Introduction

The idea that industrial agriculture is successful in providing food security during a time of climate change and increasing world hunger is grounded in the ontology and episteme of neoliberal economics. However, neoliberal economics offers a very specific worldview and is guided by a particular set of concepts and indicators. Other fields have been expanding their scope and measures by working across disciplines, with the environmental sciences, for example, attracting chemists, geneticists, botanists, astronomers and more (Davis & Ruddle, 2010; Martin, Roy, Diemont, & Ferguson, 2010). Similarly, ecology brings together natural scientists with those who know traditional ecological knowledge (TEK), for the former have found indigenous knowledge useful in perceiving dynamic interdependencies (Brook & McLachlan, 2008; Terer, Muasya, Dahdouh-Guebas, Ndiritu, & Triest, 2012). The study of agriculture recently expanded to include the field of agroecology, which also incorporates TEK, for measurement and understanding (Altieri, 2004; Björklund et al., 2012). Yet, neoliberal economics remains dominant and often directs global policy assessment of food production. The episteme of neoliberal economics[1] is central to approaches to agriculture by the G8 (and their Davos World Economic Forum conferences), the World Trade Organization (WTO), and the World Bank (WB), but it is also endorsed by most G20 economies (or members). Their policies affirm the industrial farming system, with economies of scale for increasing yields and efficiency, linked to a single global market. They believe this approach is the answer to feeding growing populations in the face of climate change threats to food production.

However, assumptions behind neoliberal economic theories, both the centralizing concepts and their measures, devalue the attributes of smallholder food production. One might call it the "mismeasure" of peasants.[2] Rao (2009) identified this major challenge facing world agriculture:

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[1] Neoliberal economic theories, based on the writings of Friedrich Hayek, Ludwig von Mises (Austrian school) and Milton Friedman (Chicago school), gained political prominence from the 1960s, especially after the 1973 coup of Augusto Pinochet against Salvador Allende. In the aftermath, Friedman and the "Chicago boys" transformed Chilean economic policies to attract foreign investment with the goal of promoting growth. Different theorists offer important nuances, but neoliberal economic policy centers on similar recommendations: rule of the market as the most efficient allocator; deregulation to promote innovation; privatization; and reduction of government expenditures. This last policy demonstrates some of the disagreements among neoliberals, for some would recommend cutting all government expenditures, including military budgets, while others focus on reducing specific public funding, such as agriculture or education.

[2] This phrase recalls the seminal work of Gould (1981), *The Mismeasure of Man,* which exposed the problems of measuring human intelligence (from the size of craniums to contemporary I.Q. exams) with a single quantity.

> To sum up, the formal obeisance to market principles in food-agriculture either conceals or ignores the effective undermining of peasant and subsistence producers that the neoliberal approach embodies. The presumed non-viability or inefficiency of small-scale production . . . effectively implies that large parts of developing economies have no good "reason" to exist except on account of inappropriate state policies. (p. 129)

This article contributes to the debates about neoliberal economic theories by proposing that transforming economics is a prerequisite for recognizing the *value* of smallholder food production.[3] Alternative concepts and measures indicate the problems of neoliberal economics in its linear, short-term profit maximization for individual utility-maximization. Ecological economics has very successfully challenged this narrow approach and demonstrated how neoliberal economic policies devalue natural capital. For example, the way in which discount rates are calculated (based on today's savings bank interest rate) diminishes the future value of natural capital (e.g., trees, water) to the extent that ecological economists recommend removing them from cost-benefit analyses (Davidson, 2000; Daly & Farley, 2011). As will be discussed below, ecological economics leads the way in re-evaluating and re-valuing natural capital by viewing the planet as a closed system in which externalities cannot exist.

Unfortunately, review of the literature reveals that ecological economics has not yet directed much attention to crop production, except perhaps via its view of ecosystem services (Daly & Farley, 2011). Alternatively, traditional ecological knowledge (TEK) gives full consideration to smallholder food production, including foresters, fisher folk, and pastoralists. As will be discussed below, organized smallholder food producers are ahead of political economic theory; in global conferences held throughout the United Nations (UN) family each year, they repeatedly argue alternative scientific views and demand food sovereignty.

The goal of this article is, therefore, both modest and ambitious. It aims to extend the debates about the transformation of economic theory—from assumptions to concepts to measures—in order to see and value the vast complexity of food producing techniques that

[3] Although discussion of the complex concept of "value" could be a full article in and of itself, in seeking clarity, "value" here refers to the recognition of use and exchange values of services (ecosystem and human nutrition) provided by smallholder farmers. It extends to include recognition of their traditional ecological knowledge in choosing what not to use (non-use value). Neoliberal theories try to accommodate this assessment by using a contingent evaluation of *stated* value preference versus price-based *revealed* preference. However, neoliberal economists continue to try to bring "non-use" back into the marketplace by operationalizing the concept by asking what the respondents would be willing to pay for to maintain a feature, such as the Grand Canyon or "biodiversity."

acknowledge the biophysical limits of planet earth and have “evidence-based” sustainability for hundreds, if not thousands, of years. The task involves bringing marginal economic discussions into transforming mainstream neoliberal economic theories. To begin this task, the next section gives a summary overview of the theories that validate industrial agriculture in production and exchange. Because a full review of neoliberal economic theories is beyond the scope of this paper, the following sections will link neoliberal economic theory and policies to food production. The third and fourth sections will introduce the contributions of ecological economics and TEK to a new understanding of economic relations for food production. Although neoliberal economic cost-accounting has already signalled the difficulty of calculating fuel energy balances of ethanol versus petroleum (United States Department of Energy, 2013), ecological economics and TEK, as I will discuss, have much more to offer than simply exposing energy inefficiencies. The final section serves as a beginning to the development of a new theory, in that I suggest various ways in which educators across a multitude of disciplines can create a theory, based on different concepts and different measures, that more fully reflects the value of smallholder food production.

Neoliberal Economic Theories and Industrial Agriculture

Industrial agriculture follows neoliberal economic theories closely, with an emphasis on large-scale, efficient production in a global market to provide food security. Producers in this system artificially manufacture nature to overcome microclimate variability in order to construct economies of scale. For example, soil uniformity can be increased through the chemical manufacturing of inorganic fertilizers, while seeds can be bred for a few selected traits, such as increased yields and short stalks for easier machine harvesting. Thousands of hectares of a single crop rationalize the need for water diversion, as well as require increased pesticides to deter fungi or insects attracted to the seasonal banquet. Reconstituting nature to achieve economies of scale, the fields become like a factory floor, with factors of production organized to maximize efficiency and output. Industrial agriculture, often fostered by government subsidies, measures its success mainly by increased yields to feed the growing world demand (Mushita & Thompson, 2007).

Because explanations for how this farming system will feed the world during climate change crises follow neoliberal economic theories so closely, it is difficult to separate theory from policy. For example, the policy goal of increased production is often defined by one indicator, yield per acre, which is presented by agricultural economic theories. In contrast, as

elaborated below, alternative theories raise the question of increased nutrition because high yields of one crop alone could reduce nutrition. The analysis presented in this article, therefore, begins by addressing the ontological bases of neoliberal economic theories, the very foundational worldview shared with neoclassical economics: the economy is an open system allowing for endless growth of production, and any apparent limits to growth will be overcome by technological innovation. The factors of production for neoclassical and neoliberal economics are also the same: land, labor, and capital. Both sets of theories focus on the individual actor, who has sufficient information to make rational choices about supply (production) and demand (consumption) in an open market.

Neoliberal economic theories distinguish themselves from neoclassical economics by placing greater emphasis on the market as the center of all economic activity. The fundamental assumption (or ontological base) is that, given scarcity, the market is the most efficient allocator for individuals to maximize their utilities. The formal market integrates demands for supplies to encourage innovation and increase production, while simultaneously satisfying an increasing demand; with this growth, general welfare is assumed to increase. The centrality and efficiency of the market determine the exchange value, or the maximization of utilities for all those participating in the market. To encourage innovation, advance production, and improve general welfare, value is added within the industrial commodity chains to maximize the return on investment. Exchange value realizes use value, the value of labor or of nature. Commodification for market exchange, then, becomes a necessary step to realize value. Without this measure, an item can remain uncounted and invisible.

This idealized expression of market relations has been challenged since its inception (Weaver, 2011), but not to the extent of removing it as the operative mechanism for understanding food production and exchange in a global market. The critic most relevant for agricultural policy is Karl Polanyi, who rejected the high level of abstraction of this model well before the current popularity of neoliberal economics. Arguing that markets are “embedded” in societies and cultures that profoundly affect exchange relations, his major contribution was to challenge the idea that abstract exchange relations are the same as a functioning marketplace:

> Production is interaction of man and nature; if this process is to be organized through a self-regulating mechanism of barter and exchange, then man and nature must be brought into its orbit; they must be subject to supply and demand, that is, be dealt with as commodities, as goods produced for sale . . . But, while production could theoretically be organized in this way, the commodity fiction

> disregarded the fact that leaving the fate of soil and people to the market would be tantamount to annihilating them. Accordingly, the countermove consisted in checking the action of the market in respect to the factors of production, labor and land. (Polanyi, 2001/1944, pp. 136-137)

Anthropologist Stephen Gudeman's book, *Economy's Tensions* (2008), summarizes the contemporary, cross-disciplinary challenge to the universality of neoliberal market theory:

> [It is a] theory of value that privileges the actions of a calculating individual who resolves the problem of unlimited wants and scarce resources with reference to the marginal utility of the goods desired . . . Anthropologists have always had difficulty with this theory of human nature; those who have studied non-market economies first hand in different parts of the world have been unanimous in their rejection of the assumption of *homo economicus* as a cultural universal. (p. 10)

Gudeman discusses how monetary valuation is mathematically spurious, for it always reflects relations of "mutuality" and trust. At the same time, the "price" of an item, a seed for example, can be much below its "value," as its exchange is not simply as a commodity but as an expression of sharing genetic heritage from one locale to another or one family to another.

Even though the idealized model of efficient market allocation has been long criticized, and even though other disciplines openly reject theories of rational choice (of which *homo economicus* is one expression), neoliberal economic theories remain dominant in global agricultural policies.[4] Woodhouse (2008) points out that discussions of the global agricultural market found in the *World Development Report 2008* assume the global market for agricultural commodities 1) is well integrated, 2) acts on substantial if not perfect information, and 3) rationalizes food production and distribution. Current global agricultural policies tend to perpetuate the market assumptions of neoliberal economics by assuming the analytical model works in reality. Policies expand the theory to the extent that they promulgate one market with one global price for a commodity:

> The corporate food regime exemplifies, and underpins, these [market] trends, through the determination of a world price for agricultural commodities strikingly divorced from cost . . . the world price of the corporate food regime is

[4] For example, Dalrymple (2006) reports that over 50% of the social scientists working in international agricultural research centres (IARCs) are economists. Given the findings across several prominent scholars, as published in the edited book by Cernea and Kassam (2006), Box (2008) advocates for a new field of "agro-social scientists" that would extend beyond the field of economics (p.174).

> universalized through liberalization, currency devaluation, reduced farm supports, and corporatization of markets, rendering farmers everywhere vulnerable . . . (McMichael, 2005, p. 267)

The policies use neoliberal economic theories as rational justification for promoting a single global market.

Consistent with the hegemony of market theory, the long debates over agriculture during the Uruguay Round for the World Trade Organization (WTO) revolved around creating a singular global market for agriculture. The WTO redefined food security as a global market relation, telling Botswana, for example, that it made more sense to sell its diamonds for maize than to grow it or to source it from its regional neighbors. Botswana could buy the cheapest grain on the global market because of economies of scale in production and marketing (Mushita & Thompson, 2007). U.S. Agriculture Secretary John Block asserted that, before the formation of the WTO, "the idea that developing countries should feed themselves is an anachronism from a bygone era. They could better ensure their food security by relying on U.S. agricultural products, which are available in most cases at lower cost" (McMichael, 2005, p. 278). However, as McMichael (2005) analyzes, this food security results from the "political construction of commodity prices" (p. 279). Part of the continuing dialogue about agriculture in the WTO involves the European Union's affirmation of the "multifunctionality" of agriculture to modify this hegemony of the single global market (Potter & Tilzey, 2007). Originating in the Doha Round of the World Trade Organization, "multifunctionality" points out that agriculture comprises more than producing food or fiber. It also includes rural employment, environmental protection, and landscape preservation. Renting et al. (2009) report from their research on "multifunctionality":

> [the] underlying assumption in the market regulation approach, i.e. that farmers are profit-maximizers, may not be true as they may also derive direct utility from the public goods involved . . . This calls for a better understanding of the evolving motivations of actors involved, as well as their changing socio-political environment, to understand the development and operation of markets. (p. 115)

Agricultural policies based in neoliberal economic theories that centralize the role of the market overlook many activities enhancing farm output and devalue smallholder food production.

Deconstructing the ontological bases of neoliberal economic theory that validate industrial agriculture is a task well beyond recognition of occasional market failures. Ecological economics furthers the task by pointing out that factors of production extend well beyond land,

labor, and capital, even if “land” incorporates soil, sub-soil, and minerals. Feminist economists have long revealed how “labor” extends well beyond the formal labor market. As will be analyzed in the next section, ecological economists are transforming neoliberal (and neoclassical) economics’ centralizing concepts of land, labor, and capital as the factors of production. They want to alter these concepts in order to recognize the value of nature, whether formally cultivated or retained as “wilderness,” as an additional factor of production, called natural capital.

The individual unit of analysis versus the collective decisions and operations of a homestead or community is another strong reason why neoliberal economics cannot value smallholder agriculture. For example, assuming participation by individuals, farmer surveys often reduce households to the “head of the household.” Constraining the unit of analysis to the level of the individual directs researchers’ and policy-makers’ attention. Carlos Oya (2007) remarks how it influences assumptions about peasant farmers: “The theoretical basis of agricultural adjustment strongly hinges on the notion of an ‘idealized’ homogeneous mass of atomized and rational peasant farmers who can be analyzed like profit-maximizing ‘firms’ with an additional household consumption dimension” (p. 276). For any who have worked among smallholder farmers, in any country, it would be difficult to find one major decision or work habit that is singularly undertaken. The farmers calculate and adapt, but not as isolated individuals. As long as exchange value negotiated among autonomous individuals directs neoliberal economic theories, they will continue to denigrate the capacity of peasants. It is not a matter of a cultural miscue here or there, but rather, an inappropriate perspective or tool of analysis, like choosing a microscope when binoculars are needed.

World Bank studies continue to give the amount of “off-farm” revenue used to provide for the rural family as a failure of the smallholder (Staatz & Dembélé, 2008; see also Gopinath & Kim, 2009). These economists implicitly assume that the rural to urban migration that occurred in the twentieth century will continue unabated, for no one wants the harsh farm life. Every summer, however, more European and American youth are seeking internships on small farms to learn new skills and to investigate alternatives to the windowless cubicles of most professional jobs. It is also too early to know the pattern for the twenty-first century (Blunch & Verner, 2006; Dethier & Effenberger, 2012). Smallholders in Southern Africa, for example, have long since organized family life by having members work in the cities, some in the mines, and some remaining on the land (Minter, 1986; Schmidt, 1992). When the urban sector experiences unemployment and hard times, the farm family unit sends in groundnuts, maize, and other food. Meanwhile, during times of drought, such as the “worst one of the century” in 1991-1992 in

Southern Africa, urban members of a family reciprocate, finding the lowest cost grain to buy and sending it on buses to family in rural areas (Thompson, 1993). This symbiosis could be a sign of "diversification to reduce risk" or one of failure, depending on the theoretical lens. Yet, bifurcating families into rural or urban immediately distorts the picture. As feminist economists Diane Elson (1995, 1997) and Sandra Harding (1998; Harding & Norberg, 2005) taught us, neoliberal economics thrives on categorization, clear distinctions (linear, independent variables), and hierarchy (male over female). These traits distort the value of smallholder farmers as much as they distort the analysis of women's work or power, for the theories reify the economic power of large scale industrial agriculture as much as they do patriarchy. For example, it is estimated that the industrial farming system feeds only 15-20% of the world's population, with the majority of humans eating from local markets provisioned by smallholder producers (ETC Group, 2009; United Nations Environment Program (UNEP), 2011). To suggest alternatives to the neoliberal worldview, the next sections introduce two transformative theories that offer very different ontologies, new concepts, and alternative measures for evaluation.

Transformative Theories: Ecological Economics

> While American consumers saved, on the average, close to a nickel [5¢] on every hamburger imported from Central America, the cost to the native environment was overwhelming and irreversible. Each imported hamburger required the clearing of six square yards of jungle for pasture. (Rifkin, 1992, p.191)

Ecological economics changes the ontological perception of the economy from an open system to a closed one. Not only is an economy "embedded" in a socio-cultural context as explained by Polanyi, but it is also embraced by planet earth. In a closed system, every action impacts another, for there are no externalities, but rather, irreversible biophysical limitations. Entropy teaches that an economy must adapt to renewable energy, for in a closed system, energy dissipates. On a human timeline, the solar radiation flow is endless, but solar energy captured in the ground (terrestrial flow) will eventually be irreversibly used up. Thus, entropy increases (Eriksson & Andersson, 2010). No technological innovation can reverse this dissipation, but technoloogy can be directed to more efficiently use the immediate solar radiation flow. Another example of biophysical limitation directly related to agriculture is topsoil. Its minerals, organic matter, and microorganisms can all be destroyed to the extent that the soil

can never be revived to its original organic composition; plants adapted to that soil may also become extinct as did hundreds of prairie grass varieties across the U.S. Great Plains.[5] Neoliberal economics puts an element like "dirt" at the bottom of its value chain because nothing has been "value-added," while freely circulating capital is at the top. Rejecting this ontology, ecological economics reverses this hierarchy and puts natural capital (e.g., soil, energy) as more precious (valuable), for it provides the foundation or roots of transient finance capital.

In ecological economics, the concept of natural capital is an essential factor of production and cannot be ignored or treated as an externality. It incorporates more than the "land" (its minerals and waters) of neoliberal economics and includes the whole natural world, from air to microorganisms to processing energy (photosynthesis) and regenerating life (seeds; maize is the only food plant that needs human intervention). Because of the pressure to quantify everything, ecological economists most often express natural capital in measures of ecosystem services, such as the amount of carbon a tree processes (Funtowicz & Ravetz, 1994; Ma & Swinton, 2011; Martinez-Alier, 2001). In other words, ecological economists still commodify natural capital in order to measure value in the marketplace. But at least tabulating the ecological services of trees (carbon sink, wind break, shade) gives them value before they are cut down. Food production can occur with zero finance capital, but not without the natural capital of seed or water; only a few plants can grow without soil. For the future of the planet, overcoming the loss of viability of natural capital (eradicated forests, polluted waters) is just as important as sustaining the life of a malnourished child. To ecological economists, natural capital is as vital as labor is as a factor of production.

Ecological economics also transforms the concept of "scarcity" from an expression of unmet needs or desires of a human in the marketplace to an emphasis on the depletion of natural resources or natural capital. Another U.S. dollar can always be printed ("quantitative easing"), but in nature, biophysical limits are a reality, even if they are temporarily eased by technological innovation in the short term. Biophysical limits define "scarcity" for ecological economics, not unmet human desires (Delpeuch, Monnier, & Holdsworth, 2009; Schor, 2005). As Amanor (2008) documents, many African economists link scarcity and the depletion of natural resources with the rapid expansion of the global market, discussing how the global market is fostering insatiable human behavior that is not sustainable.

[5] Soil erosion continues under industrial agriculture. In 1989, the U.S. Department of Agriculture reported that 2.7 billions tons of eroded sediments enter small streams each year, meaning that about 10 tons of soil is eroded for every person in the U.S. at that time (Perelman, 2003).

Based in the analyses of entropy and biophysical limits, ecological economists see degrowth as inevitable and are analyzing how to make it a socially acceptable and stable process, rather than a descent into another economic crisis (Kallis, 2011; Douthwaite 1992). Those in the global food movements, for example, educate the public about meat consumption; they state that eating massive amounts of beef is no longer a "rational choice" for one's health, nor for the planet. As Cornell University ecologist David Pimental (1997) documented over a decade ago: 1) Nearly 40% of world grain, and 50% of U.S. grain, is fed to livestock rather than consumed directly by humans; 2) U.S. grain-fed beef consumes 100,000 liters of water for every kilogram of food produced; and 3) on U.S. lands where feed grain is produced, soil loss averages 13 tons per hectare per year (p.1). Natural biophysical limits render it impossible for every human to eat beef at the average annual amount consumed per capita by Americans, and those relatively deprived of beef will be better off with more varied taste and longer lives. Therefore, the reduction of livestock breeding and feeding is a primary example of ecological economists' concept of "degrowth." Another example is to reverse the distance travelled by food crops from field to fork by consuming local foods. Does it make ecological or market sense for an onion or tomato to travel 5,000 kilometres to the consumer if they can be produced locally? Similarly, one does not need to eat strawberries all year long; it is a choice. Thus, by reducing food processing and food transport consumption of entropic fossil fuels, one could reduce the gross domestic product (GDP), a "degrowth" that respects sustainability.

Nature's response to increasing carbon emissions, through greater weather extremes, suggests that neoliberal economic calculations have long been incorrect. Disintegrating ice caps are killing polar bears; global ecosystems are more interconnected than once believed. Neoliberal economics is responding to climate change by increasing the number of discount rates and incorporating more externalities in cost-benefit analyses. In other areas, however, its logic and application (ontology and episteme) are simply helping to circulate air pollution, since carbon trading is not reducing greenhouse gas emissions. Encouraging new understandings, the climate change debates over the last two decades reaffirm the approach of ecological economics. Mother Nature is exposing the fact that current market valuation and cost-benefit calculations are political, not economic:

> The monetary values given by economists to negative externalities or to environmental services are a consequence of political decisions, patterns of property ownership and the distribution of income and power. There is thus no reliable common unit of measurement, but this does not mean that we cannot

> compare alternatives on a rational basis through multi-criteria evaluation. Or, in other terms, imposing the logic of monetary valuation . . . is nothing more than an exercise in political power. (Martinez-Alier, 2002, p. 150)

And the consequences of this political power are very familiar:

> Economic logic fetishizes growth in quantitative terms, standardizing agriculture in input-output terms. In externalizing ecological effects such as chemical pollution, soil and genetic erosion, carbon emissions, and discounting energy costs and subsidy structures for agribusiness, this logic seriously undervalues the economic costs of agro-industrialization. In so doing, small-scale agriculture is presumed to be inefficient—as evidently confirmed by de-peasantization trends. While such abstract economic valuation is artificial, it nevertheless has real, and violent, consequences. (McMichael, 2008, p. 45)

Transformative Theories: Traditional Ecological Knowledge

> Treat the earth as the plate you eat from. Food comes from the land and the sea. To abuse either may diminish its generosity. In other words, don't break the plate.
>
> -- Tlingit wisdom, Southeastern Alaska (Dowie, 2009, p.108)

Traditional ecological knowledge (TEK) has never separated the market from its social context, economic calculations from their political meanings, or humans from their symbiotic interactions with other species. As a consequence, TEK is not a cohesive body of theories or literature. In a sense, no one can really define it, for the knowledge varies from culture to culture and time to time, expressing dynamic vitality. However, Dowie (2009) offers this insight:

> TEK is the collective, zoological, hydrological, cultural and geographical know-how, rooted in spirit, culture and language essential to the survival of a particular . . . community in a particular habitat. It is "knowing the country." Ethnoecologists and ethnobiologists, relatively new interdisciplinary scientists who study folk taxonomy and traditional ecological systems, tell us that while the 450,000 or so surviving indigenous cultures of the world are remarkably different in many respects, there are some important similarities among them . . . most particularly in the parts of [their] cosmologies that deal with the meaning of land and

> nature…Nature not only supports; it teaches. And the lessons combine to form TEK. (p. 108)

Thus, there are a few general tenets that can clarify the ontological and epistemological bases of TEK before we continue to engage in the aforementioned theoretical debates. The first general tenet is that the TEK worldview is not static, for it does not separate the past from the present or from the future, as economic regression analyses often do. Despite being based on profound respect for ancient knowledge, it is constantly evolving, considering any impacts of today's thinking or actions on future generations. Zapatista women in Chiapas, for example, refuse the dichotomy of modernity and tradition, insisting on "the right to hold to distinct cultural traditions while at the same time changing aspects of those traditions that oppress or exclude [us]" (Eber, 1999, p. 16). TEK does not idealize or romanticize tradition, knowing full well that every type of sexual, social, and authoritative power relation can be found within ancient cultures as well as within nature. For example, in Africa, colonial masters co-opted traditional leaders and manipulated their teachings to gain pervasive control. At the same time, TEK does not allow us to ignore the complex, dynamic, confusing, messy interactions of humans grounded in their natural environments.

The world, and especially humans' place in it, is organic—there are no easy categorizations and no parsimony for quick decisions. TEK directs attention to multiple complexities and acknowledgement of ever-present uncertainty. One gains expertise after long study but not in narrow disciplines that artificially isolate and separate. Skills are highly honored (e.g. plant breeder, botanist, midwife, weather predictor), but they are not separated from community and natural interactions. A local plant offering antibiotic compounds may kill detrimental bacteria in a human body, but healing is viewed as a process that is more complex. The natural sciences are now regrouping into cross-disciplinary fields, from astrophysicists to system biologists (King, 2000; Lewontin & Levins, 2007), complementing specification and enumeration with complexity and uncertainty. TEK honors this complexity, focusing on dynamic interactions within nature in order to understand them. Martinez-Alier (2002) explains this shift by calling for "a new route of modernity. . . based on scientific discussion with, and respect for, indigenous knowledge, improved ecological-economic accounting, awareness of uncertainties, ignorance and complexity, and nevertheless, trust in the power of reason" (p. 147).

TEK would agree with the criticisms of ecological economics toward neoliberal economics, but would add much more. Nature is not simply natural capital; it is sacred and the source of sustenance and spirituality. To destroy nature is to destroy oneself, one's family and

heritage (Pierotti & Wildcat, 2000). A hunter kills an animal for food, but honors its spirit both before and after the kill. Many indigenous peoples also teach about the use of every morsel of the animal for tools, clothing, food, and shelter, with minimal remains for the scavenger mammals and birds. Food is viewed not as an agricultural industry, divorced from the cycles of regeneration across all aspects of the natural world, but "includes wild plants and animals, and the relationship between these and Mother Earth" (Global Forum, 2009, p. 3).

In contrast to the worldview of neoliberal economics, TEK's ontology centralizes distribution or sharing, instead of relegating it to a residual that results from the "trickle-down" left-overs of macro-economic growth. Because the unit of analysis is the community, not the individual, distribution of wealth is more important than the quantitative increase in wealth. Neoliberalism replies to this approach to wealth by claiming that these extreme expressions of "community first" stifles innovation. At the same time, privatization by one individual or corporation can also stifle the development or improvement of an idea or process. Among the Basarwa people of Botswana and Namibia, for example, the "owner of the arrow" that killed the animal does not receive an allocation of the shared meat; to eat, others must give him and his family part of their share. Neoliberal economics, in contrast, teaches that the successful hunter can privatize the whole animal and barter for payment from the others for them to eat. It would analyze the approach of the Basarwa as offering no incentives to the expert hunter. TEK emphasizes collective hunting (i.e., multiple trackers, some who flush the animal out of the brush before the marksman can aim) and shared distribution within the community. Distribution is a key concept that is just as important as incentives.

Distribution extends into intergenerational justice, offering a very different timeline than neoliberal cross-sectional analysis or the quarterly "bottom-line" (corporate profit accounting) it serves. Most all indigenous peoples share a version of the Haudenosaunee (the Six Nations Iroquois Confederacy of the eastern U.S.) precept from their Great Law of Peace, which mandates that any decision made by the nations must consider the impact it will have on the seventh generation yet to come. How would neoliberal economists do that cost accounting? The precept takes into account more than numbers, as it foregrounds uncertainty and ignorance. Engineers calculate how to build a bridge or a levee to endure the one-hundred-year storm, but economic calculations stall at ten-year projections for good reason: they are dealing with human interactions with nature, not solid structures.

Intergenerational justice is particularly important in food production and is a key reason why 161 countries ratified the Cartagena Protocol on Biosafety (Convention on Biological Diversity, 2003). The Cartagena Protocol seeks to protect biological diversity from potential

risks of experiments from biotechnology, especially genetically modified organisms (GMOs). Thus, a government does not have to prove that harm or damage has already been done, but simply has to decide whether or not the uncertainty of harm or damage is too high, invoking the precautionary principle to protect biodiversity for the next generations. This biosafety protocol is one of a handful of international legal agreements to legitimize the stewardship values of indigenous peoples toward nature.[6] Using biodiversity to serve human needs requires awareness of the seventh generation.

Another example of intergenerational justice is the rejuvenation of soil. Soil can be regenerated in as little as three seasons with careful composting and choice of crops, or it can require well over ten years. Worst-case scenario, as stated earlier, the soil can be so degraded that it never returns to a "living soil" of thousands of microorganisms. Inorganic fertilizers do not "rejuvenate" soil; they only provide the chemicals needed by the crop for one season, with much of the chemical residue seeping into ground water, streams, and lakes. The ancestors of indigenous peoples cultivated and hunted for thousands of years, without degrading the soil or destroying the material base of their livelihoods. Indigenous peoples have not just "conserved" the environment but have transformed it through "the deliberate breaking of conservation rules and regulations," which have been found "to maintain, even enhance, floral diversity at various settings around the world" (Dowie, 2009, p. 139). The Amazon, as we know it today, is not pristine, but is human-created, as Mann (2006) documents so well. Thus, many indigenous groups state, "[W]e are the alternative model of sustainable food production and protection of biodiversity" (Global Forum, 2009, p. 1).

Another concept that is more important to TEK than scarcity, growth, or exchange value is trust. Those who were speculating in CDOs (collateralized debt obligations) and derivatives in London, New York, Hong Kong, and Tokyo in 2008 would now embrace this concept. This point goes back to Polanyi's "embedded" market because exchange is not simply an abstraction on a computer screen animated by a keyboard. Even the fast trading ("slicing and dicing") of CDOs requires knowledge and trust from whom one buys and to whom one sells. In short, neoliberal economists already know what indigenous peoples might teach them, but they continue to calculate as if the market were a mechanism, not a socio-political-cultural relation. For TEK, trust offers indispensable economic value, from sustenance to protection to sharing innovation and knowledge.

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[6] The two other international agreements are UNCLOS (UN Convention on the Law of the Seas) and the ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture). The U.S. has not fully ratified any of the three agreements.

Debating New Theories

The complexity of the ecological crisis combined with increasing numbers of hungry people in the midst of surplus production calls for a fundamentally different episteme. Debates continue about whether neoliberal economic theories are perpetuating the worldview and methods of mis-measurement that extend the crises. Those theories predict the demise of peasant farmers as an inevitable result of their inefficiency in production and their inability to supply the global food market. Data demonstrate that the farmers depend on off-farm revenue to survive. Meanwhile, migration is increasing urbanization, and peasant knowledge and skills are obsolete in this era of computerized tractors, which are tracked by satellites that regulate the release of appropriate amounts of fertilizer for each corner of agricultural field. Any individual who tries to explain peasant production is summarily dismissed, as Oxford economist Paul Collier (2008) mocks,"The first giant that must be slain is the middle- and upper-class love affair with peasant agriculture . . . Peasants, like pandas, are to be preserved. But distressingly, peasants, like pandas, show little inclination to reproduce themselves" (p. 70).

In contrast, ecological economics and traditional ecological knowledge can explain the United Nations Environment Program report that smallholder farms produce the majority of world food grains and often give higher food production yields than industrial agriculture. For example, in Africa about 90% of all agricultural (not just food) production is produced by smallholder farmers (UNEP, 2011). Conversely, the landmark report by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (2009), that engaged 400 scientists over three years, concludes that industrial agricultural practices are endangering the planet while failing to rectify the hunger of one billion people. To reverse this, the report recommends investments in ecological practices and in the kind of science that encourages participatory knowledge creation and the integration of indigenous knowledge.

Introduction to the debates that will transform neoliberal theories begins with replacement of the concept of food security with food sovereignty. From the early 1990s, the WTO, throughout its conferences, defined "food security" as a concept referring to commodities entering the global food market. The FAO Early Warning Systems participated in the acceptance of this narrow definition by counting only certain major grains that are delivered by national and regional markets linked to the global market as food. Otherwise, there is no food security; for example, cassava/manioc, potatoes, and cooking bananas (plantains) do not count.

Organized peasant farmers have responded to this hegemonic discourse by declaring

food sovereignty as their goal. *La Via Campesina* first articulated food sovereignty at the 1996 Food Summit, later defining food sovereignty as the "right of peoples, communities and countries to define their own agriculture, labor, fishing, food and land policies, which are ecologically, socially, economically and culturally appropriate to their unique circumstances" (Ainger, 2003, p. 11; see also Beuchelt & Virchow, 2012 and Patel, 2009). Food sovereignty means that the government of Botswana, for example, may choose to encourage production of sorghum and millets in selected semi-arid parts of the country instead of selling its diamonds to buy maize on the world market, the prices of which are both set by cartels. Neither the selling of diamonds nor the purchase of maize has anything to do with a market representing "efficient allocation" or "price equilibrium." Making the concept of food sovereignty central to analyses is just as political as the creation of policies by the WTO, the World Bank, or the G8.

Food sovereignty changes the concepts and their ontological bases in other ways. It emphasizes that hunger is not a problem of scarcity but of rights, as articulated in the UN Declaration of Human Rights (United Nations General Assembly, 2007). Food is not every agricultural product, from cotton to tobacco or sugar, but the "three sisters" of basic carbohydrates (grains, tubers), protein (pulses), and nutrients (greens). For TEK, the right to consume this basic fare is a human right, not a market transaction.

Food sovereignty also extends to the concept of farmers' rights, now legally recognized in the International Treaty on Plant Genetic Resources for Food and Agriculture (Food and Agriculture Organization of the United Nations, 2004). Recognizing farmers' role in increasing biodiversity for millennia, the treaty brings into international law the right of farmers to save, exchange, and breed any seeds. The WTO via UPOV (Union for the Protection of New Plant Varieties) is trying to disallow farmers these rights by invoking intellectual property rights over seed. Affirming TEK rather than the commodification of seed, the international plant treaty sustains farmers' rights for 69 varieties, the ones providing 75% of human food. Farmers' rights are the key to food sovereignty, for they allow farmers to retain and experiment with a crucial input to food production, their seeds (Munzara-Chawira & Mafuratidze, 2009). If a farmer or a country must buy new seeds every season, then they lose control over production; what is available will be determined by the global seed cartel, not by local TEK that may provide a diversity of food items with higher nutrition and resilient production.

Farmers can be considered to be scientists whose "experiments" supply us with the food diversity we now eat. Their "laboratory" testing is closer to natural condtions, unlike the controlled conditions used by seed corporations. Time after time, promising controlled laboratory experiments fail in the field:

> The lessons of the field trial were fascinating. We found innovations that gene activity in a field is extraordinarily variable, and our preconceived laboratory-based notions of how genes worked would turn out to be very inadequate when dealing with field populations. Our technology, though cutting-edge, was not up to the questions that real-world agriculture presents. I became increasingly aware that the availability of tools, and their capabilities, completely dictated the science that was done, and who was doing it. (Jefferson, 2006, pp. 17-18)

A hungry world in the midst of climate change needs laboratory and field science, as well as all of the synergy and resilience biodiversity can provide. Becker (2003) argues that the two approaches to knowledge (i.e., Western scientific method and TEK) can be complementary:

> [T]he two sources of understanding have some common ground: they both rely on direct observation, experience, experimentation, and interpretation. What western science has to offer that TEK lacks is a broader appreciation of context beyond the local level that may actually favor local sustainability and, thus, cultural survival. What TEK has to offer that western science lacks is depth of experience in a local context and a window to cultural interpretations that may be unique and wonderful, yet reasonable. These knowledge systems can be complementary, and it seems naïve to think that thwarting interaction between them would be desirable. (Conclusions section, para. 4)

Smallholder farmers grow as many as 20 crops on one hectare, recognizing the importance of micro-climates in the field, reducing risk through variable times of planting and harvesting, integrating pest management, and providing high nutrition from the biodiverse yields (Mushita & Thompson, 2007). Although this expertise is highly complex and coordinates many variables, it is not readily quantified at a macro level. These applied “scientists” make decisions based on careful observation and data collection, but the data is not what the global market requires.

The debates among economists center on the measures, or the system of economic valuation. Neoliberal economics values efficiency most. Thus, applied theorists in industrial agriculture gather data to demonstrate that mechanized monoculture is the most efficient way to grow food, and they are correct when the denominator is labor, for the yield per unit of labor is very high for this farming system. Further, the current measure of efficiency for land use is yield per hectare, and industrial agriculture may win that “efficiency” label, although that claim is now debated, as UNEP (2011) reports. For example, a new concept called “overyielding” (Altieri,

2009, p. 5) refers to intercropping two crops, such as sorghum and groundnuts, where both yield more if they are integrated onto one hectare, than if each were planted on half of a hectare separately. The smallholder producers, who are feeding the vast majority of the world's population, are working to change the measure from bulk yields to "nutrition density per hectare." The biodiversity of 15 to 20 crops per hectare provides much more nutrition than a single crop of one narrow genetic strain.

If the factor of production of natural capital is added, as both ecological economics and TEK would require, then industrial agriculture cannot be phased out fast enough. Industrial agriculture is addicted to large quantities of fossil fuels, with very unsustainable yields per energy unit. If we measured the energy from burning of fossil fuels per yield of calories available in the food, industrial agriculture would not measure up; the energy burned is much greater than the caloric supply harvested.[7] For many crops, the amount of water required is also quite high, much of it being wasted through evaporation and run-off. Therefore, if natural capital is placed as the denominator within the efficiency quotient (i.e., yield per unit consumption of natural capital), then industrial agriculture will no longer be considered efficient at all.

If all the factors of production are accounted for, then industrial agriculture is only efficient in yield per labor unit. Often, labor can be in short supply on small farms, making labor an important consideration. However, if large-scale industrial farming continues its pattern, then it will make most smallholder farmers "surplus labor" and push them off their ancestral lands into the urban morass, with little hope for employment (Ellis, 2006; Davis, 2006; Friedmann, 2005). Finally, as mentioned above, the timeline to measure "efficiency" under neoliberal terms is at most the annual season. Accounting done by the corporate boards of agribusiness requires very quick results relative to the cycles of nature – so quick, that often nature has been devastated and abandoned (e.g. rubber gathering by King Leopold in the Congo to present-day decimation of forests for cattle feed).

Other measures also favor industrial agriculture in ways that are hard to understand. Fertilizer use is still reported by the World Bank as a positive "development" indicator in its world development statistics. Africa is always far below other regions of the world in its use of kilograms of fertilizer per hectare, and those numbers are used to demonstrate the "backwardness" of African agriculture. Yet, high fertilizer use indicates land degradation, or a

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[7] According to UNEP (2011),"Industrial agriculture consumes on average ten exosomatic energy calories (derived from fossil-fuel energy resources) for every food endosomatic energy calorie (derived from human metabolism of food) that is produced and delivered to the consumer" (p. 41).

paucity of nutrients in the soil. Why does the measure of chemical input endure as an indicator of “development” over measures of nutrients or the organic composition of soil? Industrial agriculture counts for about 40% of greenhouse gas emissions (GHG), with the use of nitrogen fertilizer as a major factor of those emissions (along with methane from livestock). Contesting the validity of efficiency measures, transformative theories call for replacing measures of “efficiency” by those of “resilience.” Ecological economists and others reveal how neoliberal measures endure by ignoring “omitted variables” and by using indicators that obscure the degradation of nature and malnutrition of humans, similar to what some approaches have done when analyzing gender disparities (Beneria & Permanyer, 2010).

If scholars decline to employ the ontology, concepts, and measures of neoliberal economics, they will join global social movements resisting the takeover of their land, water, seed, and knowledge (Holt Giménez & Shattuck, 2011; Warner, 2007). The struggle is on the ground, but transformative theories, concepts, and measures can contribute much to changing not only the discourse, but the policies. More fundamentally, neoliberal development programs often privilege efficiency and technical interventions above social justice. Instead, indigenous peoples and transformative theories of TEK first honor the principles of human rights and intergenerational justice. Indigenous peoples organize globally to turn the valuation of economic theories into serving human rights:

> We, the Indigenous Peoples, and Indigenous women in particular, should have the right to participate in the definition of specific policies that affect our right to food. This includes the right to use methods like crop rotation; the recognition of nomadic pastoralism, traditional hunting and gathering; and creating policies to guarantee our systems of land and resource tenure. (Global Forum for People’s Food Sovereignty, 2009, pp. 3-4)

> Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge . . . as well as the manifestation of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora . . .
> (United Nations General Assembly, 2007 - United Nations Declaration on the Rights of Indigenous Peoples, Article 31)

Their practices are leading the way, on the ground and in the soil, but the hegemony of neoliberal economic theories within global agricultural policies continues. Ecological economics

and traditional ecological knowledge (TEK) offer ways to transform neoliberal economic theories in order to reevaluate and value smallholder food production.

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