogenys, Myrmecia*	*Dinoponera, Leptogenys, Pachycondyla, Polyergus*

[†] Excerpted from Andersen (2000), used in accordance with the Creative Commons License, available at http://creativecommons.org/licenses/by-nc-sa/2.0/

Table 4.4. Sorenson similarity indices (beta diversity) and number of shared species between SMAB and non-SMAB farm field and forest sites in 2005. (A) shows values for farm field sites. (B) shows values for farm forest sites. Sorenson values may range from 0 and 1, are "above" the diagonal. Shared species are the whole numbers "below" the diagonal. (DM and SR are SMAB farms; SH and OS are non-SMAB.)

A	DM 05 Field*	SR 05 Field*	SH 05 Field	OS 05 Field
DM 05 Field*		0.526	0.571	0.381
SR 05 Field*	5		0.353	0.333
SH 05 Field	4	3		0.316
OS 05 Field	4	4	3	

B	SR 05 Forest*	SH 05 Forest	OS 05 Forest
SR 05 Forest*		0.313	0.357
SH 05 Forest	5		0.267
OS 05 Forest	5	4	

(*) denotes a farm that is a partner of SMAB.

Table 4.5. Sorenson similarity indices (beta diversity) and number of shared species between SMAB and non-SMAB farm field and forest sites (2006). (A) shows values for farm field sites. (B) shows values for farm forest sites. Sorenson values may range from 0 and 1, are "above" the diagonal. Shared species are the whole numbers "below" the diagonal.

A	DM 06 P*	DM2 06 P*	SR 06 P*	SEDD 06 P*	SH 06 P	OS 06 P	SHb 06 P
DM 06 P*		0.267	0.091	0.429	0.4	0.267	0.286
DM2 06 P*	2		0.235	0.222	0.4	0.2	0.222
SR 06 P*	1	2		0	0.235	0.235	0. 25
SEDD 06 P*	3	1	0		0.444	0.222	0.25
SH 06 P	3	2	2	2		0.6	0.444
OS 06 P	2	1	2	1	3		0.444
SHb 06 P	2	1	1	1	2	2	

B	DM2 06F*	SR 06F*	SH 06F	OS 06F	SHb 06F
DM2 06F*		0.333	0.343	0.296	0.444
SR 06F*	6		0.378	0.207	0.421
SH 06F	6	7		0.143	0.324
OS 06F	4	3	2		0.345
SHb 06F	8	8	6	5	

P = Farm Field
F = Forest
(*) denotes a farm that is a partner of SMAB.

Table 4.6. Sorenson similarity between farm fields and their same-site associated forest fragments.

	Sorenson
DM2 06*	0.273
SR 05*	0.308
SR 06*	0.129
SMAB Average	0.237
SH 05	0
SH 06	0.174
OS 05	0.231
OS 06	0.133
SHb 06	0.087
Non Average	0.125

(*) denotes a farm that is a partner of SMAB

Table 4.7. Final regression values from linear and linear mixed effects models on studied farm sites.

Field Results *Response Variable*	collday β_1	SMAB β_2	nefraarea β_4	shapeind β_5	loclforarea β_7	localedge β_8	Variance: year	Variance: farmlabel	Variance: Residual	r2 adjusted r2 F-statistic; df	Equation p-value (*lm only*)	Bonferroni-corrected p-value
ICE (*lm*)												
Value of β	-0.217				2.31					0.4275	0.11	0.00385
t-value	-2.324				1.42					0.2843		
p	0.049*				0.19					2.99; 2,8		
ICE (*lm*)												
Value of β	-0.177									0.28	0.092	
t-value	-1.886									0.20		
p	0.091									3.55; 1,9		
NSI (*lm*)												
Value of β		22.54								0.467	0.020*	0.00278
t-value		2.81								0.408		
p		0.021*								7.88; 1,9		
F. Grp H (lm)				0.176								
Value of β				5.308						0.758	<0.001**	0.00278
t-value				<0.001**						0.731		
p										28.17; 1,9		
F. Grp E.												
Value of β				0.094		-0.00366	0.00376		0.00488			0.00556
t-value				6.418		-3.101						
p				<0.0001**		0.0056**						
Spp. *H*												
Value of β	-0.0130			0.221			0.0217	0.108	0.0234			
t-value	-3.56			3.09								0.005
p	0.0026**			0.0057*								
Spp. *E*												
Value of β				0.0723								
t-value				2.655								
p				0.012*			0.00538		0.0222			0.005

Table 4.8. Final regression values from linear and linear mixed effects models on studied forest sites.

FOREST RESULTS *Response Variable*	collday β_1	SMAB β_2	nefraarea β_4	shapeind β_5	loclforarea β_7	localedge β_8	Variance: year	Variance: farmlabel	Variance: Residual	r2 adjusted r2 F-statistic df	Equation p-value (*lm* only)	Bonferroni-corrected p-value
ICE												
Value of β		-13.37		-0.689		-0.341	2.38	17.33	0.284			0.00833
t-value		-2.623		-0.616		-4.724						
p		0.017*		0.28		0.0011**						
NSI	(*see text*)											
(F. Grp H)												
(Value of β)	(-0.00761)						(0.0573)		(0.0248)			
(t-value)	(-2.091)											
(p)	(0.037*)											
F. Grp H							0.0242		0.0406			
Value of β												
t-value												
p												
(F. Grp E)												
(Value of β)	(-0.00485)	(-0.228)				(-0.00350)	(0.0152)		(3.78E-04)			0.00455
(t-value)	(-9.582)	(-5.091)				(-3.08)						
(p)	(<0.001)**	(0.001)**				(-0.009)*						
F. Grp E												
Value of β	-0.00421						0.0121		0.00417			0.00455
t-value	-2.815											
p	0.0130*											
Spp. *H*												
Value of β		0.394			0.268		0.0118		0.0316			0.00714
t-value		1.995			1.633							
p		0.043*			0.073							
Spp. *E*												
Value of β	-0.00193	0.0850			0.0728		5.08E-04		7.40E-04			0.00714
t-value	-2.869	2.807			2.803							
p	0.012*	0.013*			0.013*							

APPENDIX A

Ant species and morphospecies (organized by subfamilies) found in seven vegetable farms using tuna bait sampling over a two-year sampling period. Voucher specimens deposited at the Laboratory of Myrmecology at CEPLAC (Comissão Executiva do Plano da Lavoura Cacaueira)

Farms	SEDD*		DM		DM2*		SR		OS		SH		SHb*	
Species	**P**	**--**	**P**	**--**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**
DOLICHODERINAE														
Linepithema cerradense Wild							x							
Linepithema neotropicum Wild							x	x	x					
Linepithema pulex Wild												x		
Linepithema sp. 1														x
Linepithema sp. 2						x		x						x
Tapinoma melanocephalum (Fabricius)						x								
ECITONINAE														
Labidus coecus (Latreille)							x		x		x			
FORMICINAE														
Brachymyrmex brevicornis Emery			x				x		x					
Brachymyrmex heeri Forel						x		x		x		x		x
Brachymyrmex sp. 1								x				x		x
Brachymyrmex sp. 2								x				x		
Camponotus blandus (Smith)													x	
Camponotus cingulatus Mayr								x						
Camponotus crassus Mayr			x									x		

Farms	SEDD*		DM		DM2*		SR		OS		SH		SHb*	
Species	**P**	**--**	**P**	**--**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**
Camponotus lespesii Forel												x		
Camponotus melanoticus Emery							x							
Camponotus rufipes (Fabricius)			x				x	x						
Camponotus sericeiventris (Guerin-Meneville)								*x*				*x*		
Camponotus tenuiscapus Roger							x							
Camponotus vittatus Forel								x						
Camponotus (Myrmaphaenus) sp.									x					
Camponotus (Myrmobrachys) sp.								x						
Paratrechina sp. 1								x						x
Paratrechina sp. 2									x	x				
Paratrechina sp. 3	x		x								x	x		
MYRMICINAE														
Adelomyrmex sp.						x								x
Atta sexdens rubropilosa Forel									x					
Cardiocondyla minutior Forel			x											
Carebara urichi Wheeler										x				
Cephalotes sp.												x		
Crematogaster victima Smith	x		x		x				x		x	x		
Megalomyrmex silvestrii Wheeler												x		
Mycocepurus goeldii (Forel)			x				x							

Farms	SEDD*		DM		DM2*		SR		OS		SH		SHb*	
Species	**P**	**--**	**P**	**--**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**
Pheidole cuevasi Wilson														
Pheidole fallax Mayr			x				x		x		x	x		
Pheidole germaini Emery												x		x
Pheidole gertrudae Forel			x						x					
Pheidole jelskii Mayr					x	x	x			x	x	x		
Pheidole leonina Wilson					x	x		x		x		x		
Pheidole midas Wilson								x						
Pheidole radoszkowskii Mayr						x	x		x	x		x		x
Pheidole sp. 1 gp. flavens			x					x				x		
Pheidole sp. 3 gp. diligens							x	x						
Pheidole sp. 4 gp. diligens							x	x		x				x
Pheidole sp. 5 gp. diligens									x					
Pheidole sp. 7 gp. flavens									x	x				
Pheidole sp. 9 gp. diligens									x					
Pheidole sp. 10 gp. tristis						x						x		
Pheidole sp. 11 gp. tristis						x								
Pheidole sp. 12 gp. tristis	x													
Pheidole sp. 13 gp. diligens								x	x					x
Pheidole sp. 14 gp. diligens								x						x
Pheidole sp. 15 gp. flavens										x				x

Farms	SEDD*		DM		DM2*		SR		OS		SH		SHb*	
Species	**P**	**--**	**P**	**--**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**
Pheidole sp. 16 gp. flavens										x				
Pheidole sp. 17 gp. diligens							x	x				x	x	x
Pheidole sp. 18 gp. diligens						x						x		
Pheidole sp. 19 gp. fallax						x								x
Pheidole sp. 20 gp. fallax												x		
Pheidole sp. nr. transversostriata								x						x
Solenopsis globularia (Smith)					x									
Solenopsis saevissima (Smith)			x		x	x	x	x	x	x	x		x	
Solenopsis (Diplorhoptrum) sp. 1						x	x			x		x		x
Solenopsis (Diplorhoptrum) sp. 2						x		x		x				x
Solenopsis (Diplorhoptrum) sp. 3								x						
Wasmannia rochai Forel										x				
PONEROMORPH														
Ectatomma edentatum Roger						x		x		x		x		x
Gnamptogenys striatula Mayr								x		x		x		x
Gnamptogenys sulcata (Smith)							x							
Hypoponera opacior (Forel)	x		x						x		x		x	
Hypoponera sp. 1												x		
Hypoponera sp. 2											x			
Odontomachus chelifer (Latreille)						x				x				
Odontomachus meinerti Forel								x		x				
Pachycondyla striata Smith						x								

Species	Farms	SEDD* P	--	DM P	--	DM2* P	F	SR P	F	OS P	F	SH P	F	SHb* P	F
Pachycondyla verenae (Forel)				x											

* Denotes that site was only sampled in 2006

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CHAPTER 5

CONCLUSION

There is increasingly little reason to think that universal food security and conservation of the world's irreplaceable biodiversity cannot be provided for at the same time. In Chapter 2, I reviewed the evidence that sufficient food for the entire human population can be provided using alternative agricultural methods – methods which the extant evidence implies are much better for biodiversity than the status quo of conventional, Green Revolution methods. Given the evidence that what we do in human-managed areas in the matrix between native habitat fragments has profound and dynamic effects on the biodiversity of the entire landscape, talk of a Faustian bargain between human development and nature are not just counterproductive; it is to a large extent outdated. Although difficult decisions must always be made, the problems facing the world in terms of food insecurity and hunger are not associated with a lack of food, but with a failure in the systems that should guarantee a right to food. Belo Horizonte has shown that it is potentially possible to design institutions supporting this right while also providing for the possibility of improving the conditions for biodiversity at the same time. And the example of Belo Horizonte should not actually be completely surprising – as I showed in Chapter 2, the literature on ecology and on food security implies that exactly this type of sustainable development should be possible. The scientific literature to date shows that alternative agricultural methods that can generate substantive support and benefits to biodiversity (and that can take advantage of some of the benefits and services offered by biodiversity itself) can also provide sufficient food for today's population, as well as a future population projected to number as much as 10 billion. In this way, Chapter 2 presented evidence that with regards to conservation of biodiversity, alternative agriculture holds clear benefits, and with regards to hunger, the question is not whether enough food can be produced using conventional or alternative methods, but rather how we will choose to resolve the problems of fair distribution and substantive equality that maintain hunger in the face of global plenty.

Chapter 3 specifically examines how changes in local food policy institutions in Belo Horizonte have addressed these problems. By following a comprehensive approach to food

security that incorporates Rocha's "Five A's" of food security (Rocha 2003) – availability, accessibility, acceptability, appropriateness and agency – Belo Horizonte's Municipal Secretariat of Food Supply (SMAB) has found a way to provide human rights related to food and health through reductions in malnutrition and infant mortality in a city of 2.5 million people. They have at the same time improved the human rights and sustainability of farmers and farms around the city through the economic and institutional connections with these small family farms. Chapter 3 shows that SMAB's formation followed Kingdon's (2003) model of problem, policy and politics streams, where the independently evolving "streams" of societal problems, policy solutions, and political circumstances came together and were effectively managed by two policy entrepreneurs in order to provide a step change in food policy. Patrus Ananias de Souza, Mayor of Belo Horizonte in 1993, and his appointed head of SMAB, Maria Regina Nabuco, acted as "policy entrepreneurs," who were able to advance an agenda focused on food security motivated by personal convictions, priorities and preferences. Such entrepreneurs increase the likelihood that institutional change will happen when an established problem is joined with policy solutions that have developed and evolved over a period of time, and politicians and the public's attention is drawn to the issue at the same time. This model, which Kingdon based in part on the earlier work of Cohen, March and Olsen (1972) (which I therefore referred to as the "Kingdon/CMO model") was found to adequately explain not just the circumstances of SMAB's creation, but the present circumstances where attention has drifted from a focus on food security and SMAB in Belo Horizonte. Many of the gains and programs of SMAB have become established and institutionalized, but those who work for and with SMAB perceive its forward progress to be stalled, in stagnation. This would be predicted under the Kingdon/CMO model, as a significant part of the stagnation in the creation of new programs and increase in resources for SMAB came with a change in political administration, with two men, Célio de Castro and Fernando Pimentel, succeeding Ananias, and a political appointee from a different party and with different priorities and expertise than Nabuco became head of SMAB. However, if we use the Kingdon/CMO framework, we also can predict that the remaining problems around food security may in the future rejoin the stream of policy solutions SMAB's functionaries are still developing and advocating, along with political attention from the public and the city administration; the exact timing is not predictable, but as the streams evolve independently they may come together again, helped along by development of indicators for continued problems in food security, continued policy development, and political pressure from the public and interest groups.

Chapter 3 additionally connected SMAB's urban policies with the farmers it works with located in the matrix of the Atlantic Rainforest landscape around the city. SMAB's functionaries

have a vision of food security that includes what one could classify "appropriateness" as defined by Rocha: environmental sustainability and benignity. Although their direct ability to specifically press a sustainability mandate is limited by the city's borders, they have indirectly influenced sustainability in the Atlantic Rainforest through their advocacy for sustainable, organic and agroecological methods, their dedicated extensionist whose expertise and advocacy helps encourage and inform farmers with regards to these methods, and via the economic security SMAB's partnership provides the farmers. The farmers that work with SMAB are able to directly sell to consumers in the city, cutting out wholesalers and other intermediaries that typically benefit from a 100%+ markup in produce prices (farmer interviews; de Araújo and Alessio 2005). The pattern seemed to be that farmers who were able to find or afford direct access to consumers saw greater economic security, as demand and prices were apparently more constant than those the farmers received from intermediaries. Research generally supports a pattern of more sustainable agricultural practices among farmers with economic security (see i.e., D'Souza and Ikerd 1996, Templeton and Scherr 1999, see i.e., Rosset et al. 2006), with the caveat that there must be incentives for farmers to produce for the public good. It was shown in Chapter 3 that there was near universal agreement among the interviewed farmers, SMAB partners or not, about the importance and validity of the right to food, and of conservation of the Atlantic Rainforest (consistent with environmental attitudes of Brazilians found in Simões 2001). With the economic, technical and moral support of SMAB, their partner farmers appear to be encouraging higher biodiversity, likely due to infrequent use of pesticides and increased crop diversity.

An interesting offshoot of Chapter 3's finding of a shift in governmental priority in the Pimentel administration to housing quality and *aglomerado* regularization is the possibility that this represents another sustainable development project, in the sense of sustainable development used throughout this thesis. That is, *Vila Viva* ("Living Village"), a series of projects with the philosophy of "total intervention" in the poor and underdeveloped shantytowns that are called *favelas* or *aglomerados*, has aspects oriented around the generation of employment, improved housing and improved sanitation, formal titles to housing, environmental remediation and reclamation of ecosystem services, improvement of educational facilities and generation and access to community activities like sports centers. In addition to these aspects, Vila Viva is based on demands from the populace from the "Participatory Budget" program, where a section of the city budget is determined via citizens' and neighborhood communities' own priority-setting. This program of democratization appears to provide a number of components for embeddedness – a form of social capital "synergy" outlined by Evans (1996) and analyzed in the context of SMAB in Chapter 3. Embeddedness can help enable effective action, policy implementation and

institutional change, and Evans outlines five factors that may in turn support embeddedness: competent government bureaucracy, democratic and competitive politics, the rule of law in terms of political "rules of the game", egalitarian social structures, and complementarity between government and private actions. Vila Viva, similar to SMAB, appears to depend on and simultaneously work to deepen aspects of embeddedness, especially egalitarian social structures in the form of participatory budgeting, which looks to provide all citizens direct access to parts of the administrative budgetary process and agenda setting, and complementarity, with the city government providing resources, expertise and training for Vila Viva projects, but depending on the local residents to compose 80% of the labor force, bringing their expertise and refined knowledge of local infrastructural and cultural conditions (participant observation, presentation by Mayor Fernando Pimentel, April 4, 2008).

In the aspect of providing improved sanitation, Vila Viva may provide for human rights outlined in the Universal Declaration of Human Rights (United Nations 1948), the International Covenant on Human Rights (United Nations 1966), and the Millennium Development Goals (United Nations Development Programme (UNDP) 2008): the highest attainable standards of physical health, improvement in environmental hygiene, control of epidemic and endemic diseases, and provision for the reduction of infant mortality. Indeed, to the last point, Lampreia (1995) found that the level of infant mortality doubled from approximately 50 to 100 deaths/1000 live births among extremely poor families earning the same wages if they lacked basic water and sanitation services. At the same time, the project looks to reclaim polluted creeks throughout the *aglomerados* and to provide preservation and restoration through natural areas referred to as "linear parks" – these linear parks provide ecosystem services in relation to erosion control, water purification, water retention and mudslide mitigation, and public green spaces for community education and enjoyment.

The point of reviewing Vila Viva here in greater detail is to highlight other projects that may be providing for "true" sustainable development – development of substantive equality and human rights while maintaining or even aiding conservation of environmental quality and biodiversity. The fact that this project exists in Belo Horizonte not only points to another area of innovation and potentially illuminating study, but also helps explain the perceived stagnation of SMAB and the slow-going in expanding its resources, mandate, and abilities to make the program yet more comprehensive in the area of food security. This movement of the agenda away from expanding food security towards another project is both discouraging and heartening – to those who study food security and have real passion for the area, it may be worrisome to see it recede from the limelight, even as SMAB maintains its foundational innovations during its "stagnation"

– but by confirming the Kingdon/CMO model it shows what must be done to prepare for further innovation of the food policy institutions in Belo Horizonte, and perhaps elsewhere. The development and publicization of indicators on the scope of the problem (exactly the kind of close monitoring not yet common in Brazil (Defourny 2006)), development and advocacy of technically and financially feasible policy solutions, political pressure, education, community mobilization, and support of sympathetic politicians increase the likelihood that there will be a policy window where problems, policies, and politics come together for potential policy entrepreneurs to take advantage of. None of these factors provide for immediate change in the Kingdon/CMO model, but they do also prove that change is feasible – sometimes in incremental steps and sometimes in dramatic leaps. In that way, Kingdon/CMO shows that (agenda) change always happens, it just depends on who and what is ready to take advantage of the window of opportunity.

Having explored the social aspects of SMAB and its interactions with farmers in Chapter 3, Chapter 4 empirically tested for differences in biodiversity between SMAB partner farms and other local farms that were not partnered with SMAB, using ants as an initial indicator organism. It was found through linear mixed model regressions that participation in SMAB may have had an effect on ant abundance, ant species diversity as measured by Shannon's H, and ant species evenness, measures of ant alpha (single-site) diversity. Looking at beta diversity, or the difference in species identities between sites, the results showed greater beta diversity within SMAB farms than there was within non-SMAB farms, with suggestive (but not statistically significant) differences in temporal beta diversity and farm-versus-field beta diversity between SMAB and non-SMAB farms as well. Although collection day and shape index were significant factors in ant species diversity, and there were potential confounds in the data in the form of inexact information on farmer practices, SMAB participation consistently showed up as a factor in diversity measures, indicating that the influences reviewed in Chapter 3 have indeed created discernable differences in matrix quality in the agroecological landscape around Belo Horizonte (here, the "matrix" refers to the areas surrounding "natural" habitat fragments, such as farms and pastures situated around fragmented forest areas). The economic stability and technical interactions from SMAB appears to be generating greater sustainability in the form of higher biodiversity within the farm fields and the forests on SMAB farms. My results thus conform with the substantial literature on the significance of interactions between human-managed land, especially agricultural matrices, and the fragmented natural habitats within them – and the potential for humans to manage such land in ways beneficial to such habitats. To my knowledge,

mine is the first work to so intimately integrate the direct effects of a political change in a food system with local changes in biodiversity.

LITEARTURE CITED

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