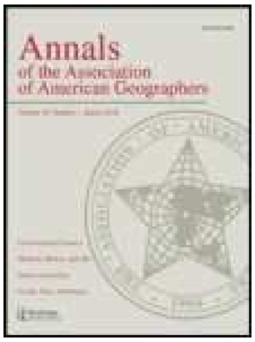

Annals of the Association of American Geographers

ISSN: 0004-5608 (Print) 1467-8306 (Online) Journal homepage: http://www.tandfonline.com/loi/raag20

Biology and Beyond: The Science of “Back to Nature” Farming in the United States

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Organic farming, biodynamic farming, and other alternative approaches to agriculture are often described in spatial terms such as "close to," "going back to," and "following" nature, and correspondingly represent a production process that is ineluctably local, farmer-led, and relies on minimal external inputs, especially in terms of science and technology. In contrast to this representation, however, this article argues that going back to nature is, and has been, a scientific process. An examination of the development of several key ideas in alternative agriculture reveals the participation of scientists and the pursuit of scientific research resulting in a diverse range of society-nature relationships and agricultural technologies. By applying Bruno Latour's circulatory model of scientific work to the endeavors of people involved in U.S. alternative agriculture, I show how networks of people involved in alternative agriculture, like scientific disciplines, have produced "immutable mobiles," or ideas that travel across time and space, and have made control of knowledge as much a focus as control of crop production. This investigation seeks to contribute to current analyses of the rise of the organic agriculture movement and more broadly to our understanding of the dynamics of alternative groups and the generation of alternative ideas. Latour's model proves effective for analyzing the mechanisms through which new knowledge is generated, even outside conventional academic disciplines. Deploying this model within a context of power, particularly Foucault's ideas about discourse, is necessary to evaluate why some ideas prove more successful than others.
Key Words: alternative knowledge, Bruno Latour, organic agriculture, soil fertility.

Examples of farmers' knowledge and non-Western indigenous knowledge are often appreciated as local phenomena—rich and complex systems beautifully attuned to the surrounding ecology. A great deal of research and field experience supports that perspective, even though it risks a false divide between scientific and alternative or farmers' knowledge. As many have argued, alternative knowledge systems can be supported by long-lived institutions enlivened by generalizeable concepts and methods transferable across time and space—characteristics often considered hallmarks of Western science (Agrawal 1995; Watson-Verran and Turnbull 1995; Raedeke and Rikoon 1997; Kothari 2002). In addition, an expanding body of scholarship has emphasized the diversity, discontinuity, and contingency of conventional scientific processes (e.g., Aronowitz 1988; Brown 1993; Croissant and Restivo 1995; Jasanov 1995; Galison and Stump 1996; Haraway 1996; Nader 1996; Rouse 1996a; Demerrit 1998; Gieryn 1999; Knorr-Cetina 1999).

Alternative agricultural theories and practices in the United States (by which I mean practices not typically researched and taught by land grant universities and other mainstream centers of knowledge production) have been characterized as ascientific or even oppositional to science by advocates and detractors alike (e.g., Degregori 2003; Smidt and Brimer 2005). As I will detail here, however, many U.S. alternative agricultural efforts have collaborated with accredited scientists and made scientific research and technological development a central part of their self-definition and bids for legitimacy. Arguments for an improved agricultural science form a foundational piece of the alternative agricultural platform built in the United States (and other countries) during the past sixty to eighty years. The rise of so-called "industrial" farming in the United States since the end of World War II, characterized by increased use of synthetic chemicals as well as expansion and homogenization of production (Goodman, Sorj, and Wilkinson 1987; Foster and Magdoff 1998; Smil 2001), has been accompanied by reactionary movements to define agriculture in other ways.

In this article I track the emergence of three distinct alternative theories about soil fertility embedded in efforts around *organic, ecoagriculture*, and *biodynamic* farming. I employ Bruno Latour's circulatory model of scientific work to explore how networks of people involved in these alternative groups have made control of knowledge as much a focus as control of crop production and have produced "immutable mobiles," or ideas that travel across time and space (Latour 1999). The development of scientific information, I argue, has been a

Annals of the Association of American Geographers, 97(2), 2007, pp. 298–312
Initial submission, June 2005; revised submissions, April and September 2006; final acceptance, September 2006
Published by Blackwell Publishing, 350 Main Street, Malden, MA 02148, and 9600 Garsington Road, Oxford OX4 2DQ, U.K.

critical strategy used by these groups in their bids for expanded legitimacy with farmers and also with consumers, policymakers and others involved in the food system. I show how the development of alternative agriculture has been a scientific enterprise, how that effort is a social, communicative activity, and how the alliances pursued by these alternative groups have played a role in the current acceptance of their ideas.

Conventional and Alternative Ideas about Soil Fertility

Soil fertility, the management of soil to feed plants, has been a central and continuous focus for groups working on alternative agriculture. Arguments have been made since the 1920s that the use of industrially produced agricultural chemicals destroys soil life and structure—the very basis on which sound agriculture depends. Whereas a conventional farmer might view the process of feeding crops as supplying a water soluble diet of mainly three chemical nutrients, nitrogen, phosphorus, and potassium (or NPK), alternative approaches expand and develop very different information about plant-soil relationships. Alternative agriculture advocates view the conventional approach as a depauperate and vastly abbreviated understanding of plant health and plant-soil relationships, emphasizing in contrast the great range of soil microorganisms or diversity of chemicals that play a role in the plant-soil relationship.

Conventional farmers in the United States employ industrially produced chemicals to control weeds and pests and also to manage soil fertility. Per-acre consumption of industrially produced fertilizers containing NPK has risen, at times precipitously, since the end of World War II when industrial capacity for capturing nitrogen was freed up from military activities and focused on producing agricultural inputs (Foster and Magdoff 1998; Smil 2001). The synthesis of ammonia for nitrogen fertilizer production ranks as one of the most important industrial discoveries, meriting the award of two separate Nobel prizes—first to Fritz Haber in 1918 and then to Carl Bosch in 1931. For more than seventy years, millions of tons of ammonia have been produced annually through the Haber-Bosch process; fertilizer made from this ammonia is estimated to be responsible for sustaining roughly 40 percent of the world's population and is the source for 40–60 percent of the nitrogen in the human body (Smil 2001; Fryzuk 2004). The USDA Economic Research Service reports some 20 million nutrient tons of NPK applied to more than 302 million farmed acres in this country in 2001. On U.S. cornfields alone, commercial nitrogen was applied to 98 percent of 61.2 million crop acres in the year 2000, at an average application rate of 137 pounds per acre.

Since the beginning of this spectacular development, however, the use of these chemicals in agriculture has had critics. Even while desperate for solutions to soil fertility and pest problems in the first half of the last century, farmers, scientists, and others voiced concerns over the environmental sustainability of such practices, and critiqued the social implications and perceived collusion of government and industry in the support of the "chemical" approach to growing food (Steiner 1924/1993; Albrecht 1938; Rodale 1945, 1949; Howard 1946; Pfeiffer 1947a; Balfour 1950). In 1940 the British botanist Sir Albert Howard expressed dismay at the state of agriculture in Britain: "The amalgamation of the artificial manure industry, the Ministry of agriculture, the experiment stations, the agricultural colleges, the agricultural press, and the country agricultural committees is complete. All urge upon the farmer and the gardener the use of more and more chemicals almost as a moral duty" (1940, 7).

Generative Networks: Creating New Ideas about Growing Food

I use the term *generative network* to describe the relationships and activities of farmers, crop consultants, research scientists, publishers, journalists, gentleman farmers, gardeners, health officials, and others working together and with crops, animals, and soil to develop and disseminate alternative ideas about soil fertility in the United States. The arena of "alternative agriculture" is wide and diverse. Alternative farming networks include Bill Mollison and his work on permaculture, the Leubkes' efforts related to microbial composting, Masanobu Fukuoka's natural farming, and biointensive farming advanced through the work of John Jeavons. The alternative approaches of organic agriculture, biodynamic agriculture, and ecoagriculture stand out in particular as influential and longer-lived networks. Organic and biodynamic approaches are among the oldest, biodynamics originating in the 1920s and organics in the 1930s. The federal government, of course, now regulates organic production, which is nowhere near the alternative it once was. The shift from marginalized to mainstream for organics has been so radical, and has accompanied a general cultural acceptance of an "ecological" view of the world in so many sectors besides agriculture (FitzSimmons 2004), that it is easy to forget how outrageous the organic worldview appeared only a few decades ago.[1]

Although these groups do agree on certain soil fertility principles (e.g., organic matter is considered generally important), key principles and practices are emphasized very differently. Some farmers may apply a combination of these approaches or move between information networks looking for new ideas, and each group provides an alternative concept of nature and has developed diverse technologies for managing it. In addition, these groups are differently organized and motivated, employing different discursive strategies, and support distinct conferences, newsletters, journals, and farmer audiences.

Together, these three networks have had a tremendous impact on the development of alternative agriculture around the world. They share a strategy of using science to build distinct bodies of knowledge and to withstand decades of marginalization and often outright derision from people in the mainstream. Although the science of organic farming has become increasingly acceptable in many conventional circles, some scientific ideas from biodynamic and ecoagriculture approaches remain beyond the pale. The juxtaposition of these three networks allows us to consider the diversity of agricultural visions of nature and to see similarities in strategies of knowledge-creation; it also provides opportunities for evaluating the success of alternative knowledge networks. Bruno Latour's work on the production of scientific information offers many insights into how these alternative networks have developed an alternative science enabling farmers to "go back to nature." Extending beyond a survey of strategies and with a goal of increasing understanding of the current resonance of once-alternative ideas, I consider these networks in terms of their discursive context with the help of the work of Michel Foucault.

Tracing Latourian Networks

Bruno Latour has written about the efforts of scientists working to develop powerful disciplinary identities (1999); his ideas provide an excellent approach for analyzing knowledge production in alternative networks as well. In his book *Pandora's Hope*, Latour explores the work of soil scientists laboring to establish and defend scientific facts in the context of their discipline. He develops a model of scientific knowledge production in which the activities of human and nonhuman agents are a kind of "blood-flow," sustaining the life of accepted facts and the credibility and value of disciplines to the larger society (1999). This approach, an essentially communicative understanding of the development of scientific knowledge, emphasizes dynamic relationships with material nature and also the particular strategies scientists choose to delimit and characterize their ideas, and to build alliances to convince others of the importance of their work. Margaret FitzSimmons (2004) has used Latour's approach in her analysis of the disciplinary tactics of ecologists, allowing her to show how the Ecological Society of America has created the conditions for a powerful public conviction of the importance of ecology and significant funding for research.

Latour identifies four types of activities in his circulatory model. All four of these efforts are ongoing and simultaneous, pumping life and credibility into theories, technologies, and facts:

- *Mobilization* involves activities perhaps most readily associated with science—that is, the identifying, defining, and labeling parts of the natural and material world and the prioritization of those parts in explaining the functioning of a system. Mobilization also involves the development of technologies that frame and define these engagements with the material world.
- *Public representation* involves fostering a public appreciation and understanding for scientific work. This is what Latour identifies as the "massive socialization" of novel objects that would present a "terrible shock to people's everyday practice" if continuous efforts were not being made by scientists to talk to reporters and policymakers and others explaining and justifying them. Stem cells offer a good example of a novel object that has been at the center of a great deal of efforts related to public representation.
- *Autonomization* is the establishment of areas of expertise; the boundary work of creating standards by which the expertise of a group is evaluated and set apart as a valuable and necessary enterprise.
- *Alliances* refers to how knowledge producers build the necessary connections with powerful groups that can help fund jobs, buildings, and equipment. As Latour illustrates, "The military must be made interested in physics, industrialists in chemistry, kings in cartography, teachers in educational theory, congressmen in political science" (1999, 104).

Applying Latour's model in the context of "unconventional" science underscores the communicative, discursive nature of knowledge production, and reveals the similarity of strategies between groups working in areas of accepted, mainstream science and others working to build alternative ideas. As Donna Haraway (1997) has observed, all technology requires institutional and social support; even so-called natural technologies like breast-feeding (and organic agriculture) are unsuccessful without teachers to educate new practitioners, experts to solve problems, and groups to retain information, gather knowledge, and provide social approbation. Even where groups overtly tout motivations beyond some objective will to know (e.g., a religious, economic, or ecological mandate), they engage similar strategies to selectively engage with the material world, to build legitimate scientific arguments, and to disseminate ideas. Actors in all three networks also share foundational criticisms of mainstream agricultural science. These groups challenge the alignments of power in the production of agricultural knowledge and argue that a materialistic, reductionist, and industrial orientation of science and technological development leaves the endeavor poorly situated to support sustainable agriculture. Once they move beyond this initial critique of the conventional scientific enterprise to build alternative scientific ideas, however, the three groups orient themselves to very different aspects of nature and look in very different directions to further their research and development interests. Alternative agricultural discourses thus both critique conventional science practice and rely on scientific arguments to gain legitimacy. Through both distinction and alignment, alternative agriculture proponents work to establish their territories of knowledge.

For more than fifty years, books, research articles, farmers' workshops, conferences, field days, and, more recently, Internet discussions have carried the discourse of alternative agriculture's generative networks, creating and circulating knowledge. Beginning in the 1930s and 1940s in the United States, the development of ideas about soil fertility is reflected in books and magazine articles about alternative agriculture. For this research I read past research on alternative soil fertility management and also attended many current agricultural conferences and workshops and interviewed farmers and other practitioners and teachers. Steve Diver of the National Sustainable Agriculture Information Service, who has also surveyed the development of alternative approaches in farming (2002), is agnostic about the superiority of one approach over the other, emphasizing farmer success with them all. As he put it to me in a 2001 phone interview: "The way people approach soil fertility depends on production, philosophy, scale, etcetera. There are no absolutes. All these approaches work because nature is so diverse and forgiving. Whether you focus on Albrecht [a key figure in the ecoagriculture approach] or on organic matter, there is good technology and good science behind all of these ideas."

Limits to the Network Approach

In the following sections I use Latour's model to explore the three agricultural generative networks and the processes through which new ideas and practices have been generated and developed. Latour's work has been well received by geographers interested in new approaches to human-environment relationships; his emphasis on nonhuman agency and the falseness of a divide between society and nature have been critical contributions. At the same time, his work has been the subject of an ongoing discussion about his perceived failure to deal with predicted and predictable relations of power and social hierarchies (Goodman and Watts 1997; Castree 2002; Whatmore 2002; Smith 2005). Indeed, even while he claims to put the political back into the lab, Latour does not relate his ideas to the very sizeable and influential areas of scholarship focused on patterns of power and dominance.

As he makes clear in *Reassembling the Social*, Latour wishes social scientists to study the particular actors and specific activities through which power is created and to steer clear of substituting these activities for "an invisible, unmovable, and homogeneous world of power for itself" (2005, 86). He wants us to avoid relying on "invisible social forces" (the market, the state, class) or to "confuse the assembling of the collective with the mere review of the entities already assembled or with a bundle of homogeneous social ties" (103). He advocates instead for a very "practical world-building enterprise" of carefully and humbly observing relations, following associations, tracing networks.

Latour's position is bound to upset people because it is not just an academic project that has produced evidence and theories of patterns of power, but it is also an overtly political position in which people have invested a great deal of effort not only to explain the world but also to critique and change it. In addition, tracing Latourian connections is a multifaceted undertaking as one pursues various economic, moral, political, and other relationships between humans and nonhumans, all of which are potential agents. It seems almost disingenuous that Latour pays so little attention to the methodological challenge of how a researcher must choose an orientation and a place to start, and must make priorities in tracing associations.

Foucault's writing about the discursive nature of society, the capillary nature of power, and knowledge as a powerful shaper of institutional commitments and individual behavior offers an effective complement to Latour's focus on the associations and relations of actors and networks. The works of Foucault and Latour, in fact, inform each other in useful ways. By revealing the falseness of a nature-society divide, for example, Latour offers a way to extend Foucault's ideas into the natural world and the natural sciences, an area Foucault left undeveloped (Rouse 1996a; Rutherford 2000). Foucault explains the relationship between power and the creation of truth in a way that augments Latour's approach with attention to power: "Truth is a system of ordered procedures for the production, regulation, distribution, circulation and operation of statements. . . . Truth is linked in a circular relation with systems of power which produce and sustain it" (1980, 133). Foucault also describes how science and scientific institutions are part of a "system of exclusion" reinforced and renewed by a whole strata of practices, including teaching, publishing, learned societies, and laboratories, as well as how knowledge is put to work in society (1981, 55). He offers multiple examples of how scholarly work must be sensitive to current arrangements of power and explore how technologies, protocols, and conventional modes of understanding all work together in perpetuating those arrangements.

Foucault (1990, 100) also offers insight into the strategies people may use to challenge alignments of power and to gain legitimacy. He writes that

> we must conceive of discourse as a series of discontinuous segments whose tactical function is neither uniform nor stable. To be more precise, we must not imagine a world of discourse divided between . . . the dominant discourse and the dominated one, but as a multiplicity of discursive elements that can come into play in various strategies. It is this distribution that we must reconstruct. . . . Discourse transmits and produces power; it reinforces it, but also undermines and exposes it, renders it fragile and makes it possible to thwart it.

Joseph Rouse, for example, employs Foucault's approach in his examination of Creationist groups' strategies for gaining legitimacy. These strategies include, he writes, "an interesting mix of trying to subvert or co-opt elements of the dominant epistemic alignment that established and enforced the rationality of belief in Darwinian theory, and in trying to create alternative alignments (Christian schools, creationist research and textbooks, etc.) that would enable them to bypass it" (1996b, 414). In other words, these groups both challenge conventional evolutionary theory in scientific terms and also work to build relationships with groups who may or may not be persuaded by scientific argument.

Attention to Foucault's "dominant epistemic alignments" charges the discursive medium within which we as researchers work to trace networks and to decipher strategies and understand why specific strategies might appear promising to actors within a network or end up being related to a group's success. Importantly, this also underscores that the success or failure or a group cannot be attributed solely to the agency of members of the network, another aspect of Latour's approach that has been criticized (Star 1991; Haraway 1996). In other words, the success of a group may be as much "being in the right place at the right time" as the result of well-designed strategies on the part of actors within a network.

In the next section I describe how people involved in these generative networks conceptualize soil fertility and the implications for concepts of nature and technological development (Latour's "mobilization"). I also describe key strategies pursued by people trying to convince others of the importance of their ideas about soil, revealing how people both critique and employ the language of science ("public representation" in Latour's model). There are, of course, many other activities engaged in by the networks of organic, biodynamic, and ecoagriculture farming; I do not discuss organic certification and regulation, for example, or anthroposophy (the larger philosophical context for biodynamics). My focus on soil fertility is informed by the centrality of soil across alternative agricultural efforts as well as my interest in how scientific arguments are used to define very different concepts and technologies of nature.

Natural Engagements: Biology, Energy, and Spirit in Alternative Soil Fertility Management

Organic Agriculture

> The surest route to improving soil fertility is to provide the most hospitable conditions for soil life . . . adequate food, air, and water.
>
> —(Gershuny and Smillie 1986)

A central focus for organic theories of soil fertility is life in the soil. From the efforts of pioneers and founders such as Sir Albert Howard, Lady Eve Balfour, Newman Turner, and others involved in Britain's natural farming movement in the 1930s and 1940s up until today, organic supporters have argued for building the biological diversity and health of the soil in order to feed the plant. Only a few short decades ago, organic agriculture was considered to be the territory of back-to-the-land cranks, offering little in terms of real improvements in crop production or economic development. Currently, of course, organics enjoys widespread attention reflected in a booming market for organic products (20 percent per year since 1990), a federal law legislating organic production standards, increasing acceptance and teaching in research and educational institutions, and a growing list of peer-reviewed scientific publications establishing the validity of the organic approach. Before this widespread acceptance, however, organic agriculture stood apart for its focus on a (now routinely accepted) biological, ecological conception of nature, placing the relationships between living things, and processes of death and decay, as central to farm management. The health of the soil, defined by the number and diversity of living soil organisms, was proposed by early supporters of the organic approach as foundational to crop production as well as to healthier crop plants and more general farm prosperity.

Sir Albert Howard, considered a founder of organics by many, worked as a botanist for the British government in India in the 1920s and 1930s and was inspired to these ideas in part through what he learned from traditional peasant agricultural practices, especially composting, as well as what he read in the work of other scientists writing at the time. He applauded "the Indian cultivator" for conservation of soil fertility, stating: "He is by no means ignorant and backward, but among the most economical farmers in the world" (1940, 210). Howard's work also mentions S. A. Waksman's 1938 volume, *Humus: Origin, Chemical Composition, and Importance in Nature*, and F. H. King's *Farmers of Forty Centuries* (1911), both of which emphasize the importance of biological activity in the soil and the critical relation of biological processes of decay to soil fertility and sustainable agriculture. Howard focused on the role of soil's organic matter—and especially humus—in plant health and its connection and importance to a healthy agricultural enterprise (Howard 1940, 1946, 1947; Gieryn 1999). A survey of his publications reveals research on a range of plantation crops in different countries to develop composting technology taking advantage of local sources of biological matter and cycles of death and decay, and fostering biological activity to create the critical plant-feeding element of humus.

This focus on biological elements of soil and the development of technologies, such as composting and crop rotation in order to encourage healthy soil bacteria, was central to the development of the organic theory of soil fertility. The development of composting required "enrolling" natural actors, as Latour might describe it, engaging with the bacteria and fungi that participate in the breakdown of plant and animal wastes and the creation of humus. "It must never be forgotten that living organisms and not human beings are the agents which make compost," Howard wrote (1947, 212). The identification and classification of these tiny natural actors, and research into how to best create conditions conducive to their participation in fostering soil fertility, form a central focus of organic practice. In *The Soul of Soil*, a short, widely read primer on organic soil management, authors Grace Gershuny and Joseph Smillie write, for example, "Compost fosters the biological processes in the soil. Its use is a major tool in the creation and preservation of soil fertility" (1986, 52). Eliot Coleman, an organic farmer and author in New England, writes similarly, "Even though a product is produced, in farming the process is anything but industrial. It is biological. We are dealing with a vital, living system rather than an inert manufacturing process" (1989, 3). Agriculture is no more an industrial process than is music, insists Coleman, who compares the farmer to an orchestra conductor, whose job "is not to play each instrument but rather to nurture the union of the disparate parts . . . and combine them in a harmonious whole." He also echoes the words of Sir Albert Howard: "Even if I thought I knew everything I would rather let it be done for me by the real experts . . . activities of bacteria, fungi, dilute soil acids, chemical reactions, rhizosphere effects, and countless others we are unaware of" (1989, 99). The roles of soil microorganisms and organic matter in soil fertility and the development of expertise in practices like composting remain central focal points, and related technologies have undergone continuous research and development in organic research (e.g., Harwood 1984; Lampkin 1990; Ingham, Moldenke, and Edwards 2000).

In terms of how organic supporters reach out to other audiences about the importance of their approach—the "public representation"—Sir Albert Howard argued at length that following an organic agricultural path was central to a healthy body and also to the health of the nation. Howard and his colleagues were fully convinced that included in the price paid for a sick agricultural system was poor human and livestock health, declining as a result of food grown on depleted soils (e.g., Balfour 1950). He made a pitch for a more public appreciation of these ideas, and in *An Agricultural Testament* (1940) describes at length the importance of soil fertility to human health. He joined other British "organicists" in prescribing a whole natural program of improved nationhood through soil health (Matless 1998). J. I. Rodale, whose publishing activities were the primary vehicle by which Howard's ideas were introduced to the

United States, was primarily interested in organic agriculture from a health perspective, according to his son Robert (USDA NAL 1989). Rodale's publications targeted individual consumers as much as they did farmers, emphasizing in publications such as *Fact Digest* the alternative of organic food for people concerned about pesticide residues and overprocessing of food. In 1947, J. I. Rodale started the Soil and Health Foundation, later renamed the Rodale Institute, to pursue research on organic agriculture and connections to human health. Thus, the connection of soil health and human health through organic practice, a central piece of the success of organic agriculture today, was also part of how early supporters publicly represented the network.

Contestation over scientific proof of the nutritional superiority of organic products has meant that many contemporary proponents of organics argue for a soil health–human health connection more obliquely, and scientific work attesting to the absence of pesticide residues has become a more central piece of arguments for the health advantages of organic consumption (e.g., Baker et al. 2002; Benbrook 2003). Other proponents of the organic cause have argued that it is dangerous for the movement to base too much of its self-promotion on the health connection, since in the face of lack of definitive scientific evidence, organics stand to lose legitimacy, and it is the larger health of the soil, the farm, and the surrounding environment that is a more foundational concept (Gussow 1991). Health claims of organic agriculture are a focal point for challenges from the movement's detractors, who call attention to the lack of evidence for nutritional advantage and also food safety issues related to the use of manure and compost (Tierney 2000; Trewavas 2001; Avery 2003). However, many organic advocates remain direct about the nutritional superiority of organics. Author Eliot Coleman (1989, 33) has written:

> There is definitely a "biological value" in food plants . . . lost by inadequate soil fertility. . . . For the most part, scientific evidence on the subject of food's biological value is contradictory and incomplete . . . there are documented differences in food quality . . . but not enough to constitute "absolute proof"—as if absolute proof is ever possible with any biological concept . . . but the sensible consumer doesn't always wait for science. The consumer has generally led science rather than followed it.

Coleman's statement also reflects an attitude frequently encountered in opinions voiced by members of the organic network: that biologically complex systems are very difficult for conventional science to accurately embrace. Additionally, the lack of data proving a soil health–human health connection, supporters suggest, is only because the research has not yet been done—conventional science is just not "there yet." Many organic advocates (Lipson 1997; Kirschenmann 1999) argue that researchers at land grant universities can do a great deal to further the organic agenda by developing more effective "systems research" methodologies and by adopting more precautionary and participatory approaches involving farmers. Associated with this orientation, people in the organic network have actively pursued policy changes to bring more public money f rom the government to fund organic research (Sooby 2003).

Ecoagriculture

> Since energy is the key to crop production, it is important to provide energy to the field as well as to create conditions . . . whereby energies from the cosmos, fertilizers, rain, sunlight, etc. can be received, controlled, and transferred.
>
> —(Wheeler and Ward 1998)

A second approach to soil fertility considered here involves a vastly expanded focus on the chemical and energetic nature of the soil and soil fertility. Charles Walters, agriculture journalist and publisher, claimed the term "ecoagriculture" to describe a combination of ecological farming approaches that he believed would aid farmers in economic success. Since 1970 his publishing enterprise, Acres U.S.A., and newsmagazine of the same name have provided a platform for the airing of a wide variety of alternative theories and practices. The publication reflects a unique focus on agriculture, emphasizing the importance of micronutrients in plant health, nutrient balance, and "energetics" created by different ratios of nutrients in the soil. Energetics, supporters say, works much like a low-level magnetic field influencing plant health, and can be managed through the administration of various chemical nutrients as well as organic matter management.

The ecoagriculture network is a homegrown phenomenon. Charles Walters was a child of the dustbowl and dedicated his career as a journalist and publisher to supporting farmers. Before founding Acres U.S.A., he worked for the National Farmers Organization (Walters 1986). He founded Acres, he told me in a 2001 phone interview, in order to provide a forum for ideas that he believed were being ignored in mainstream agricultural media. *Acres U.S.A.* reports a circulation of approximately 12,000, and the organization sponsors an annual meeting in the Midwest; the one in 2000 was attended by some 1,200 people. The network relies heavily on the work of agricultural consultants to both develop and circulate ideas. People like Gary Zimmer of Midwestern Bio-Ag and Neal Kinsey of Kinsey's Agricultural Services have well-established agricultural consulting businesses offering regularly scheduled field days, workshops, and a network of regularly attended conferences around the world.

Walters views agricultural consultants as effective vehicles for the development and circulation of new ideas because, as he puts it, "they know more than one farm." Walters has assisted several consultants in writing books published by Acres U.S.A., and told me that a primary role of the magazine, particularly the interview section, has been to create a written record of ideas developed by consultants and others. "About a third of the people interviewed in that section are now dead," Walters said. "If we don't write down their ideas, they get buried with them."

The ecoagriculture network is also responsible for the continued circulation of work by William Albrecht. A soil scientist at the University of Missouri from 1919 until he retired after 1960, Albrecht pioneered and championed the "cation-balance" or "base saturation" theory of soil fertility, which focuses on the need for particular ratios or balances between nutrients in the soil, especially calcium, magnesium, and potassium (Albrecht 1938, 1948, 1958). Although positively entertained at the time, his work has not survived well in mainstream agronomic circles and is rarely mentioned in contemporary soil science literature. Albrecht worked hard also to champion the "trace" elements: calcium, magnesium, and iron, as well as cobalt, boron, sulfur, and others. His articles, spread out over more than four decades, call attention to these ignored elements, argue for their value, and describe the soil testing technologies available for detecting them and the experiments engaged in to verify their presence, and their relationship with each other.

For Albrecht the presence of these nutrients and their balance was fundamental—no addition of compost or humus would improve soil fertility if this basic requirement had not been met. As a result of this focus, Albrecht was not a supporter of what he called "the organic cult," and he believed firmly that chemical soil amendments were necessary in order to avoid mining the soil. He also did not distinguish between organic and industrially produced chemical fertilizers, a point that kept his work from being published later by Rodale Press, which focused on approaches using exclusively organic methods. He also challenged the organic concept that legume cropping always adds nitrogen to the soil, stating, "Soils must be well stocked with calcium, magnesium, potassium, boron, manganese, copper, zinc and many other 'trace' (elements) before legumes will grow. Only after legumes have a *balanced* soil fertility . . . will those plants add the nitrogen of the atmosphere" (1958, 170). Albrecht was a vocal critic of mainstream approaches to fertility management, however, especially soluble fertilizers. He repeatedly called attention to chemical relationships involved in plant nutrition, and what he described as "insoluble but yet available" elements. This is purposefully in contrast to conventional approaches, which rely on aqueous (soluble) solutions of nutrients to feed crop plants. "The transpiration stream of water from the soil, through the plant, and into the atmosphere is independent of the nutrient stream from the soil into the roots," he argued (1958).

Albrecht also presented an interesting mix of high and low technology approaches for understanding the importance of good soil. In addition to describing soil tests, assays, and field experiments, he also advocated soil fertility management via a very passive medium: by "following the cow":

> We need to start observing and judging the cow as she is a chemist on the hoof guiding her own nutrition. That observation and the subscription to her suggestions may well be exercised in advance of our judging her merely as so much beef carcass. . . . Cows must have always been chemists of renowned capabilities to have done so well in keeping the stream of their own lives flowing all these years in spite of us, rather than because of us.
>
> —(1958, 82)

Acres U.S.A. continues to keep Albrecht's work in circulation through publishing, and several consultants teach his approach.

Other consultants and scientists in the network focus on various low-frequency forces emitted by nutrients, which, they argue, can be managed to productively influence the nutrition of crops and the health of consumers. As I learned from the 1999 conference "Subtle Energies in Agriculture" in Phoenix, Arizona, and from subsequent reading and conversations, these energies can be paramagnetic, planetary, or energy created in the soil by interactions between nutrients, all of which can be manipulated to manage crop production.[2] The pages of *Acres U.S.A.* present a much expanded and elaborated set of ideas about the nature of chemical nutrition in soil fertility, going beyond a focus on elements themselves to a focus on the energies exchanged between nutrients in the soil, which can influence plant growth. Ecoagriculture offers numerous specialists and special technologies for accessing the chemical soil universe. Proponents discuss the familiar soil nutrient test, but expand it to include many other nutrients. Other technologies include an electronic scanner developed by Dr. T. Galen Hieronymus that reads the energy intensity of a chosen element; the ERGS meter, which reads Energy Released per Gram per Second of various substances; a paramagnetism meter that "measures the ability of the soil to tune into and receive magnetic energies of the cosmos" (Wheeler and Ward 1998, 54); and a radionic scanner, which produces a General Vitality reading.

Like members of the organic network, the work of public representation pursued by writers and teachers in the ecoagriculture network contains arguments focused on health: that preventing disease and pests in livestock and crops begins with a healthy soil. Especially later in his career, William Albrecht argued forcefully for the connection between soil chemistry, specifically nutrient balance, and the health of livestock and people—work that was never accepted in mainstream soil science journals. In 1957 his "Pattern of Caries in Relation to Pattern of Soil Fertility in the United States" was published in the *Journal of Applied Nutrition*, and in 1950 his articles "Our Teeth and Our Soils," and "Health Is Born in the Soil" were published in *Let's Live* (Albrecht 1950a/1996, 1950b/1996, 1957/1996). In contrast to the organic network's focus on individual health, however, the main focus of the ecoagriculture network is farmers concerned about the health of their livestock and plants, especially as it relates to yield. Consultants who currently practice the Albrecht approach tout the merits of rock powders and other inputs that amend the chemical makeup of the soil as a necessary first step toward good soil biology and ultimately good crop yields and healthy livestock consumers.

Other members of the ecoagriculture network focus on energetic signals given off by crop plants, arguing that insects read these signals and are readily attracted to sick, vulnerable plants but will avoid healthy ones. Alternative ideas about human health are related to many of these arguments, and people involved not infrequently cite the works of maverick medical doctors such as Wilhelm Reich[3] and Carey Reams. Inspired by the Reams approach, which contends that nutrients emit different energies that influence plant growth and human health, Wheeler and Ward, in a book published by Acres U.S.A., argue for the use of a refractometer, a tube-shaped instrument with an eyepiece in one end and a prism at the other. Light passing through juice pressed from a plant's leaves, stem, or fruit and placed on a glass plate at one end is refracted through the prism and reveals the presence of energy-releasing minerals, or the lack of them, in the plant's sugars and starches—its brix level. The authors write, "by raising the sugar levels of his plants, the farmer is able to feed increasingly more valuable feedstuffs. He will have raised the energy value of his feeds with resultant improvements in animal performance, and his veterinary bills will reduce substantially" (Wheeler and Ward 1998, 119). The use of such technology to monitor crop and livestock health is a prevalent aspect of the ecoagriculture network, and the knowledge-consuming farmer a central focus.

Critiques of conventional agricultural and medical science abound in the ecoagriculture literature. In contrast to the organic network where science is described as "not there yet," ecoagriculture participants more frequently reflect the opinion that conventional science is a lost cause. Wheeler and Ward write, for example, that "Science applied to agronomy was . . . pseudo-science masquerading as science because it blindly followed reductionist science procedures without observing the whole picture or relating the results to the reality of nature . . . Modern agronomy applied linear thinking and linear procedures to a non-linear (complex) system called life and got the wrong answers" (1998, 214).

The authors call the NPK approach simplistic, both because it ignores the roles of other nutrients and also because it ignores differences in quality between different sources of the N, P, and K. In contrast to attitudes held in the organic network, ecoagricultural discourse reflects far less interest in developing allies within established scientific institutions. Certainly in keeping with the personal attitude of Charles Walters, much ecoagricultural outreach appeals to farmers who would equate their success with independence from a suspect system of government-supported agricultural research and development. "The answer to pest crop destroyers is sound fertility management in terms of . . . scientific farming principles that USDA, Extension and Land Grant colleges have refused to teach ever since the great discovery was made that fossil fuel companies have grant money" (2003, xiii). Ecoagriculture proponents regularly invoke the economic vulnerability of farmers who choose to follow prescriptions of establishment science, and argue that this kind of science just doesn't "work."

Biodynamic Agriculture

> We must approach everything in farming with the conviction that in order for the whole thing to work, we need to pour life and also astrality into everything around us.
>
> —(Steiner 1924/1993)

The third approach examined here is biodynamic agriculture, built on a set of lectures given in 1924 by Rudolf Steiner, a scientist and philosopher whose work on natural science and spirituality was inspired in part by Goethe. Steiner referred to his work as “spiritual science,” and he elaborated on a wide range of topics including medicine, art, architecture, education (he developed the Waldorf educational model), and agriculture. His ideas led to the founding of the anthroposophy movement in Germany in 1912. Steiner approached spirituality not on a religious or individualistic basis, but as a set of predictable, natural forces that guide and shape physical and emotional formation. Biodynamic agriculture involves the understanding and manipulation of these forces, often referred to as cosmic, ethereal, and astral forces, which shape animal and plant growth and development. Biodynamic management can be accomplished through various on-farm practices that concentrate, or build, these forces in soil and plants. Special herbal preparations, for example, are formulated by the farmer and administered to fields, plants, or compost piles in order to manage positive natural forces to promote growth and fruiting in crop plants, or the processes of digestion and decay in a compost pile.

Steiner gave his lectures over a period of nine days to a group of farmers concerned about soils becoming depleted and deterioration in the health and quality of crops and livestock. The lectures, held in June of 1924 at a farmer’s estate in what is now Poland, form the basis of biodynamic practice. One of the farmers present was the father of Ruth Zinniker, who currently farms in Wisconsin on the first biodynamic farm in the United States. Biodynamics is promoted in the United States through research and educational organizations such as the Bio-Dynamic Farming and Gardening Association, the Josephine Porter Institute, the Michael Fields Institute, and the Woods End Institute. A scientist and student of Steiner’s, Ehrenfried Pfeiffer (1947a) was instrumental in bringing Steiner’s ideas to the United States, starting a research lab in New York in 1938, and initiating the journal *Biodynamics*. Biodynamic agriculture is certified for market by an international organization, Demeter. Demeter’s website[4] reports a membership of some 3,000 partners in forty countries, involving more than 1,000,000 hectares of biodynamic cultivation. Demeter is a registered trademark in more than fifty countries, representing a steady increase since the organization’s inception. Although the trademark has a relatively low profile in the United States compared to Europe, Australia, and New Zealand, Jim Fulmer, the director of U.S. Demeter, informed me in a 2005 phone interview that interest in certified biodynamic cultivation is growing in the United States, particularly in the wine industry.

Nature, as understood by Steiner and by biodynamic practitioners who follow his ideas, cannot be comprehended without an understanding of spiritual forces. Like organic farmers, biodynamic farmers pay close attention to soil life, but they also observe cosmic and ethereal influences, which drive and define the behavior of natural elements like nitrogen, silica, lime, water, and other elements in soil, plants, and animals. These influences are rhythmic, shifting on diurnal and seasonal bases, and farmers are able to both take advantage of and actively manage these life forces in order to improve soil fertility and crop production, fight disease and pests, and, critically for the biodynamic farmer, improve the spiritual and nutritional substance of crops. Specific technological developments include the use of astronomical calendars indicating force ebbs and flows, and biodynamic preparations that are mixed and placed in the soil, compost pile, or other places on the farm during various times of the year. The preparations channel the natural forces to enhance plant growth and fruit production as well as to enliven the soil and promote decay in a compost pile. Research on the influence of biodynamic preparations and other practices has occurred both on farms and in laboratories for decades. Although the majority of it is published in German, scientific work on biodynamics has been published in English as well (e.g., Pfeiffer 1947b; Koepf 1993; Brinton 1997). The biodynamic approach has received increasing attention, especially in the wake of the success of organics, and has been assessed very favorably in mainstream research venues (Reganold et al. 1993, 2001).

General understanding or acceptance of biodynamics remains at a minimum, however, no doubt due to Steiner’s apparently bizarre worldview of the role of the cosmos in plant and animal development. Moreover, Steiner’s concept of a spiritual science is problematic for a conventional view that typically places spirituality and science at opposite ends of a spectrum. Even while reviewing favorable research findings about biodynamically treated soil, for example, a Ph.D. soil scientist from a land grant institution recently described the biodynamic practice of administering herbal preparations as similar to “driving a tractor naked.”[5] In other words, biodynamics works because it follows practices we recognize from organic agriculture as ecologically sound. The rest is wacky practice with no apparent positive or negative influence on soil fertility.

In terms of public representation, a deep connection between agriculture and physical and spiritual health is of fundamental importance in biodynamics. A farmer’s care of the soil is often compared to a doctor's care of a patient's body, and through the production of food, farmers contribute specifically to the spiritual as well as physical health of people and animals. In his book on biodynamic farming, Herbert Koepf positions biodynamics within a larger endeavor of improving the health and well-being of society. He writes, "Balanced environmental influences bring about the harmonious development of a plant. It seems obvious that such plant foodstuffs are also the most wholesome and beneficial for the human and animal organisms" (1989, 175). According to the Biodynamic Farming and Gardening Association, biodynamic gardeners brought the CSA concept (Community Supported Agriculture) from Europe to North America in the mid-1980s with the explicit purpose of furthering society's physical and spiritual health through agriculture. In a CSA arrangement a biodynamic farmer can contribute to more general spiritual health by producing nutritionally complete food and providing it directly to consumers who "subscribe" to or underwrite the farming operation. More than 600 farms and gardens from around the United States are listed in the Biodynamic Farming and Gardening Association's CSA/Biodynamic database.

In his lectures Steiner argued for his approach as a spiritual science but was tentative about encouraging scrutiny of biodynamics from conventional scientists who would ridicule the approach. Dr. Ehrenfried Pfeiffer and a number of other credentialed scientists in the network, however, have been very clear about their use of science to establish the effectiveness of biodynamics and to combat the label of "cult" (Goldstein 2000). Herbert Koepf has written, "Conventional and biodynamic farming share, in part, a large body of knowledge, but they are at variance on how to utilize it" (1989, 35). Koepf is adamant that the path of knowledge and awareness he describes is not traditionalism, but rational, clear-minded, and scientific thinking. "Biodynamics has nothing to do with either the narrow-minded reflection of lunar rhythms in life or a blind belief in traditional sayings. Biodynamic farmers and research approach a problem through an unbiased reading of the phenomena and through clearly designed experiments" (113).

Evaluating Network Success

As laid out in the preceding sections, deploying Latour's approach in the kind of charged discursive medium described by Foucault guides us to think about broader conversations, arguments, and institutional arrangements within which alternative agricultural networks have operated and to which they have responded. We might consider a whole galaxy of issues such as shifts in personal consumption patterns, international trade and agricultural policy, the development of new technologies, nutrition, rural development, migrant labor, food security, and food safety. Recurrent problems and institutional failures in a number of overlapping areas have provided opportunities for marginalized ideas to gain more adherents (Rao, Morrill, and Zald, 2000). The entertainment of alternative agriculture by larger audiences, especially the growth of organics in the marketplace, occurred as economic, environmental, and social ills in conventional agricultural began to accumulate throughout the 1980s (Adams 2003). In the mid-1980s more than 200,000 farms went bankrupt, and conventional agriculture became a new environmental frontier as pesticides and nitrates were identified in the groundwaters of most states. Overfertilization by farmers was fingered as responsible for health and environmental blights like "blue babies" and the "dead zone" in the Gulf of Mexico. The U.S. Environmental Protection Agency identified agriculture as the largest nonpoint source of water pollution. Pesticides and antibiotics in food became major public issues. Augmenting this, trends in agricultural concentration resulted in dramatic land use and demographic changes in rural areas and a whole new public image problem for the American farmer. Rural residents found themselves living near huge livestock operations that held thousands, even millions, of animals. Problems with smell, noise, and air and water pollution created an increasingly critical public view of agriculture. Many more people began to think about the origins of the food they eat.

These crises in conventional agriculture provided multiple opportunities for alternative ideas about food and farming to move more into the mainstream. Much has been written about the rise of the organic movement and the political economy of the emergence of the organic market (e.g., see Buck, Getz, and Guthman 1997; Guthman 1998, 2000, 2004; Allen and Kovach 2000; DeLind 2000; Vos 2000; Campbell and Liepins 2001; Mansfield 2004; Ingram and Ingram 2005; Ingram, forthcoming). A focus on the production of alternative soil science and the discursive elements around which networks have organized adds to this discussion by indicating why some alternative ideas have resonated so well and where generative networks can claim responsibility for their success. For example, compared to biodynamics and ecoagriculture, organics has clearly benefited from the rise of biological ecological discourse in the sciences (Benson, Maienschein, and Rainger 1991; FitzSimmons 2004). In addition, the increasing dominance of consumer culture and society's particular focus on the (human) body as a focal point of consumption (Baudrillard 1998) was well anticipated by people in the organic network.

As I have reviewed here, all three of these networks argue extensively for a soil health–human health connection. However, the organic network aggressively positioned itself to benefit from increasing food safety concerns and consumers' personal health focus. With his concentration on personal health, and the strategies he pursued (e.g., magazines dedicated to nonfarmers) to educate individual consumers about the ills of conventional produce and the benefits of organic agriculture, J. I. Rodale beautifully anticipated a growing consumer concern with various methods of food production, especially as they related to human health. Organic farmers also responded to this growth in consumer interest, and organized themselves to certify their produce as exceptional, indeed superior, for more than a decade before the federal government became involved in organic standard setting. The power of consumers is also reflected in the burgeoning list of ecolabels being developed by farmers' groups and others working to respond to the new demands consumers are making regarding the quality as well as the quantity of their food. These ecolabels are requiring farmers to expand the list of elements they have previously considered important in food production. People in these networks have paid comparatively little attention to labor issues, for example, those related to both self-exploitation as well as dependence on undervalued and underrepresented work forces. Observing the lack of discourse on these issues in the past helps explain why these generative networks were so poorly prepared to handle this core social justice issue (Allen 1993).

The ecoagriculture and biodynamic networks have continued to make their primary audience farmers, especially farmers in crisis rejecting the mainstream. This has led to the staying power of the networks, but not explosive growth. Both ecoagriculture and biodynamics, oriented toward farmers looking for new ways to farm, have seen growth even as conventional farmers experience health, environmental, and financial troubles. They have also benefited from expanding markets for "green" products, leading more conventional farmers to consider approaches developed in alternative networks for economic reasons. A focus on energetics or spiritual forces in nature, however, remains utterly outside of conventional scientific circles, restricting the number of people engaged in research and outreach efforts on these topics. Organic agriculture, in contrast, has gained numerous accredited supporters within academic disciplines, resulting in increasing peer-reviewed research and the availability of more public funds for organic research and extension.

Conclusions

While the generative networks of organics, biodynamics, and ecoagriculture all produce arguments for going back to nature, they engage nature in radically different ways and develop diverse scientific languages, frameworks, and technologies for managing that nature. Latour's model provides a method for opening up the black box of nature in alternative agriculture and examining the processes through which material nature is engaged, and strategies through which members of alternative networks create separate bodies of knowledge and appeal to wider audiences. These groups have created whole new "nature-cultures," "hybrid geographies," and "imbroglios" for us to consider (Whatmore 2002), advocating variously for biological, energetic, or spiritual connections between farmers, animals, crop plants, soil microbes, and consumers. Although we may not be convinced by any of these specific ideas, the success of these generative networks with a wide range of production-oriented farmers indicate tremendous possibilities for agricultural relationships that have been very meagerly represented in conventional agricultural science and practice.

The generative networks examined here share a common critique of conventional agricultural science. Although they end up realizing very different natures, proponents of alternative agriculture all reject the dominant model as reductionist and mechanistic. This rejection of conventional science, however, is not a rejection of the scientific process, and network participants claim to offer an improved agricultural science. Alternative ideas and practices are often couched in terms sensitive to the role of place and the expertise of individual farmers, but they also relate to alternative technologies that have been generalized, proving effective in different locations and times and transcending boundaries between nations and also between scientists and farmers. Generative networks have kept ideas alive by producing what Bruno Latour has identified as "immutable mobiles": ideas, techniques, and technologies that allow the centers of networks to "act at a distance" (1987).

By categorizing the activities of engagement with material nature separately from those involving public representation and building alliances, Latour's model further allows us to unhitch various evocations of nature from any political mandate. We can call into question, as Noel Castree has, the idea that "talk" of nature, especially a fixed or permanent nature people turn to for moral or political guidance, is inherently conservative (2004). A review of the writings from these networks indeed reveals some very conservative ideas, but also very progressive ones. Therefore, when proponents describe themselves or are described as "working with" or "dancing with" nature, for example, we always need to ask: who leads, and when? Who decides on the music? Latour's model suggests that there are no easy short cuts in our evaluation of these groups. The alternative agricultural networks explored here are informed by a whole spectrum of political and ethical attitudes brought together by a commonly held sense that agricultural science needs to do a better job at observing, responding, and working with nature. Latour allows us to focus on not only the various ways that people envision that job, but also to identify the decision points, key actors, and alliances that contribute to the development of agricultural visions. The ultimate goal of taking this process apart, of course, is to position ourselves to do a better job in the future as we choose our paths back to nature.

Acknowledgments

I would like to thank the anonymous reviewers and section editor for their useful and constructive comments. I am also grateful to Margaret FitzSimmons and Ken Agnew for their engagement and support in the development of the ideas in this article and to Helen Ingram for her willingness to read and reread and for her sound advice.

Notes

1. In a 1971 statement on organic farming, former U.S. Secretary of Agriculture Earl Butz said, "We can go back to organic farming if we must—we know how to do it. However, before we move in that direction, someone must decide which 50 million of our people will starve" (Butz 1971, 19).
2. Attending an Acres Ecoagriculture conference is a mind-bender: One joins an audience that includes Amish in traditional dress and crop consultants in ties (both with cell phones), and bean and corn farmers in caps and overalls, all listening attentively to a lecture on paramagnetism and how to manage subtle energies to promote crop production and fight pests.
3. Reich, who wrote among other things about the social function of sexual suppression, especially its role in fascism, was sent to a U.S. federal penitentiary in 1955, accused of violating interstate commerce laws by marketing an "Orgone Box" as a medical device, especially for solving orgasm difficulties.
4. http://www.demeter.net/ (last accessed 30 January 2007).
5. Statement made during a presentation at the Biodynamic Farming and Gardening Association Annual Conference, 14–16 November 2003, Ames, Iowa.

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