Place-Based Agriculture: Christian Environmentalism Informing Collaborations in Agroecology & Biotechnology

David S. Koetje

To improve food security and environmental sustainability, it is imperative that we follow a paradigm for agricultural research and policy-making rooted in the places we seek to sustain. Place encompasses the ecological and cultural contexts of human enterprises. Appropriate technologies can enhance the resilience of places. However, place is ignored in the prevailing paradigm of industrial agriculture, eroding the cultural and ecological interrelationships upon which agriculture depends. To reverse this trend, we need to develop place-based agricultural systems attuned to the ecology of local bioregions, to the needs and knowledge of local communities, and to the cultural values of precaution, care, and restraint. This new paradigm emerges from a Christian environmental perspective that engages agricultural biotechnology toward the goal of promoting cultural and ecological resilience. In this way, agroecology and biotechnology can collaborate to enhance global food security and ecological sustainability.

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Sense of place helps us to realize that complex webs of environmental and cultural interactions matter a great deal in agriculture.

While most farmers have always paid at least some heed to their cultural and ecological contexts (i.e., their place), agrarian (organic and sustainable agriculture, or agroecology) farmers typically are more keenly attuned to place. A concept gaining prominence in environmental philosophy and science,[1] sense of place helps us to realize that complex webs of environmental and cultural interactions matter a great deal in agriculture.[2] A growing number of consumers concur, spurring organics as the fastest-growing food sector in North America.[3] Unfortunately, place is still deemed irrelevant in industrial agriculture and agricultural biotechnology (agbiotech),[4] where the focus is still on intensive monocultures grown with little respect to place. Most stakeholders in this system are seemingly unaware of ecological literature demonstrating that species-rich ecosystems (such as polycultures) are more resilient to environmental stress.[5] To their credit agbiotech scientists are working to develop transgenic plants with improved environmental stress tolerance, knowing that stress limits crop yields.[6] However, most are failing to incorporate the underlying causes of environmental instability into their solutions. They will claim that this is not their responsibility. As an unintended consequence, the global industrial food system often undermines the resilience of cultural and ecological systems upon which agriculture depends.

In other words, when place is ignored food systems become increasingly vulnerable to crop losses, social discord, and market instabilities. Biotic stress (e.g., pests and pathogens) and abiotic stress (e.g., weather

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extremes, mineral deficiencies/toxicities, and pollution) together reduce average crop productivity by 65–87%.[7] These forms of crop stress are often exacerbated by agricultural intensification: abandoning or simplifying crop rotations, removing field boundary habitats (which act as refuges for beneficial insects and birds) to make way for larger machines, breeding for crop uniformity and yield, relying heavily on fertilizers and pesticides, and intensively irrigating crops.[8] Social discord invariably ensues when corporations announce their intentions to set up large-scale livestock operations (e.g., industrial hog or poultry production facilities) in rural communities.[9] Communities are often split over the social and environmental costs versus the potential economic benefits. In reality, such corporations contribute very little to the community, culturally or economically.[10] The potential for market instabilities is exacerbated by agribusiness consolidation of economic power, which is occurring in both conventional and organic food sectors. When a handful of corporations—ADM, ConAgra, Cargill, and a few others—collectively control more than half of the market share at critical steps in the food system "from seed to shelf," then rural infrastructures and local economies erode—even collapse.[11]

Not recognizing the implicit interconnections between food and places, agbiotech and industrial agriculture proponents tend to overlook the broader social implications, such as globalization, stratification of power, ethics, equity, individual rights, and choice.[12] Instead, policy questions about the efficacy of genetically modified (GM) foods typically focus on narrowly-defined health and environmental safety issues.[13] In attributing the outcry against GM crops to public mistrust of food safety regulators, they fail to recognize that these concerns arise because food has deep cultural significance, heightening opponents' furor.[14] To manipulate food is to run the risk of tampering with our social fabric.

Most profoundly, by failing to come to grips with the importance of place, the agbiotech industry has alienated itself from a potential ally—agrarian agriculture. In fact, the two systems are currently on different ideological tracks (Table 1).[15] Developed by agricultural scientists schooled mainly in industrial agriculture, current GM crops primarily boost farm profits by reducing inputs. Environmental benefits are a secondary good. Likewise, the profit motive underlies the development of second generation GM crops, which promise health benefits to consumers. Agriculture needs to be profitable, of course. But given the contrasting paradigms, is it any wonder that biotechnology is currently considered anathema in

Table 1. Clashing Paradigms in Modern Agriculture

Industrial Agriculture	Agrarian Agriculture
Modernist worldview • nature as machine • human sovereignty	Romantic worldview • nature as organism • sovereignty of nature
Reductionistic	Holistic
Econocentric (anthropocentric)	Ecocentric (non-anthropocentric)
Utilitarian ethic	Care theory
Global economy	Local economy (foodshed)
Social & ecological risks • intensification • mechanization	Crop management risks • environmental stresses reduce quantity, quality
Exuberant about agbiotech	Wary of agbiotech
Scientific risk assessment	Precautionary principle
Maximizing productivity & profitability	Sustaining productivity & enhancing biodiversity
Policies should distribute rights to individuals	Policies should promote social & ecological wellbeing

agrarian agriculture? Agrarian farmers have traditionally engaged in their enterprise out of a deep conviction that ecological interrelationships particular to places are paramount in sustaining agricultural productivity. Technologies are adopted only if they are appropriate for a given ecological and cultural context. Profits are secondary to a kind of kinship between people and the land. This is why those who espouse this ideology are willing to pay a premium for organic foods.

Agricultural biotechnologists typically justify their cause by appealing to the long history of human manipulation of crop genomes through seed selection and conventional breeding. GM crops, they argue, are just an extension of human manipulations that have gone on for millennia. Furthermore, GM crops are needed to fend off hunger and produce crops in a more environmentally-friendly manner. While these arguments have merit when viewed from a reductionistic perspective, they lose some of their punch when viewed through a wider lens. Anthropologist Glenn Davis Stone counters convincingly that hunger is due not to food shortages, but to unjust socio-economic structures and policies.[16] These clearly must be addressed as an integral component of agriculture. But the question remains of how to feed the anticipated 8–10 billion people expected by 2050 while protecting ecosystems. Solutions will require the concerted efforts of agro-ecologists and biotechnologists. However, most biotechnologists and industrial agriculturists do not yet recognize the root of the problem: the loss of contextual perspectives erodes our ability to judge what technologies and practices are appropriate to a given place. Therefore, until agbiotech undergoes a paradigm shift, it is likely to contribute little to global food security and ecological sustainability. Conforming to the norms of place-based agriculture—focusing primarily on farming concerns at a bioregional scale—will promote thriving, resilient food systems.

Advocating Change

My vision for place-based agriculture is rooted in Christian environmentalism, which recognizes creation as fundamentally interrelational—a *perichoresis*.[17] In sharp contrast to today's individualism that fosters fragmentation and alienation in our global food system,[18] nurturing of cultural and ecological interrelationships is the standard by which we judge the efficacy of technologies and policies in place-based agriculture. This requires that values be considered up front, as a means to inform science and practice.[19] It requires deeper levels of reflection and humility in our public discourse—especially in discussing scientific claims and world views. It also requires re-evaluation of some fundamental assumptions concerning economics, technology, and social theory. Can we reverse globalization's ill-effects that sever interconnections among land, farmer, and consumer, or should we commit to develop more locally-based food systems? Should we dismiss agbiotech on the basis of the claim that it is unnatural,[20] or can we adapt it to restore or enhance cultural and ecological relationships? There is nothing particularly Christian about the prevailing industrial mode of agriculture (Table 1). Place-based agriculture, therefore, offers an opportunity for Christians to advocate needed reforms.

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As both a Christian environmentalist and biotechnologist, I am in rare company. Taking agbiotech into consideration makes most environmentalists very uneasy; yet I believe there are compelling reasons for carefully investigating biotechnology applications in place-based agriculture. Moving genes from one kingdom to another is one extreme within the realm of possibility afforded by biotechnology. If moving a flounder gene into a strawberry could enhance cold tolerance in the plants, should we do it? Certainly we should not do so callously, just because we can or because we find evidence of trans-kingdom gene flow in nature. But if transgenic crops with enhanced cold tolerance could better support local food systems in cool climates, could we not consider adopting them? If we rule out inter-kingdom gene transfers, would we consider transferring genes between species that are close relatives? The spread of transgenes to a wild relative or to non-GM fields of the same crop is a big concern, yet non-GM crops are just as capable of spreading "genetic pollution" via intra- and interspecies pollination. If genetic technologies can be developed to help prevent this,[21] would it not be important to adopt them judiciously to protect the integrity of native ecosystems? Biotechnology also encompasses non-GM tools for plant tissue culture (a type of vegetative propagation) and genetic marker-assisted breeding. Since these are akin to accepted means of asexual and sexual propagation, why not make careful use of them?

Should we accept animal biotechnology? Livestock cloning, genetic modification, and patenting are very controversial; the issues, extremely difficult. Dieter Hessel, director of the ecumenical Program on Ecology, Justice and Faith, argues:

> Something analogous to "just war" criteria are needed to guide biotechnical efforts to manipulate animals. Such ethical criteria would put the burden of proof on those who would intervene drastically in

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> nature to alter species or to proceed in ways that place ecosystems at risk.[22]

While animal biotechnology must be approached with due caution, I contend that it could be appropriate for place-based agriculture. It may be helpful, for example, in minimizing the exchange of pathogens and parasites between livestock and wildlife, or as a supplement to breeding programs in restoring desirable instinctive behaviors compromised by domestication and intensification. But before we attempt to apply such solutions, we must agree to practice agriculture and agbiotech in a way that is "sensitive to the 'expectations of the land' and replaces the universalizing perspectives of agricultural science that treats all places the same."[23]

If we accept agbiotech in place-based agriculture, then toward what ends should we attempt to develop it? We live in a diverse world as creatures of God, fellow sojourners with all of creation. But the world we live in is tainted with the effects of our fall into sin. While the Bible does not spell out what the full ramifications of the Fall are, it clearly teaches that our relationships to God, to other parts of the creation, and to each other are corrupted. These relationships could only be made right again through the redemptive work of Jesus Christ. But this did not immediately restore everything. By God's grace we can now participate in that work whose goal is shalom, liberating the creation from sin's effects so that it can function as God first intended it.[24] Clearly, we have a long way to go. In an age of agricultural production sufficient to supply the food needs of all humanity, millions starve or are malnourished. Food security is elusive. Prime farmland is lost to erosion and urban sprawl. The problems are complex, entangled in political, economic, social, and moral sins. Certainly biotechnology is not the savior that some make it out to be, yet we ignore it at our peril. Within a place-based paradigm that upholds local cultures and ecosystems, I believe that it can be an appropriate tool for shalom. But using this tool will require us to act in a Christ-like manner, submitting ourselves to serve the creation and our most vulnerable brothers and sisters by giving up the illusions of control over the means of food production.

Lessons from the Green Revolution

The Green Revolution of the 1960s and '70s saw the development of high-yielding dwarf varieties of wheat, rice, and other grains by crop breeders in the public sector. It enabled

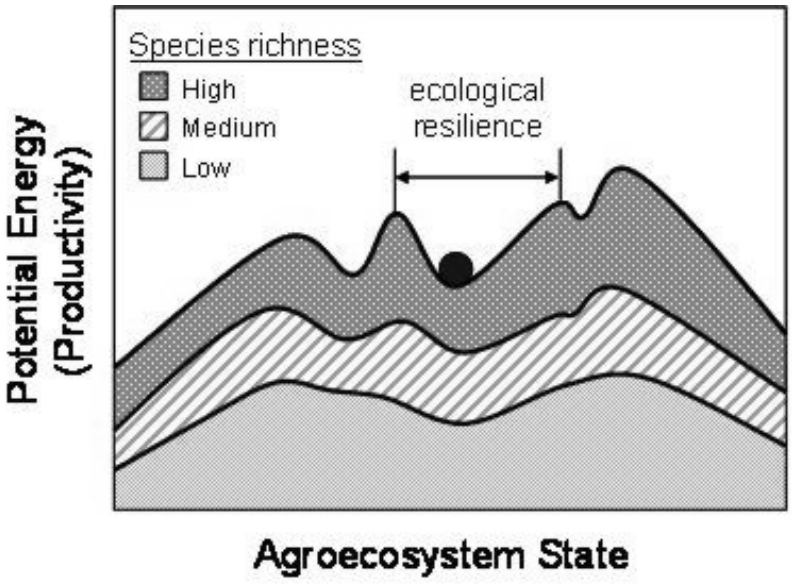

Figure 1. Basic concept of ecological resilience as it applies to agroecosystems. Agroecosystems can exist in different states of productivity and resilience. Like natural ecosystems, they are stable within certain thresholds (peaks in the curves), a function of species richness (i.e., number of functional groups), mutually reinforcing structures and processes (i.e., functional redundancy), and spatial-temporal (i.e., scale) effects. Ecological resilience corresponds to the width of the troughs in these curves. Although these troughs depict potential states of similar productivity, the current state (ball) is most resilient. Note that overall productivity increases with increasing interconnections (upper curve).[30]

countries to produce more than enough grain to feed their own people. India's case is probably the most renowned, moving from devastating famines one after another in the mid-1940s and '50s to becoming a net exporter of wheat and rice in the 1970s.[25] Equally important were the agricultural reforms and infrastructure investments that coincided with the adoption of the new grain varieties. Nevertheless, the Green Revolution was a mixed success. The resulting intensification of production required more water and chemical fertilizers. Soil fertility suffered. The new type of farming required more capital. Those who could not afford it were forced to migrate to the burgeoning slums in India's cities, where many unskilled workers languished. While India's government grew rich on grain exports with some stockpiles even rotting in the ports, millions continued to go hungry.

While the successes of the Green Revolution demonstrate the positive role genetic technologies can play in improving crop productivity, its failures underscore the importance of place. Research conducted in one place on very productive land cannot automatically be translated to another place without incurring some unintended and unforeseen consequences. Gordon Conway of the Rockefeller Foundation acknowledges that for agricultural research to be applicable under highly diverse conditions it must be conducted under those conditions in those places.[26] He advocates a "doubly green revolution" that is place-based, "starting with the socio-economic demands of poor households [before] seeking to identify the appropriate research priorities" and making "greater use of indigenous resources."[27]

Place as a Normative System

Moral philosophies and ethical traditions have an enormous impact on the development and adaptation of agricultural policies and technologies.[28] To determine what is appropriate for agriculture, I am advocating a greater emphasis on place as a normative system. This practical, more complex system is based on biocentric and theocentric values identified by Spaling and Wood.[29] While not ignoring utility, it downplays the prevailing econocentric utilitarian approach in agriculture for the reasons outlined above. But what does it mean to consider place as normative? Imagine a particular agricultural place. What are the normal characteristics of that place? What are the human relationships to it? How would you devise technologies to fit it? Your answers to these questions would begin to define what I mean by a place as a normative system. In place-based agriculture, we chiefly are concerned about the cultural and ecological characteristics of a particular bioregion—or foodshed. Our goal is to develop technologies that are appropriate, that match the needs and cycles of that place in a way that is resilient— that is, promoting ecological and cultural sustainability. These then are the five earmarks of place-based agriculture as a normative system:

1. *Place-based agriculture is attuned to the ecological resilience of local bioregions.* To develop and implement appropriate technologies, it first seeks to understand local ecological resilience. Especially important are the mutually reinforcing structures and processes that keep agroecosystems within certain stable states (Figure 1).[30] Species richness enhances resilience by enhancing functional redundancy: loss of one species can be compensated by another with the same function. Monocultures, thus, have lower resilience. Reinforcing structures and processes are also dependent on scale: organisms interact more with others their size; fast processes may cumulatively affect slow processes.

2. *Place-based agriculture is responsive to the needs and knowledge of local communities.* It operates under the assumption that locals, through their experience in a place, have learned about its needs and nuances. This does not remove the need for experts because often we fail to see what is right in front of us. Rather, the experts work with the locals to see and to understand what is needed. "Local knowledge and the practical become intertwined with the cosmological, how one sees the world."[31]

3. *Place-based agriculture is sensitive to community values.* While values in a pluralistic society may be contentious, "an approach that explicitly recognizes differing land ethics may suggest policy options that might lessen conflict and bring a satisfactory, long- term resolution."[32] The communal nature of this is key. "The moral economy of the foodshed will not be based on individuals with unrestrained freedom to pursue their own self-interest, but will be shaped and expressed in communities that attempt to build sustainable relationships amongst themselves and with the land. Wise ethical systems are, in their living out, place-based."[33] In this way, policies in place-based agriculture work to enhance local cultural resilience, not global efficiency.[34]

4. *Place-based agriculture exercises precaution, care, and restraint.* Those who exercise precaution think before they act. In this is great wisdom. Current agricultural policies require safety and efficacy tests prior to marketing of new products. But questions remain: How much testing is enough, under what conditions, and for what contingencies? To resolve these issues requires greater attentiveness to place and contextual moral deliberation amongst stakeholders.[35] We also would do well as a society to reconsider our addiction to individualism and consumerism, which erode our sense of community, caring, and restraint. We must regain the joy of Sabbaths.[36]

5. *Place-based agriculture solutions enhance embeddedness in local ecosystems and cultures.* Founded on a perichoretic understanding of humans in the natural world, place-based agriculture develops technologies and practices attentive to the paces and scales of local ecosystems as models.[37] Therefore, husbandry, contextual research, and community well-being take priority over mechanization, purely reductionistic research, and individual liberty.[38]

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Models for place-based agriculture exist. A sampling of these includes the following:

- The Educational Concerns for Hunger Organization (ECHO).[39] ECHO's focus is on alleviating hunger in the tropics by working with native peoples in their places to develop new agricultural crops and products. They maintain a seed bank at their Florida campus. They also fund a number of small grants to explore specific novel technologies, supporting the integration of farm-based and science-based technologies.
- Natural Systems Agriculture at the Land Institute.[40] The Land Institute advocates a paradigm for food production where nature is mimicked rather than subdued and ignored. They have already demonstrated the amazingly high productivity of native mixed prairies, and are now trying to perennialize key annual crops in developing farming practices that mimic a native prairie system. The Matfield Green Consortium works to translate the work and philosophy of the Land Institute into meaningful place-based educational materials for K–12 schools.
- Community Supported Agriculture (CSA) and local food policy councils.[41] CSAs draw local consumers into partnerships with local farmers who are receptive to their values. Most are organic. Local food policy councils and CSAs strive to develop regional food supplies and strong local economies, to maintain a sense of community (place), to encourage land stewardship, and to honor the local knowledge of producers on small to medium farms. While both provide a means for place-based communal contracts between growers and consumers, they still face significant challenges.

Do GM Crops Belong in Place-Based Agroecosystems?

Unfortunately, current GM crops do not conform to the place-based norms outlined above. While herbicide tolerant crops do facilitate soil conservation through no-till agriculture, they still rely heavily on chemical inputs to prop up intensive monocultures. Weeds, defined as plants growing in the "wrong place," will always exist. But they become a serious problem when agricultural practices open up niches best suited for r-selected species (those that reproduce quickly and/or are invasive). By putting more effort into research on polycultures, we may identify more appropriate and sustainable solutions to weed control. Particularly troubling are non-indigenous invasive species. Exacerbated by global trade, these require a type of research and management vigilance similar to that which the Centers for Disease Control practice for emerging human diseases. Biotechnologists and ecologists must collaborate together in addressing this problem. Similarly, I am not convinced that Bt crops and animal vaccines are the best solution for controlling pests. Pest populations thrive in large, persistent monocultures. Relying exclusively on biotechnologies will only speed the evolution of pest resistance, much like the current crisis of antibiotic resistance in microbial pathogens. Polycultures, crop rotations, and trophically based pest management must be integral to solutions.[42]

Regarding the place of biotechnology within place-based agriculture, I advocate "critical engagement." This is borne out of my Christian faith, which places the doctrines of the Creation, Fall, Redemption, and Restoration at the foundations of an all-encompassing world view that guides a sense of vocation.[43] I contend that tenets based on these widely-held doctrines contribute rationales for both promoting and restraining biotechnology (Table 2). No doubt this is one reason why Christian organizations struggle to formulate appropriate responses to concerns and issues raised by biotechnology. Nevertheless, I see this tension as healthy. It provides a context for both criticism and engagement—hence critical engagement. It bids us to think and care before we act. It compels precaution even as we consider how biotechnology might enhance our care of creation.

Precaution as a guiding principle, spawned by the environmental movement of the 1970s, has gradually become more formalized since the advent of GM foods.[49] In recent years, a Precautionary Principle has evolved through a series of articulations and clarifications. One rendition, known as the Wingspread Statement, was formulated via consensus by a diverse group of scientists,

law makers, politicians, philosophers, and environmental activists. It defines the Precautionary Principle succinctly:

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.[50]

Moreover, the Wingspread Statement contains three important caveats. First, precaution shifts the burden of proof from the public (or opponents, more specifically) to proponents. Second, it necessitates an open and democratic decision-making process where stakeholders' views are represented. Third, precaution requires consideration of the full range of options, including no action before proceeding.

When integrated with our Christian faith tenets and their implications for agbiotech (Table 2), I find these caveats very fruitful. For example, if we understand that God has entered into covenantal relationships with all living creatures (e.g., Gen. 9:8–17), then it follows that we should not take lightly the genetic alteration of those creatures or the physical alteration of their environments. Precaution in the face of alterations that may affect the intrinsic relational nature of organisms seems particularly appropriate. Moreover, the caveats are consistent with the Christian assertion that faith must inform all of our actions, including those involving science and technology. In this world view, faith is a prerequisite to social and moral responsibility.

However, overtly putting values first in matters of science and technology seems to be a radical notion in our society—suspected because it introduces personal biases into the decision-making process. Instead, "scientific agencies … are required by law to develop regulations based on sound science," which is assumed to be value-neutral.[51] Critics' views are not considered unless couched in scientific terms. The result is political disenfranchisement, dissonance, and/or gridlock. Applying the Precautionary Principle could provide an essential corrective. Nancy Myers explains it this way:

> The principle makes it clear that decisions and developments in science and technology are based first of all on values and only secondarily on scientific and technological fact and process. Moreover, a precau-

Table 2. Tenets of the Christian Faith Inform Our View of Agbiotech

Doctrines and Their Tenets	Implications for Agbiotech
Doctrine of Creation	
Tenets that promote agbiotech • Humans are called to serve as God's viceroys (Gen. 1:28) and protector-servants (Gen. 2:15) of God's creation. • God allows us to use some plants and animals to meet needs (Gen. 9:3).	Agbiotech may be an appropriate tool for creation care "with compassion and mercy, like to that of God Himself."[44]
Tenets that restrain agbiotech • Our world belongs to God (Ps. 24:1). • God calls creation "very good" (Gen. 1:31). • Creatures have intrinsic value (Gen. 1:22). • Creation is an ongoing Trinitarian activity (Ps. 104).	When interacting with other creatures, we must consider that God has a covenantal relationship with them. God loves all creatures and delights in wildness (Job 39).
Doctrine of the Fall	
Tenets that promote agbiotech • Technology and public policy can be used to deter human sin/abuses (Rom. 13:1–3).	Agbiotech may be appropriate within certain contexts, especially as a means of alleviating sin's effects.
Tenets that restrain agbiotech • Technologies are often used or thwarted for evil purposes (Ps. 35:12). • God judges us on the basis of our land stewardship (Lev. 26:33–35). • Places bear the consequences of human apostasy (Hos. 4:1–3).	We must bear in mind the noetic effects of sin in our work, combating it via "communal, multiperspectival effort."[45]
Doctrine of Redemption and Restoration	
Tenets that promote agbiotech • Redemption is cosmic, not just personal (John 3:16). • Seeking justice, loving mercy, and walking humbly with God (Micah 6:8) are measures of our ministry of reconciliation (2 Cor. 5:18).	Technology's purpose is to sustain, restore, and improve.[46] "The place God calls you to is the place where your deep gladness and the world's deep hunger meet."[47]
Tenets that restrain agbiotech • We rely on God's grace, not solely on our own power, to sustain us (Eph. 2:8). We must learn to cultivate contentment (1 Tim. 6:6). • We are accountable to God who "opposes the proud, but gives grace to the humble" (James 4:6).	Agbiotech and its policies must conform to God's restoration plan. "Humans are accountable to the Creator for their relationship with the land."[48]

> tionary approach is best carried out in the context of goals that embody values of communities and societies.[52]

Instead of decisions made exclusively by agbiotech practitioners, the Precautionary Principle advocates goal-setting involving the widest possible array of stakeholders: farmers, rural community leaders and governments, consumer groups, environmental groups, faith-based groups, and so forth.

Instead of one-size-fits-all solutions intended for global distribution, the Precautionary Principle advocates solutions that are appropriate to a particular place.

Instead of letting market forces drive technology development (assuming new technology that sells is inherently better, unless critics can produce compelling evidence to the contrary), the Precautionary Principle compels proponents to prove the worth of a technology before proceeding with its application.

In essence, the shared goals and values that emerge from open dialogue, necessitated by the Precautionary Principle, set the context for scientific and social assessment. They provide a framework for doing science in a manner consistent with the values of our Christian faith. As Dieter Hessel puts it:

> Attention to eco-socially appropriate technology does not rule out [biotechnology]; it asks for deeper ethical reflection, alert to intuitive religious sensibilities about what is good and right, and for more democratic social involvement to limit or channel this qualitatively different human activity for the good of all.[53]

But what are we to make of biotechnology practitioners' opposition to the Precautionary Principle? They are justifiably worried that a strong version of the Precautionary Principle could escalate costs of implementing this, or any other new technologies with unpredictable consequences, to prohibitive levels. Henk van den Belt makes a good case that this is untenable. A strong version "commits us to each of two contradictory policies: (a) We must not develop GM crops, and (b) We must develop GM crops."[54] While the first is readily apparent, the second option could be true if GM technology is later deemed absolutely necessary to prevent environmental degradation and to meet the food needs of a burgeoning population. Is there a middle position, namely that a weaker version of the Precautionary Principle may be appropriate? Van den Belt seems to hint of receptiveness to this when he characterizes the positions of those who hold to the Precautionary Principle and of those who hold to sound science as "unduly polarized." A weaker version, applied on a case-by-case basis, seems consistent with my arguments above.[55] It would balance place-attentive risk assessment with a collectively brokered objective.

Ecological principles, inherently focused on interrelationships, must have a greater role in governing our priorities if agbiotech is to be useful for enhancing agroecosystem integrity and resilience …

Enhancing Cultural and Agroecosystem Resilience

Those involved in agbiotech can contribute to restoring the myriad of relationships marred by sin, including genetic interactions between organisms that may have been compromised (e.g., via gene silencing) through millennia of human intervention in polycultural landscapes as we intensified monocultural systems. Ecological principles, inherently focused on interrelationships, must have a greater role in governing our priorities if agbiotech is to be useful for enhancing agroecosystem integrity and resilience (properties that cannot be deciphered through purely reductionistic research). The term agroecosystem, "an ecological and socio-economic system, comprising domesticated plants and/or animals and the people who husband them, intended for the purpose of producing food, fibre or other agricultural products,"[56] conveys the complexity and richness of this new paradigm. Agroecology is widely embraced as key to sustainability (often a politically contentious concept). It is helpful to link these two terms together. "Agricultural sustainability," explains Gordon Conway, "is the ability of an agroecosystem to maintain productivity in the face of stress or shock."[57]

This is analogous to ecologists' current understanding of ecological resilience and succession. In contrast to earlier models of a linear progression of events from simple organisms to balanced interconnecting life systems, we now recognize ecosystems as complex, dynamic, irreversibly evolving systems with humans as a keystone species.[58] Ecosystems are not balanced, nor are they in equilibrium. Indeed, ecosystems can

be shocked or stressed into an altered state if certain thresholds are exceeded (Figure 1). Regrettably, this often occurs through human activity even before those thresholds are known.

We must resist the urge to modify "just because we can" … we first need to acknowledge our dependence on God … Then, we need to cast ourselves playfully in the role of God …

Deciding what is appropriate for place-based agroecosystems is no small task. It will take collaborative effort among growers, scientists, policy-makers, community leaders, consumers, and other stakeholders attuned to place to reach consensus. We need policies, management practices, and ecologically appropriate buffers to protect the agroecosystems of one region from those of neighboring regions. We will need to honor the decisions of communities on whether to adopt GM crops, and if so, which ones. The work ahead will be long and difficult, but I think it is essential for developing a truly sustainable agriculture. First, this requires a more thorough, integrative research of the interconnecting systems that affect ecosystem resilience. Biotechnology and the emerging field of systems biology can contribute a wider assessment of genetic diversity and a more detailed account of the interplay between environmental stress and gene expression. Second, these findings must be coupled to democratic approaches to problem-solving, where stakeholders' interests, especially those often disenfranchised in our current system, are represented fairly. Third, care theory, which emphasizes the relational nature of humans and the importance of community integrity,[59] also should inform our decision-making in agbiotech as it reflects values critical to the sustainability of agroecosystems. With its overemphasis on individual liberty and consumerism, our current system often runs roughshod over the best interests of our communities, especially in rural areas where this has already reached crisis proportions.[60] Care and restraint are essential.

Exemplary biotechnologies that may be considered for place-based agriculture include the following:

- *Microbial biotechnologies to aid nutrient cycling.* In traditional rural ecosystems, soil fertility was maintained with some degree of success by incorporating animal manures and crop residues into the soil each year. Now most foods are trucked to large cities. This represents a significant challenge for any farming system. Somehow nutrients from large municipal wastes must find their way back to the farms so that soil fertility can be sustained without adversely affecting natural ecosystems. Microbial biotechnologies may offer some innovative solutions to capture those nutrients in a bioavailability form that is economically sustainable and socially inoffensive. This would also alleviate significant pollution problems.
- *Enhancing resilience within polycultures and intercropping systems.* Crops are subject to weather extremes, invasive species, emerging diseases, which substantially alter productivity. While polycultures and intercropping systems have higher resilience than monocultures, there is much we need to learn about the mechanisms of resilience at all levels of biological organization (from ecosystems to cells and genes). Genomic/proteomic and systems biology approaches can provide important insights when coupled with ecological understanding. Biotechnology may yield profoundly positive effects in restoring genes essential to resilient interactions in polycultures, genes whose expression may have been silenced through millennia of monoculturization.
- *Animal biotechnologies that help to reduce environmental impacts of livestock.* In conjunction with ecologically sound management practices, biotechnology can help to reduce the exchange of pathogens and parasites between livestock and wildlife populations. Likewise, it may be useful in restoring traits that facilitate livestock interconnections with rangeland environments—traits compromised by domestication and more recent intensification. In conjunction with less concentrated forms of animal production, it may help reduce nitrogen and phosphorous levels in manure, thereby posing less risk to aquatic systems.
- *"Green" food/fiber processing technologies.* Food and fiber processing currently contributes substantially to water/resource demand and to pollution. Biotechnologies that complement ecological sustainable practices may help to reduce these problems.

We must resist the urge to modify "just because we can"—approaching our work with greater humility instead. We need to rediscover what it means to play God in the correct way.[61] That is, we first need to acknowledge our dependence on God; our responsibilities, though great, are not of messianic proportion. Then, we need to cast ourselves playfully in the role of God, like an actor playing the part of a historical figure who first studies the life and times of that person. This is an opportunity for us to reflect about who God is as creator, healer, and advocate over all creation. It invites us to exercise those same attributes "in response to God, in imitation of God's ways, and in service to God's cause … to promote life and its flourishing."[62] ✦

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Notes

[1]A. L. Peterson, *Being Human: Ethics, Environment, and Our Place in the World* (Berkeley, CA: University of California Press, 2001), 21, 48–9; and D. R. Williams and S. I. Steward, "Sense of Place: An Elusive Concept That Is Finding a Home in Ecosystem Management," *Journal of Forestry* 92 (1998): 18–23.

[2]W. Jackson, *Becoming Native to this Place* (New York: Counterpoint Press, 1996); and W. Berry, *The Unsettling of America: Culture and Agriculture* (San Francisco: Sierra Club Books, 1977).

[3]According to the USDA (www.ams.usda.gov/nop/NOPPresentation/home.html) and Agriculture & Agri-Food Canada (http://atn-riae.agr.ca/supply/3313_e.htm), the organic food segment is currently growing at 20% annually.

[4]This is most obvious in the debates over food labeling. Lobbyists representing agbiotech and industrial agriculture interests in North America argue that country of origin does not affect foods materially, nor does the method of production (GM vs. conventional). Hence, foods do not need to be labeled in this way. However, in response to consumer demand the U.S. Dept of Agriculture has instituted a labeling system for foods produced organically.

[5]Studies of Minnesota grassland communities grown under various levels of CO_2 and nitrogen have demonstrated that biomass production is a function of both species richness and functional group richness (P. B. Reich, D. Tilman, S. Naeem, D. S. Ellsworth, J. Knops, J. Craine, D. Wedin, and J. Trost, "Species and Functional Group Diversity Independently Influence Biomass Accumulation and Its Response to CO_2 and N," *Proceedings of the National Academy of Science* USA 101 [2004]: 10101–6). These researchers have also shown that experimental reductions in plant species richness increases this ecosystem's vulnerability to invasive species, pathogens, and insects (J. M. H. Knops, D. Tilman, N. M. Haddad, S. Naeem, C. E. Mitchell, J. Haarstad, M. E. Ritchie, K. M. Howe, P. B. Reich, E. Siemann, and J. Groth, "Effects of plant species richness on invasion dynamics, disease outbreaks, insect abundances and diversity," *Ecology Letters* 2 [1999]: 286–93).

[6]Plant geneticists are working to improve crop tolerance to a plethora of environmental stresses nuanced to specific places. Aluminum toxicity, for example, is a serious problem in tropical acidic soils. High aluminum levels reduce the uptake of phosphorous by plants. Researchers have discovered that plants whose roots secrete citrate are better able to take up phosphate from such soils (J. M. de la Fuente, V. Ramirez-Rodriguez, J. L. Cabrera-Ponce, L. Herrera-Estrella, "Aluminum Tolerance in Transgenic Plants by Alteration of Citrate Synthesis," *Science* 276 [1997]: 1566–8).

[7]E. A. Bray, J. Bailey-Serres, and E. Weretilnyk, "Responses to Abiotic Stress," in B. Buchanan, W. Gruissem, and R. Jones, eds., *Biochemistry and Molecular Biology of Plants* (Rockville, MD: American Society of Plant Biologists, 2000), 1159.

[8]P. A. Matson, W. J. Parton, A. G. Power, and M. J. Swift, "Agricultural Intensification and Ecosystem Properties," *Science* 277 (1997): 504–9.

[9]J. M. Curry, "Care Theory and 'Caring' Systems of Agriculture," *Agriculture and Human Values* 19 (2002): 119–31.

[10]J. M. Curry and S. McGuire, *Community on Land: Community, Ecology, and the Public Interest* (Lanham, MD: Rowman & Littlefield, 2002), 133–8.

[11]W. Heffernan, "Consolidation in the Food and Agriculture System," Report to the National Farmers Union (1999); and P. Howard, "Consolidation in Food and Agriculture: Implications for Farmers and Consumers," *CCOF Magazine* (Winter 2003–2004): 2–6. Dozens of similar reports are available at the Agribusiness Accountability Initiative's website: www.agribusinessaccountability.org.

[12]A. Sagar, A. Daemmrich, and M. Ashiya, "The Tragedy of the Commoners: Biotechnology and Its Publics," *Nature Biotechnology* 18 (2000): 2–4.

[13]S. Sundlof, "The Role of Science in Regulation and Decision Making," *AgBioForum* 3 (2000): 137.

[14]Sampling regional cuisines (products of unique agroecosystems) is one way North Americans celebrate cultural diversity. Cultural traditions, holidays, festivals, and family gatherings invariably involve specific foods linked to the meaning of these events and serving to rehearse our collective cultural memory. Would Thanksgiving continue to hold its cultural identity without the distinctively New England turkey and cranberries? Foods have deep religious meaning, too. Most would consider it sacrilegious to substitute pizza and Coke for bread and wine at the Lord's Supper. Foods are also deeply personal. Our daily patterns of eating different foods for breakfast, lunch, and dinner provides a rhythm to our lives. In light of this, are not concerns about GM foods understandable?

[15]Industrial agriculture and agrarian agriculture represent ends on a continuum of current practices. For an analysis, I recommend D. Atkinson, "Agriculture—Reconciling Ancient Tensions," *Ethics in Science and Environmental Politics* 2002: 52–8. Subsistence agriculture also contributes enormously to food production, especially in the southern hemisphere. Although it shares some characteristics with North American agrarian agriculture, they are not equivalent—but that is another topic.

[16]G. D. Stone, "Both Sides Now: Fallacies in the Genetic-Modification Wars, Implications for Developing Countries, and Anthropological Perspectives," *Current Anthropology* 43 (2002): 611–30.

[17]Theologian Colin Gunton in *The One, the Three and the Many: God, Creation and the Culture of Modernity* (Cambridge: Cambridge University Press, 1993) uses the term perichoresis—"a dynamic reciprocity, interpenetration and interanimation" (p. 163)—to describe interrelationships within the Trinity, between God and creation, and between all elements of being in creation. In a perichoretic world "everything … contributes to the being of everything else, enabling everything to be what it distinctively is … a dynamic order that is summoned into being and directed towards its perfection by the free creativity of Father, Son and Holy Spirit" (p. 166). It follows, then, that "the character of our relation with the natural world will be at the centre of human concern … [and] at least as great a threat is made by the fragmentation of human culture" (p. 173).

[18]Curry and McGuire point out the connections between Enlightenment individualism and conventional practices and policies in U.S. industrial agriculture. Since scientists trained in the dominant means-end reductionistic research paradigm aim to produce general universal knowledge, they ignore the interrelationships unique to place—as do policy makers. Ironically, when profit maximization takes priority over land stewardship and community interests, individual farmers and rural communities lose economic and political clout to transnational corporations. See Curry and McGuire, *Community on Land*, 133–8.

[19]N. Myers, "The Precautionary Principle Puts Values First," *Bulletin of Science, Technology, & Society* 22 (2002): 210–9.

[20]To argue that something produced through human input is essentially unnatural is to follow an exceptionalist view that humans are somehow set apart from nature. A scriptural view of humanity from the stories of Noah and Job sees "the human decentered and properly placed among the myriad of God's creatures" (S. Bouma-Prediger, *For the Beauty of the Earth: A Christian Vision for Creation Care* [Grand Rapids, MI: Baker Academic, 2001], 104).

Consider also the flip side in W. Cronon, *Uncommon Ground: Toward Reinventing Nature* (New York: W. W. Norton, 1995):

> The work of literary scholars, anthropologists, cultural historians, and critical theorists over the past several decades has yielded abundant evidence that "nature" is not nearly so natural as it seems. Instead, it is a profoundly human construction. This is not to say that the nonhuman world is somehow unreal or a mere figment of our imaginations—far from it. But the way we describe and understand that world is so entangled with our own values and assumptions that the two can never be fully separated. What we mean when we use the word "nature" says as much about ourselves as about the things we label with that word (p. 25).

[21]Z. Hanley, and K. Elborough, "Re-emerging Biotechnologies: Rehabilitating the Terminator," *ISB News Report* (June 2002): 3–5.

[22]D. T. Hessel, "Now That Animals Can Be Genetically Engineered: Biotechnology in Theological-Ethical Perspective," in R. S. Gottlieb, ed. *This Sacred Earth: Theology, Nature, Environment* (New York: Routledge, 1995), 629.

[23]Curry and McGuire, *Community on Land*, 202.

[24]With insights from theologian Allen Verhey regarding our calling to imitate God, ethicist James Peterson concludes in his book, *Genetic Turning Points: The Ethics of Human Genetic Intervention* (Grand Rapids, MI: Eerdmans, 2001): "Redemption restores our pre-fall opportunity to grow toward God and into what we should be. The good creation is the starting point, not the finale we seek to regain" (p. 86).

[25]Anonymous, *Pursuit and Promotion of Science: The Indian Experience* (New Delhi, India: INSA, 2001).

[26]G. Conway, *The Doubly Green Revolution: Food for All in the Twenty-First Century* (Ithaca, NY: Cornell University Press, 1997), 41.

[27]Ibid., 42.

[28]H. Spaling and J.R. Wood, "Greed, Need or Creed? Farmland Ethics in the Rural-Urban Fringe," *Land Use Policy* 15 (1998): 105–18.

[29]Ibid., 106–8.

[30]Figure 1 is based on the concept of ecological resilience as presented in G. Peterson, C. R. Allen, and C. S. Holling, "Ecological Resilience, Biodiversity, and Scale," *Ecosystems* 1 (1998): 6–18. For more detailed analyses of the concept of ecosystem resilience, I recommend these articles: C. S. Holling "Understanding the Complexity of Economic, Ecological, and Social Systems," *Ecosystems* 4 (2001): 390–405; and M. Sheffer, S. Carpenter, J. A. Foley, C. Folke, and B. Walker, "Catastrophic Shifts in Ecosystems," *Nature* 413 (2001): 591–6.

[31]Curry and McGuire, *Community on Land*, 201.

[32]Spaling and Wood, "Greed, Need or Creed?" 115.

[33]Curry and McGuire, *Community on Land*, 202.

[34]Note however, that in North America we have typically uprooted our value systems from the land. This mistake must be rectified so that our values may be relevant in our pluralistic society. Christian groups should take the lead in grounding their faith in the type of creation care ethics envisioned in this *PSCF* issue.

[35]Curry, "Care Theory and 'Caring' Systems of Agriculture," 124–5.

[36]When considering the Sabbath principle as it applies to agriculture, the poetry and prose of Wendell Berry are particularly inspiring. For a biblically based assessment that echoes Berry's sentiments, I highly recommend this recent piece: S. P. Carruthers, "Farming in Crisis and the Voice of Silence—A Response to David Atkinson," *Ethics in Science and Environmental Politics* 2002: 59–64.

[37]W. Jackson, *Altars of Unhewn Stone: Science and the Earth* (New York: North Point Press, 1987).

[38]Curry, "Care Theory and 'Caring' Systems of Agriculture," 119–31.

[39]www.echonet.org

[40]www.landinstitute.org

[41]Local food economies support tremendous benefits to communities and their environments. For a very insightful analysis, I recommend B. Halweil, "Home Grown: The Case for Local Food in a Global Market," Worldwatch Institute paper #163 (2002).

[42]P. A. Matson, W. J. Parton, A. G. Power, and M. J. Swift, "Agricultural Intensification and Ecosystem Properties," *Science* 277 (1997): 508.

[43]C. Plantinga, Jr., *Engaging God's World: A Reformed Vision of Faith, Learning, and Living* (Grand Rapids, MI: Eerdmans, 2002); and A. M. Wolters, *Creation Regained: Biblical Basics for a Reformational Worldview* (Grand Rapids, MI: Eerdmans, 1985).

[44]Carruthers, "Farming in Crisis and the Voice of Silence," 60.

[45]S. K. Moroney, "How Sin Affects Scholarship: A New Model," *Christian Scholars Review* 28 (1999): 432–51.

[46]Peterson, *Genetic Turning Points,* 64–90.

[47]F. Buechner, *Wishful Thinking: A Seeker's ABC* (San Francisco: HarperSanFrancisco, 1993), 119.

[48]Spaling and Wood, "Greed, Need or Creed?" 115.

[49]The philosophical roots of the Precautionary Principle may be traced to the writings of German philosopher Hans Jonas who proposed a rule for decision making in the face of scientific uncertainty, especially when the matters in question have "apocalyptic potential." Whether agbiotech has such apocalyptic potential is a key issue in the GM food controversy. Supported by most environmental groups, it is hotly contested by many agbiotech leaders. Nevertheless, the European Union and other countries have endorsed the Precautionary Principle as a guiding principle, using it to call a moratorium on the sale of GM foods until more is known about potential safety risks. Moreover, it is affirmed in the Cartegena Protocol on Biosafety, now ratified by 54 nations. Since this protocol took effect on 11 September 2003, nations are now legally bound to protect against the risks of transfer, handling, and use of "living modified organisms." Perceiving these as threats to U.S. economic interests, the Clinton and Bush administrations took action against these developments with the World Trade Organization. Indeed, Greenpeace invokes the Precautionary Principle in advocating a ban on the trade of GM products. Their list of criteria that must be satisfied before they would consider accepting GM foods necessitates long term experiments on GM plants. However, they also oppose large-scale field releases essential to meet those criteria. Little wonder why the actions of Greenpeace outrage agricultural biotechnologists. Unfortunately, this also raises their suspicions about the Precautionary Principle.

[50]Although the Wingspread Statement has not been published formally, it is available at the Science & Environmental Health Network's website: www.sehn.org/wing.html.

[51]Sundlof, "The Role of Science in Regulation and Decision Making," 137.

[52]Myers, "The Precautionary Principle Puts Values First," 210.

[53]Hessel, "Now That Animals Can Be Genetically Engineered," 631.

[54]H. van den Belt, "Debating the Precautionary Principle: 'Guilty Until Proven Innocent' or 'Innocent Until Proven Guilty'?" *Plant Physiology* 132 (2003): 1123.

[55]To distinguish this case-by-case approach from the more general Precautionary Principle, some refer to it as a "precautionary approach." Others consider these terms synonymous.

[56]Conway, *The Doubly Green Revolution,* 166.

[57]Ibid., 168.

[58]R. V. O'Neill, "Is It Time to Bury the Ecosystem Concept?" *Ecology* 82 (2001): 3275–84.

[59]Curry, "Care Theory and 'Caring' Systems of Agriculture," 119–31.

[60]Agriculturist Jules Pretty argues convincingly that the legacy of modern agriculture is a "dying land" and "dying rural communities" (J. N. Pretty, *The Living Land* [London: Earthscan, 1998]). Peter Carruthers notes: "For some, the crisis in farming is a crisis of existence, and a poignant indicator and symbol of this has been the increased incidence of suicide among farming people" (Carruthers, "Farming in Crisis and the Voice of Silence," 62).

[61]A. Verhey, "Playing God," in J. F. Kilner, R. D. Pentz, and F. E. Young, eds. *Genetic Ethics: Do the Ends Justify the Genes?* (Grand Rapids, MI: Eerdmans, 1997), 66.

[62]Ibid., 69.