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Brian G. Henning
Gonzaga University, henning@gonzaga.edu

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STANDING IN LIVESTOCK'S 'LONG SHADOW'

THE ETHICS OF EATING MEAT ON A SMALL PLANET

BRIAN G. HENNING

A primary contribution of this essay is to provide a survey of the human and environmental impacts of livestock production. We will find that the mass consumption of animals is a primary reason why humans are hungry, fat, or sick and is a leading cause of the depletion and pollution of waterways, the degradation and deforestation of the land, the extinction of species, and the warming of the planet. Recognizing these harms, this essay will consider various solutions being proposed to "shrink" livestock's long shadow, including proposed "technical" or "market" solutions, a transition to "new agrarian" methods, and a vegetarian or vegan diet. Though important and morally relevant qualitative differences exist between industrial and non-industrial methods, this essay will conclude that, given the present and projected size of the human population, the morality and sustainability of one's diet are inversely related to the proportion of animals and animal products one consumes.

In 2007, 275 million tons of meat[1] were produced worldwide, enough for 92 pounds for every person (Halweil 2008, 1). On one level, this fourfold increase in meat production since 1960 might be seen as a great success story about the spread of prosperity and wealth. President Herbert Hoover's memorable 1928 campaign pledge to put "a chicken in every

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Direct all correspondence to: Journals Manager, Indiana University Press, 601 N. Morton St., Bloomington, IN 47404 USA iuporder@indiana.edu

pot and a car in every garage" has, at least for many in the developed world, largely been realized. This juxtaposition of chickens and cars is appropriate in a way that Hoover did not intend: in an important sense, the same industrial processes that have put a "car in every garage" now make it possible to "put a chicken in every pot" or a burger on every plate. What has made it possible to realize the "prosperity" in Hoover's promise is the industrialization of food production, and livestock are no exception. By applying some of the same principles that organized Henry Ford's assembly lines to agriculture (combined with the economically distorting effects of vast agricultural subsidies and other environmental and economic externalities), once-expensive food items—such as beef, pork, and chicken—are now within the reach of billions of people; indeed, they are often cheaper than fresh fruits and vegetables.

On Hoover's measure, then, the shift to intensive, industrial methods of livestock production have been wildly successful. Thanks in large part to the adoption of intensive methods, worldwide more than 56 billion animals are slaughtered each year; an average of 650 animals are killed every second of every day (Halweil 2008, 2). At eight times the size of the human population, livestock cast a very long shadow indeed. A primary contribution of this essay is to provide a survey of the human and environmental impacts of livestock production. We will find that, considering both the direct and indirect effects, the overconsumption of animal meat is now a (if not the) leading cause of or contributor to both malnourishment and obesity, chronic disease, antibiotic resistance, and the spread of infectious disease; the livestock sector may now be the single greatest source of freshwater use and pollution, the leading cause of rainforest deforestation, and the driving force behind spiraling species extinction; finally, livestock production is among the largest sectoral sources of greenhouse gas emissions contributing to global climate change.

Recognizing the inefficient and environmentally destructive nature of intensive livestock production, this essay will consider various solutions being proposed to "shrink" livestock's long shadow, including "technical" or "market" fixes, a transition to "new agrarian" methods, and the movement to a vegetarian or vegan diet. Though important and morally relevant qualitative differences exist between industrial and non-industrial methods, this essay will conclude that, given the present and projected size of the human population, the morality and sustainability of one's diet

are inversely related to the proportion of animals and animal products one consumes.

MEAT, NUTRITION, AND PUBLIC HEALTH

Humans now derive, on average, one-third of their daily protein and 17 percent of their energy (calories) from animal sources (Steinfeld et al. 2006, 269). Yet, as one would expect, these averages mask great differences in meat-eating patterns, from a low of 6.6 pounds of meat consumed per person annually in Bangladesh (Fiala 2008, 413) to a high of 273 pounds per person annually in the United States (Steinfeld et al. 2006, 269). The *way* that people interact with livestock also varies greatly. While many wealthy people only interact with animals when they are on their plate, raising livestock is the primary livelihood of one billion (36%) of the world's poorest individuals (those who live on less than $2 US per day) (Steinfeld et al. 2006, xx and 268). Reflecting this complex reality, livestock production methods vary considerably, from small-scale operations using extensive, pasture methods, to large-scale operations using intensive, industrial methods. While several decades ago the geographical distribution of these methods, extensive and intensive, would largely have corresponded to developing and developed nations respectively, this is no longer the case, with extensive methods increasingly being championed by environmentally conscious consumers in developed nations and developing nations seeking to meet rising demand and achieve economies of scale through the adoption of intensive methods.

Despite these seemingly divergent trends, 80 percent of the considerable growth in the livestock sector worldwide is from industrial livestock production (278). The vast majority of the billions of animals raised for food each year are not wandering the barnyard of a bucolic farm leading long, relatively carefree lives until the day of slaughter. Most livestock today, in both developed and developing nations, are raised using intensive methods in what the industry calls "concentrated animal feeding operations" (CAFOs, pronounced KAY-foes).[2] As Peter Singer recognized decades ago in *Animal Liberation*, animals are no longer *raised*; they are *produced* in modern factory farms where specially bred stocks of animals are maintained in confined spaces and quickly fattened to slaughter weight through a high-protein diet, often of corn or soy.[3] Rather than being raised by many skilled farmhands, a large herd or flock can easily be

"managed" by low-skilled (read low-wage) workers who maintain feeding machines, occasionally remove dead or dying animals ("downers"), and scrape waste into vast "lagoons." Cows, pigs, sheep, and chickens are no longer unique and valued (albeit instrumentally) members of an integrated farm community, they are protein conversion machines; low-value protein (e.g., corn or soy) goes in and high-value protein (animal flesh) comes out.

Yet, at the heart of our global food supply is an insidious paradox. "Today our food supply is nothing less than cornucopian, favoring the world with unprecedented quantities and varieties of food. Yet more people and a greater proportion of the world today are malnourished—hungry, deficient in vitamins or minerals, or overfed—than ever before in human history" (Gardner and Halweil 2000, 10). Taken on a global scale, it is estimated that poor nutrition, whether through hunger or overeating, "easily account[s] for more than half of the global burden of disease" (35). Many policy makers and health professionals are rightly focused on the introduction of fat, salt, and sugar (often in the form of corn derivatives) involved in the industrial processing of our food products, whereas the over-consumption of animals and animal products receives comparatively little attention. Yet, by contributing to the spread of antibiotic resistant infections, the spread of infectious diseases, and the occurrence of chronic diseases, the mass production and overconsumption of meat now constitutes one of the single greatest threats to public health. Let us briefly consider each of these three factors in turn.

In CAFOs cattle are often crammed into feedlots shoulder to shoulder knee deep in their own excrement, pigs are kept in confined sow crates with little room to move, and chickens are frequently kept in poorly ventilated sheds with less than a sheet of paper's worth of space in their overcrowded cages. Because of the intense confinement and unclean spaces found in CAFOs, producers are "forced" to give their herds and flocks large doses of antibiotics in hopes of avoiding the rapid spread of disease (and the attending loss of profit). *Indeed, half of all antibiotics produced worldwide are now administered to livestock* (Steinfeld et al. 2006, xx and 273). This routine, preventive use of antibiotics in industrial livestock production is increasingly recognized as exacerbating what some are calling an "epidemic" of antibiotic resistant infections (Spellberg 2008). As within the human community, the overuse of antibiotics is facilitating

the evolution of more antibiotic resistant infections, threatening both the human and non-human population with treatment-resistant strains and further burdening already taxed health systems.

Secondly, the *proximity* of CAFOs to population centers is quickly becoming a strong vector for the spread of infectious disease to the human population. As the British medical journal *The Lancet* reports, this is a particular challenge for officials in developing nations where the siting of CAFOs close to population centers is facilitating "the emergence of zoonotic infections, including various viral haemorrhagic fevers, avian influenza, Nipah virus from pig farming, and BSE ["mad cow" disease] in cows and its human variant" (McMichael et al. 2007, 1261). The World Bank goes so far as to claim that the "extraordinary proximate concentration of people and livestock poses probably one of the most serious environmental and public health challenges for the coming decades" (cited in Halweil 2008, 2).

Beyond antibiotic resistance and facilitating the spread of infectious diseases, the overconsumption of meat is now a leading cause of obesity (with its attendant health affects) as well as a leading cause of many chronic or noncommunicable diseases, both in developed and developing nations.[4] Indeed, the majority of those living in the developed world and a growing number of individuals in developing nations receive far more nutrition from animal sources than is healthy. Despite persistent claims to the contrary, there is little debate among doctors and nutrition experts that one can have a healthy plant-based diet.[5] For instance, contrary to the protein myth surrounding a vegetarian diet, on average both vegetarians and non-vegetarians consume more than the recommended daily allowance (RDA) of 56 g of protein. For instance, the average meat-eating American consumes 77 g of animal protein and 35 g of plant protein daily for a total of 112 g, twice the RDA for protein suggested by the United States Department of Agriculture (USDA). Yet, the average vegetarian consumes 89 g per day (Pimentel and Pimentel 2003, 661s).

As the average person now derives one-third of his or her daily protein and 17 percent of daily calories from animal sources (Steinfeld et al. 2006, 269), health professionals are increasingly recognizing the link between high intakes of meat and the rise of non-communicable or chronic diseases. A diet high in animal-sourced foods contributes significantly to, among other things, hypertension, heart disease, certain types of cancer,

diabetes, gallstones, obesity, stroke, and food-borne illness (Gardner and Halweil 2000, 41–42; Steinfeld et al. 2006, 269). With an estimated 66 percent of Americans reported as being overweight or obese,[6] the costs of treating the effects of obesity continue to escalate. According to the Centers for Disease Control, in 2000 the total cost of obesity in the United States was estimated to be $117 billion, which accounts for nearly 10% of the nation's health care tab.[7]

Given that half the world is malnourished and that more than half of all disease is linked to poor diet (Gardner and Halweil 2000, 43), it is no exaggeration to claim that we are in the midst of a nutritional crisis, a crisis that is largely of our own making. What is often overlooked is the *ethical significance* of the overconsumption of animal products and the role that it plays in this global nutrition crisis. It is a sad testimony to the great disparity in wealth that exists in the world that, perhaps for the first time in human history, there are more overfed (about 1 billion) individuals than malnourished (about 800 million) (Steinfeld et al. 2006, 6). What is important to note in this context is the sense in which these two figures are related.

A PROTEIN FACTORY IN REVERSE

Though industrial livestock production has dramatically increased production, this economic efficiency has come at the price of dramatic ecological inefficiency: animals now detract far more from the total global food supply than they provide (270). Because only a small portion of the total energy consumed by an animal is converted into edible biomass, each movement up the trophic pyramid away from primary producers results in a significant loss of energy. According to the USDA, the ratio of kilograms of grain to animal protein is 0.7 to 1 for milk, 2.3 to 1for chicken, 5.9 to 1 for pork, 11 to 1 for eggs, 13 to 1 for beef, and 21 to 1 for lamb (cited in Bellarby et al. 2008, 36). In other words, it takes 21 kg of edible grain (or 30 kg of forage) to yield 1 edible kg of lamb and 13 kg of edible grain (or 30 kg of forage) for one kg of beef. Yet a 13:1 protein ratio for beef seems efficient compared to a more comprehensive energy analysis that includes all "inputs," such as fertilizers and pesticides, required to produce a kilogram of beef. According to one study, to produce one calorie of beef requires 40 calories of fossil fuel (40:1), compared to 14:1 for milk and 2.2:1 for grain (Baroni et al. 2007, 285). If animals are now seen by the meat production industry as protein conver-

sion machines—converting "low value" grain or forage into "high value" animal protein—then they are very inefficient machines. Indeed, as Francis Moore Lappé aptly put it, they are more nearly "a protein factory in reverse" (1991 [1975], 70).

With a full third of the annual global harvest of grains being fed to livestock, the scale of lost edible nutrition is as staggering as it is morally unacceptable. "At present, the US livestock population consumes more than seven times as much grain as is consumed directly by the entire American population" (Pimentel and Pimentel 2003, 661s). Indeed, the grain fed to US livestock alone could feed all of the world's 800 million malnourished individuals (Ibid.). While concerns regarding dependency, distribution and corruption are justified, in a world with increasingly stressed ecosystems, a rapidly growing human population, and political unrest caused by high food prices, it is difficult to morally justify this profligate use of edible nutrition. As high as the human costs in terms of health and lost nutrition are, much of livestock's long shadow falls on the Earth's water, land, and air.

WATER PRESSURE[8]

For those of us fortunate enough to live in wealthy nations where sanitation and indoor plumbing are taken for granted and where fresh water is available in seemingly limitless quantities, it is hard to fathom the idea that, worldwide, one in six people do not have access to fresh water and more than twice that number, 2.4 billion people, lack access to adequate sanitation facilities (United Nations Environment Programme [UNEP] 2003). It is no exaggeration to say there is a growing freshwater crisis. Worldwide, humans use three times more water today than in 1960 (Houghton 2009, 188). John Houghton—the founding chair of the Intergovernmental Panel on Climate Change (IPCC)—notes that in many areas the use of freshwater far exceeds the replenishment rate.

> The demand is so great in some river basins, for instance the Rio Grande and the Colorado in North America, that almost no water from them reaches the sea. Increasingly, water stored over hundreds or thousands of years in underground aquifers is being tapped for current use and there are now many places in the world where groundwater is being used much faster than it is being replenished; every year the water has to be extracted at deeper levels. For instance, over more than half the land area of the United States, over a quarter of

> the groundwater withdrawn is not replenished and around Beijing in China the water table is falling by 2 m[eters] a year as groundwater is pumped out. (188)

According to the United Nations Food and Agriculture Organization (FAO), "The world is moving towards increasing problems of freshwater shortage, scarcity and depletion…" (Steinfeld et al. 2006, xxii). By the year 2025, the FAO estimates that 64% of the world's population may live in "water-stressed" basins (Ibid.).[9] And by 2050 the number of individuals living in *severely stressed* water basins is projected to rise from 1.5 billion to 3 to 5 billion (Houghton 2009, 193). While it is certainly true that the rapid growth of the human population is behind many of these figures, how freshwater is *used* has as much or more to do with this crisis than just *how many* people use it. What many often neglect is the key role that agriculture, and livestock in particular, play in both the depletion and degradation of freshwater supplies.

"Domestic" use of water accounts for only 10% of freshwater consumption while agriculture accounts for 66–70% of global freshwater usage, making it the single largest user of freshwater.[10] Hidden in this percentage of water used for agriculture is the amount dedicated to livestock production, which currently accounts for more than eight percent of global water use (Steinfeld et al. 2006, xxii). For instance, according to a study by the *National Geographic* (2010), it takes 1,799 gallons of water to create one pound (0.5 kg) of beef, 576 gallons for one pound of pork, 468 gallons for one pound of chicken, and 216 gallons for one pound of soy beans. Overall, it is estimated that producing one kilogram of animal protein requires 100 times more water than producing one kilogram of grain protein (Pimentel and Pimentel 2003, 662s).

The negative implications of livestock production are not limited to the grossly inefficient use of increasingly scarce freshwater. Livestock production also has far-reaching impacts on both the replenishment and quality of freshwater stocks.[11] In the United States, livestock produce ten times more waste than the human population (Singer 2002 [1975], 168) but, unlike human waste, which must be cleaned in waste treatment facilities, livestock effluent is collected in vast lagoons that often leak into aquifers and waterways. As Schlosser and Wilson vividly describe it, "Each steer deposits about 50 pounds of urine and manure every day. Unlike human waste, this stuff isn't sent to a treatment plant. It's dumped into pits—gigantic pools of pee and poop that the industry calls lagoons. Slaughter-

house lagoons can be as big as 20 acres and as much as 15 feet deep, filled with millions of gallons of really disgusting stuff" (2006, 166). To further illustrate the sheer volume of livestock waste, Schlosser and Wilson go on to note that the two cattle feedlots outside Greeley, Colorado produce more in animal waste than the humans in the cities of Denver, Boston, Atlanta, and St. Louis combined (167).

The problems with animal waste polluting aquifers and rivers are further compounded by the agricultural practices used to create the crops fed to animals. While global figures are not available, the FAO reports that "in the United States, with the world's fourth largest land area, livestock are responsible for an estimated…37 percent of pesticide use…and a third of the loads of nitrogen and phosphorus into freshwater resources" (Steinfeld et al. 2006, xxii). These pesticides and fertilizers make their way into the groundwater and run off into waterways, polluting freshwater sources and weakening or destroying already stressed marine ecosystems. Given the vast quantities of manure, pesticides, and fertilizers generated by intensive livestock production, we can begin to understand why the FAO finds that the livestock sector "is probably the *largest sectoral source of water pollution*, contributing to eutrophication, 'dead' zones in coastal areas, [and] degradation of coral reefs…" (Ibid., italics added).[12] Even before the explosion and sinking of a deepwater drilling rig off the coast of Louisiana (April 2010) dumped millions of gallons of oil into its waters, the "dead zone" in the Gulf of Mexico was bigger than the state of Massachusetts (Venkataman 2008).

In a world with already fragile marine ecosystems and increasingly scarce freshwater, we can ill afford to continue raising animals by such methods. Indeed, given that eating meat is nutritionally unnecessary[13] and detracts more from the global supply of food than it provides,[14] not only is the inefficient and wasteful use of increasingly scarce freshwater ecologically unsustainable, it is morally unacceptable to continue to preference the acquired taste of meat over the *need* for life-giving freshwater. Unfortunately, the impact of industrial livestock production is not limited to the quantity and quality of freshwater or the damage done to fragile marine ecosystems. The impacts of livestock production on the land and the flora and fauna that depend on it are equally severe and unsustainable.

LAND DEGRADATION, DEFORESTATION, AND THE SIXTH GREAT EXTINCTION

For millennia, agricultural production has been the driving force behind what is euphemistically referred to as "land conversion." As the human population races toward an estimated nine billion people by mid-century, the dimensions of this "conversion" are massive. Nearly a third of the Earth's land surface has already been cleared to make way for a global farm and the rate of clearing is accelerating (Steinfeld et al. 2006, xxi, 5, and 271–72).

Though few people connect the steak on their plate to deforestation in the Amazon, the link is now undeniable. "In the Amazon, cattle ranching is now the primary reason for deforestation" (Steinfeld et al. 2006, 272). Indeed, the ever-expanding demand for beef is the single greatest contributor to deforestation worldwide. "In Latin America where the greatest amount of deforestation is occurring—70 percent of previous forested land in the Amazon is occupied by pastures, and feed crops cover a large part of the remainder" (xxi). Moreover, after a brief period of decline, the rate of deforestation for pasture land is once again increasing, reaching an annual rate of more than 13 million hectares (over 32 million acres) a year, "an area the size of Greece or Nicaragua" (UNEP 2003). Not only is the *rate* of clearing unsustainable, but also the way that these cleared lands are subsequently being "cultivated" is of great concern.

The FAO reports that, worldwide, 20 percent of all pastures and rangelands and nearly 75 percent of those in "dry areas" are being degraded, "mostly through overgrazing, compaction and erosion…" (Steinfeld et al. 2006, xxi). In the United States, nearly all (90%) of crop land is being depleted thirteen times faster than the natural replacement rate of one ton per hectare per year (Pimentel and Pimentel 2003, 662s). Overall, in the United States, livestock are responsible for an estimated 55 percent of soil erosion (Steinfeld et al 2006, 273). In some parts of the world the conversion of forest and grasslands to pasture or feed crops is depleting the land causing "desertification."[15]

In hastening the destructive spread of deserts across ever-larger portions of the globe, livestock production is threatening not only livestock and agriculture, but the remaining, already-stressed ecosystems.[16] As farmers and ranchers clear forested land and draw ever-larger checks on

the non-renewable stores of fossil energy to fuel our global farm, we are pushing many species to extinction.

There is wide consensus among biologists that the present rate of extinction is 50 to 500 times the normal "background rate" revealed by the fossil record (Woodruff 2001, 5471). It is because of this that some claim that we are in the midst of the sixth great extinction in the history of our planet. Though many environmental philosophers recognize the seriousness of rapid anthropogenic species extinction, few note that the production of meat may now be "*the leading player in the reduction of biodiversity*, since it is the major driver of deforestation, as well as one of the leading drivers of land degradation, pollution, climate change, overfishing, sedimentation of coastal areas and facilitation of invasions by alien species" (Steinfeld et al. 2006, xxiii, italics added). To adapt a memorable phrase from Peter Singer: we are quite literally gambling with the future of millions of forms of life on Earth for the sake of hamburgers.[17]

COOKING THE PLANET

In considering responses to global climate change, what has largely been lost in all of the "green" talk about fuel efficient cars and compact fluorescents, windmills and photovoltaics, is the fact that *the food we eat contributes more to global climate change than what we drive or the energy we use*. Worldwide, emissions from agriculture exceed both power generation (McMichael et al. 2007, 1259) and transportation (Steinfeld et al 2006, xxi; Pelletier and Tyedmers 2010a, 2), contributing as much as a third of all greenhouse gas emissions (Bellarby et al., 2008, 5).[18] The portion of these emissions dedicated to livestock production is substantial, constituting approximately 18 percent of global anthropogenic greenhouse gas (GHG) emissions (Steinfeld et al. 2006, xxi; Halweil 2008, 2; Pelletier and Tyedmers 2010a, 2). Beyond the unstated taboo against publicly criticizing the morality of various food choices, part of the reason that the livestock sector is often omitted or ignored in discussions of global climate change may be that it is responsible for a relatively small portion of direct global *carbon dioxide* emissions (9%), primarily from the burning of biomass (deforestation) to create feedcrops or pasture. However, a closer analysis reveals that meat production has a much larger role in the emission of methane (CH_4), a potent heat-trapping gas.

Whereas carbon dioxide concentrations in the atmosphere have in-

creased by more than a third over pre-industrial levels, the concentration of methane has more than doubled in the last two centuries (Houghton 2009, 20, 50). Methane is formed through anaerobic breakdown of organic matter. Thus, there are "natural" sources of methane, the most important of which are wetlands and termite mounds. The major anthropogenic sources are coal mining, leakage from natural gas pipelines and oil wells, rice paddies, biomass burning (burning of wood and peat), and, most important for present purposes, waste treatment (manure) and enteric fermentation (bovine flatulence) (Houghton 2009, 50).[19] Though still present in the atmosphere in far smaller amounts than carbon dioxide (1.775 parts per million (ppm) vs. 380 ppm), methane plays a disproportionate role in global warming, contributing 21 percent of all anthropogenic warming (35). The reason for this has to do with differences in the molecular properties of atmospheric methane.

Unlike carbon dioxide, which is gradually "taken up" by land biota or the ocean,[20] methane is chemically broken down in the atmosphere, lasting an average of only twelve years.[21] This relatively short lifecycle is offset by the fact that methane is far more potent at trapping heat than carbon dioxide. Indeed, molecule-for-molecule, methane traps twenty-three times as much heat as carbon dioxide. Taking this differing global warming potential into account, we can calculate the overall footprint of livestock production in terms of carbon dioxide equivalent. According to a recent study, "to produce 1 kg of beef in a US feedlot requires the equivalent of 14.8 kg of CO_2. As a comparison, 1 gallon of gasoline emits approximately 2.4 kg of CO_2. Producing 1 kg of beef thus has a similar impact on the environment as 6.2 gallons of gasoline, or driving 160 miles in the average American mid-size car" (Fiala 2008, 413). Overall then, factoring in both direct and indirect emissions and the differences in lifecycle and potency of different gases, the livestock sector is responsible for nearly a fifth (18%) of all GHG emissions worldwide. It would seem that the chickens in our pots are *more* responsible for global climate change than the cars in our garages.[22]

This realization is alarming as the effect of even the relatively small amount of warming ($0.6^{o}C \pm 0.2\ ^{o}C$) in the twentieth century is already being felt, particularly in northern latitudes, where the effects are amplified.[23] In the coming decades these changes will accelerate with the rising temperature. Though there will be regional winners and losers, generally

those least responsible for causing the heat trapping gases (the developing nations) are expected to be most severely affected by the changing climate, including melting icecaps and glaciers, rising sea levels, shifting weather patterns, more intense storms, drought, desertification, species extinction, salinization of freshwater, spread of infectious disease, and millions of environmental refugees.

In sum, we have found that livestock cast a very long shadow indeed. The mass consumption of animals (and the intensive, industrial methods that make them possible) is a primary reason why humans are hungry, fat, or sick and is a leading cause behind the depletion and pollution of waterways, the degradation and deforestation of the land, the extinction of species, and the warming of the planet. The urgency of this realization becomes even more apparent when considered in light of the rapidly accelerating rate of meat consumption, which is expected to more than double by 2050 from the 1990 level of 229 million tons per year to 465 million tons (Steinfeld et al. 2006, xx). As the FAO notes, the "environmental impact per unit of livestock" must be halved just to maintain the current level of environmental damage, which is itself already environmentally unsustainable (ibid.).

Even in its characteristically guarded manner, the FAO is surprisingly direct: "Better policies in the livestock sector are an environmental requirement, and a social and health necessity" (4). Given that livestock's "contribution to environmental problems is on a massive scale…its potential contribution to their solution is equally large. The impact is so significant that it needs to be addressed with urgency. Major reductions in impact could be achieved at reasonable cost" (xx). Let us transition, then, to consider how, according to the FAO, livestock's long shadow might be shortened.

EFFICIENCY, TECHNOLOGY, AND THE MARKET

The FAO suggests the following specific measures to mitigate the environmental impact of livestock production.

- Agricultural subsidies—Governments should commit to the gradual elimination of "often perverse subsidies," which too often "encourage livestock producers to engage in environmentally damaging activities" (xxiii-xxiv).

- Overgrazing—The impact of grazing can be mitigated through the institution of grazing fees (pricing the commons), and restricting livestock access to waterways, which reduces erosion, sedimentation, and pollution (xxi).
- Freshwater—Irrigation water should be properly priced. Livestock access to waterways and riparian areas should be strictly limited. Producers should utilize irrigation practices and technology that reduce loss of freshwater through evaporation and leakage (xxii).
- Manure—Research and implementation of integrated manure management practices should be accelerated, including biogas digestion and methane capturing systems. This technology has the benefit of capturing heat trapping methane as an energy source, reducing water pollution, and creating high-quality fertilizer that can return nutrients to the soil (279).[24]
- Soil conservation—Soil erosion and degradation can be mitigated through already known practices, such as avoiding bare fallow, the appropriate use of fertilizers, "silvopastorlism," and controlled exclusion from "sensitive areas" (xxi).[25]
- Decentralization—Zoning laws should be created or changed to site CAFOs away from population centers. This will mitigate infectious disease vectors and "bring waste generated into line with the capacity of accessible land to absorb that waste" (279).
- CAFOs—Developing nations should *accelerate* the transition to intensive, industrial livestock production to increase resource efficiency and decrease environmental damage per unit of livestock (278).

The FAO suggests that industry and political leaders worldwide should urgently consider implementing these changes to how animals are raised for food. For centuries the price (if they are priced at all) of water, land, and feed have not reflected their actual scarcity. The failure to internalize the cost of these "externalities" has led to artificially low prices and the "overexploitation and pollution" of the global commons (xxiii

and 277). From an economic perspective, better "internalizing" costs will allow market forces to moderate demand; paying the "true cost" of meat will make it more expensive, which in turn is likely to result in a reduction in consumption and production. The elimination of agricultural subsidies and the pricing of water and pastureland would help to reduce the ongoing destruction of the commons. Given the entrenched nature of global subsidies schemes around the world, the political viability of this route is in doubt.

From the perspective of ethicists and activists concerned with animal welfare, the FAO's most controversial recommendation is likely to be that nations should *hasten* the transition to CAFOs. In its report the FAO claims that the environmental problems caused by industrial livestock production are *not* from their "large scale" or "production intensity," but from their "geographical location and concentration" (278). For instance, the FAO argues that raising animals in concentrated animal feeding operations (CAFOs), rather than using pasture-based methods, will *decrease* deforestation for pasture, thereby reducing a major source of greenhouse emissions caused by the livestock sector.[26]

I will evaluate the sustainability of adopting the FAO's suggestions more fully in the final section. Presently I note that, as important as many of the FAO's suggested changes are, it is misleading to suggest that they would significantly mitigate livestock production's high cost to animals, human health, and the environment. For instance, while increasing the intensity of livestock production would likely decrease deforestation for pasture, it would do nothing to reduce (and may in fact increase) deforestation for feedcrops. Further, increasing the industrial production of livestock would result in a corresponding increase in the loss of edible nutrition, use of freshwater, spread of antibiotic resistant disease, and increase in disease caused by the overconsumption of animals.

As Pelletier and Tyedmers conclude in their analysis of the FAO report: "Given the magnitude of necessary efficiency gains, it would appear highly unlikely that technological improvements alone will be sufficient to achieve the objective of maintaining the proportional contribution of the livestock sector to cumulative anthropogenic contributions to these issues…" (Pelletier and Tyedmers 2010a, 3). As I will argue more fully in the final section, even if all of the FAO's recommended measures were implemented, meat production practices would remain woefully unsustainable.

As Pelletier and Tyedmers put it, there is a "profound disconnect between the anticipated scale of potential environmental impacts associated with projected livestock production levels and the most optimistic mitigation strategies relative to these current, published estimates of sustainable biocapacity" (2).

In focusing exclusively on reforming livestock production methods and refusing to recommend explicitly the reduction of meat consumption, the FAO's report gives the false impression that current meat consumption practices can indefinitely continue, if only methods were made more "efficient" by applying industrial techniques.[27] Unfortunately, as I will show, these market-based "technical fixes" would do little more than slow the bleeding of a gaping, infected wound. Indeed, in a telling passage the FAO seems to recognize this, noting that "by applying scientific knowledge and technological capability" we can at best "offset" some of the damage. "Meanwhile, the vast legacy of damage leaves future generations with a debt" (Steinfeld et al. 2006, 5). Recognizing that current industrial agricultural and livestock production methods are unsustainable, some are calling for more dramatic changes to the way animals are raised.

LET THEM EAT GRASS

A raft of largely popular books decrying the industrialization of food production has reached a new high-water mark, led most vocally and eloquently by the journalist Michael Pollan.[28] Unlike the philosophers and activists of an earlier generation who, inspired by the work of Peter Singer and Tom Regan, fought against industrial farming because of the excessive suffering caused to animals, this "new agrarian farming movement" is focused more on the human and environmental costs of industrialized food production.[29] Though the movement is diverse, it is largely characterized by a return to more "natural" methods of producing food and raising animals, including local, organic produce and free-range animals. Thus, there is a hue and cry for a movement away from CAFOs, not necessarily because of the pain and suffering that they undeniably cause to the animals, but because of the human and environmental damage they inflict. While a complete analysis of the new agrarian movement is not possible here, it is important to consider whether and how a move away from *intensive*, factory farming and toward *extensive*, pasture-based methods would address the significant human and environmental harms currently caused by livestock production.

First, although perhaps not its explicit intention, new agrarian methods would dramatically improve the lives of livestock. As philosophers and animal activists have rightly noted for decades, intensive factory farming methods (especially in the United States) are unimaginably cruel. There is little dispute that most of the animals raised in CAFOs lead short lives of intense suffering. "The crucial moral difference," Pollan rightly notes, "between a CAFO and a good farm is that the CAFO systematically deprives the animals in it of their 'characteristic form of life'" (2007, 321).[30] Animals should be returned, Pollan argues, to their rightful evolutionary role as members of a complex farming community symbiotically related in complex webs of interdependence.[31]

The new agrarians argue that the elimination of CAFOs would not only be good for the animals themselves, it would also be good for humans. First, the widespread adoption of new agrarian methods would reduce the spread of treatment resistant infections by eliminating the preventive use of antibiotics. Second, by eliminating the confined, unsanitary conditions of CAFOs and their close proximity to population centers, pasture-based livestock production would reduce the risk of spreading infectious diseases from livestock to the human community. However, the most significant benefit to human health would probably come from the reduction of meat consumption caused by dramatically higher meat prices. Presumably, the methods advocated by the new agrarian movement would entail much smaller herds and flocks which, combined with the proposed elimination of agricultural subsidies, would dramatically increase the price of meat (and other industrially processed foods). This decrease in supply and increase in price of meat would likely result in a reduction in consumption, which would have significant benefits for human health. As *The Lancet* found in its recent study, a "substantial contraction" in meat consumption should benefit human health "mainly by reducing the risk of ischaemic heart disease…, obesity, colorectal cancer, and, perhaps, some other cancers" (McMichael et al. 2007, 1254). In this way, proponents of the new agrarian movement argue, meat would remain a part of the human diet, but it would play a noticeably smaller role.

This return to a more "traditional diet" was first championed by the Rachel Carson of the food movement, Francis More Lappé (1991 [1971], 13). Animal flesh has been part of *homo sapiens*' diet for millions of years, but until recently it has always played a minor role. This evolutionary perspective on meat eating is also at the heart of Pollan's discussion in

his acclaimed *The Omnivore's Dilemma*. Pollan takes issue with animal welfare advocates who equate the domestication and raising of animals with "exploitation" or "slavery," arguing that this portrays a fundamental misunderstanding of the relationship between humans and livestock. "Domestication is an evolutionary, rather than a political, development" Pollan writes. "It is certainly not a regime humans somehow imposed on animals some ten thousand years ago" (2007, 320). Rather, Pollan argues, the raising of animals for food and labor is an instance of human predation and, as such, it is an instance of "mutualism or symbiosis between species" (Ibid.). The suggestion, then, is that humans should see the raising and consuming of animals not as a regrettable moral failing but as an ecologically vital part of our evolutionary heritage. "Indeed," Pollan argues, "it is doubtful you can build a genuinely sustainable agriculture without animals to cycle nutrients and support local food production. If our concern is for the health of nature—rather than, say, the internal consistence of our moral code or the condition of our souls—then eating animals may be the most ethical thing to do" (327).

Overall, then, advocates of the new agrarian movement argue that, compared to the dominant industrial model, the organic, pasture-based methods are better for the animals raised, for the humans who eat them, and for our shared natural environment. As a *comparative* judgment, I am in agreement with this claim. The methods of the new agrarian movement are in many ways an improvement over the industrial livestock practices encouraged by the FAO and used by the majority of producers around the world.

Further, advocates of the new agrarian movement are right to note that vegetarians and vegans should not presume that the elimination of meat automatically makes their diet environmentally sustainable. The more industrial the agricultural processes involved in producing one's food, whether meat or plants, the greater the ecological impact. Ecologically speaking, a vegetarian diet based on heavily processed meat substitutes made out of plants that were raised in monoculture on formerly forested lands using large quantities of pesticides and fertilizers may be *more* ecologically destructive than eating a grass-fed cow.

Thus, I join those in the new agrarian movement in recognizing that the act of eating (whether plants or animals) is a fundamentally ecological act. The consumption of one organism by another is perhaps the most

basic form of ecological relation. Through the act of consumption, the other literally becomes part of one's being. Indeed, it is important to recognize that *every* organism destroys others that it might live and thrive; such destruction is at the very heart of the act of living. As Alfred North Whitehead once noted "Life is robbery…" (Whitehead 1978 [1929], 105). Every organism takes from others to sustain itself. This view is consistent with an appropriate, ecological view of our world. Ecologically speaking, the destruction of life is a vital part of the flow of energy through natural systems. And yet while life does indeed involve robbery, as Whitehead rightly recognized, "the robber requires justification" (105). As moral agents, our robbery of life must be justified.

Given the ecological standpoint adopted here, the morality of one's diet is not merely determined by *what* is eaten, but also *how* what is eaten is produced. That is, the question is not *whether* one's diet is environmentally destructive, but *how* destructive it is. While there are important, morally relevant differences between plants and animals, vegetarians and vegans should not be seduced into thinking that their hands are clean because they don't eat animals. Once we appreciate the embedded nature of our ecological existence, we realize that no living being has "clean hands." Every living organism must destroy others in order that it might sustain itself. Humans are no exception. It is not possible for humans—or any other living being—to sustain themselves without destroying other beautiful and complex forms of life. Such a moral position resists the temptation to reduce the moral life to simplistic binary states of "good" and "bad." In the final analysis, there are only ameliorative grades of better and worse relative to that ever-evolving moral ideal. In a world replete with beautiful and unique achievements of life, our aim as moral agents should be to avoid destroying or maiming another being unless such destruction is necessary in order to achieve the most robust, rich, and beautiful result possible.[32] The act of eating is an inherently moral act; our robbery of life must be continually justified.

Yet is pointing, as Pollan and Lappé do, to the evolutionary basis of our meat consumption a sufficient *moral* justification of continuing the practice? No. Explaining the *genesis* of a practice is not yet to give its *moral* justification. Indeed, Pollan himself makes this point. "Do you really want to base your moral code on the natural order? Murder and rape are natural, too. Besides, we can choose: Humans don't need to kill other

creatures in order to survive; carnivorous animals do" (2007, 320). Given that humans don't *need* to kill other creatures in order to survive or even thrive, we need to morally justify the *choice*. Beyond the evolutionary argument, the moral weight of the argument for continuing to eat animals would seem to rest on the claim that truly sustainable agriculture requires the use of livestock to complete the nutrient cycle. Yet is this the case? To conclude that such methods are *better* than industrial methods is not yet to have shown they are *good*. Is in fact eating meat "the *most* ethical thing to do"?

In his recent essay Vasile Stãnescu has noted that there is an often unrecognized "dark side" to Pollan's and Kingsolver's new agrarian model.[33] By creating "an idealized, unrealistic, and, at times, distressingly sexist and xenophobic literary pastoral…" the new agrarian movement encourages "traditional" gender roles and national or regional identities over against foreign workers and food (Stãnescu 2010, 10). While there is no necessary connection between the adoption of pasture-based livestock production and a nostalgia for supposed "traditional ways," Stãnescu is right to question whether, embedded within the call to return animals to the land, is also a call to return women to the kitchen and men to the range.

However, Stãnescu's critique goes beyond questioning the narrative that underlies the new agrarianism. He also notes that the problem with the new agrarian model is that "it is simply factually untrue" (12). Given the world's current and projected rate of meat consumption, he argues that it is doubtful whether it is physically possible to raise livestock via pasture-based methods. "[L]ocally based meat, regardless of its level of popularity, can never constitute more than either a rare and occasional novelty item, or food choices for only a few privileged customers, since there simply is not enough arable land left in the entire world to raise large quantities of pasture fed animals necessary to meet the world's meat consumption" (Stãnescu 2010, 14–15). This brings us finally to the crux of the issue: is it in fact possible to feed sustainably the present and projected human population on a diet based significantly on the consumption of animals?

A MORE SUSTAINABLE DIET

The human population will soon pass the seven billion mark.[34] Over the next forty years (by 2050), the United Nations estimates that at least two billion more humans will be born.[35] Those billions of people will

need significant quantities of freshwater and food. If present trends are any indication, much of this food will be in the form of animal products. Assuming the wide adoption and continued improvement of livestock production methods as suggested by the FAO's report, what are the likely environmental impacts of a future with nine billion meat eaters? Is the FAO right that livestock production can be made sustainable through the intensification of livestock production? Or are advocates of the new agrarianism right that the only form of sustainable agriculture is one based on pasture-raised animals? On our increasingly small planet, what form of diet is the *most* ethically responsible and environmentally sustainable?

To help answer these crucial questions, I turn to a recent study of the FAO's report by Pelletier and Tyedmers. In their study they use "simplified but robust models to conservatively estimate" the likely environmental impacts in 2050 of different dietary scenarios for meeting the USDA recommendations for protein consumption (2010a, 3). The "FAO projection scenario" represents the status quo baseline of projected increases in animal product consumption, which as we have seen is expected to be double that of 1990 levels (Steinfeld et al. 2006, xx). In the "substitution scenario," less efficient ruminant products (cows, sheep, goats, milk) are replaced by monogastic products (chickens, turkeys, eggs). Finally, Pelletier and Tyedmers consider the anticipated environmental impact of a "soy protein scenario," in which the recommended daily allowance (RDA) of protein is derived entirely from soy protein sources (vegan diet).

This study is particularly useful for our purposes because each of these scenarios is then compared against recent estimates of "environmental boundary conditions" for *sustainable* greenhouse gas emissions, reactive nitrogen mobilization,[36] and anthropogenic biomass appropriation. These boundary conditions are defined as "biophysical limits which define a safe operating space for economic activities at a global scale" (Pelletier and Tyedmers 2010a, 1–2). For instance, citing work by Allison, et al., Pelletier and Tyedmers suggest that—if warming this century is to be limited to two degrees Centigrade, which is required to avoid the most severe environmental disruptions projected by the IPCC—annual per capita greenhouse emissions must be limited to one metric ton (2).[37] On the other hand, Pelletier and Tyedmers use Bishop, et al.'s estimate that humanity can "sustainably appropriate 9.72 billion tons of net primary production annually without undermining the biodiversity support potential of global ecosystems" (2010b, 3).[38]

Although far from a complete account of sustainability, Pelletier

and Tyedmers' study provides a helpful model for evaluating whether human activity is sustainable with regard to these three critical areas. All of human activity—including not only food production, but also energy production, manufacturing, transportation—must fall within these "environmental boundary conditions" if humanity is to avert "irreversible ecological change" (2010a, 3).

The results of Pelletier and Tyedmers' study are staggering. While recognizing that their models still embody "considerable uncertainty," they find that "by 2050, the livestock sector alone may either occupy the majority of, or considerably overshoot, current best estimates of humanity's safe operating space in each of these domains" (2).[39] Specifically, by 2050, in order to meet FAO projected livestock demand (FAO scenario), livestock production will require 70% of the sustainable boundary conditions for greenhouse gas emissions, 88% of sustainable biomass appropriation, and 294% of sustainable reactive nitrogen mobilization (2). Thus, according to these conservative estimates, if humans consume animal-sourced proteins at the rates projected by the FAO, *livestock production alone* will consume the majority of or exceed entirely the sustainable boundary conditions in these three critical areas.

Note that, since they are limited to *direct* greenhouse gas emissions and *direct* appropriation of biomass, these figures are, if anything, likely to be overly conservative. If *indirect* emissions and biomass appropriations are included, for instance by including the effects of land-use conversion, then it is likely that the sustainable boundary conditions for both GHG emissions and biomass appropriation would also be exceeded (Pelletier and Tyedmers 2010b, 3). In modeling the likely direct emissions and biomass appropriation, Pelletier and Tyedmers provide an important response to the widely touted work of Pitesky, Stackhouse, and Mitloehner, which takes issue with several of the FAO's conclusions.[40] Relevant here is the claim that increasing the intensity of livestock production in developing nations would alleviate the need for deforestation and would be sufficient to make livestock emissions sustainable. However, Pelletier and Tyedmers' model demonstrates that this reasoning is likely to be mistaken. Even with the widespread use of the most "efficient" livestock production methods, livestock production would use an unsustainable portion of the environmental boundary conditions for carbon dioxide emissions, nitrogen emissions, and, especially, biomass appropriation.

What if, instead of relying on ruminant sources of protein (beef,

sheep, goat, and milk), humans derived their protein from more efficient, monogastric sources (chicken, turkey, and eggs) as in the substitution scenario?[41] According to Pelletier and Tyedmers, if poultry products were consumed instead of ruminants, "anticipated marginal CO2-e emissions would rise by 22% and biomass appropriation would increase by 15% relative to year 2000 levels.… However, relative to the FAO projections scenario, substituting poultry for marginal ruminant production would reduce greenhouse gas emissions by only 13%, biomass appropriation by 5%, and reactive nitrogen mobilization by 8%" (Pelletier and Tyedmers, 2010b, 3). Thus, overall, the substitution scenario would only yield an aggregate reduction in impacts of 5–13% over that of the FAO projection scenario, suggesting that the sustainability of a diet of mainly monogastric animals is also doubtful.

What if all humans obtained their recommended daily intake of protein from plant (in this case soybean) sources as in the soy protein scenario? Creating the 457,986 thousand tons of soy beans (ibid.) necessary to feed the projected nine billion humans in 2050 would no doubt have a considerable impact on the environment. However, relative to the FAO scenario for 2050, it would represent a 98% reduction of greenhouse gas emissions, a 94% reduction in biomass appropriation, and a 32% reduction in reactive nitrogen mobilization. Thus, the entire human population could, in principle, meet its protein needs from plant sources and only contribute 1.1% of sustainable greenhouse gas emissions, 1.1% of sustainable biomass appropriation, and 69% of sustainable reactive nitrogen mobilization (ibid.). Thus, a plant-based diet is not only more *healthful* than the other diets,[42] it is also the most *sustainable* form of diet.[43]

Thus, even under the most optimistic scenarios for technological improvements in livestock efficiency, nine billion humans could not continue to eat animals at the current and projected rates and avoid catastrophic environmental harms. "As the human species runs the final course of rapid population growth before beginning to level off midcentury," Pelletier and Tyedmers (2010a) write, "reining in the global livestock sector should be considered a key leverage point for averting irreversible ecological change and moving humanity toward a safe and sustainable operating space" (3). In the end, the more animal products one consumes, the more destructive one's diet is to the environment. Though important and morally relevant qualitative differences exist between industrial and non-industrial methods, given the present and projected size of the human population,

the morality and sustainability of one's diet are inversely related to the proportion of animals and animal products in one's diet. Thus, if we are to ensure adequate food and water for all humans without exceeding the Earth's capacity to support life, we must find the courage to address directly the morality of eating meat on an increasingly small planet.

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NOTES

1 Although "meat" should be inclusive of all forms of animal flesh, including aquatic, following standard usage in this field, the term "meat" will largely refer to beef, pork, chicken, and lamb.

2 According to Halweil (2008), "Factory farms account for 67 percent of poultry meat production, 50 percent of egg production, and 42 percent of pork production" (2).

3 See Singer 2002 [1975].

4 Cf. "Worldwide the number of overweight people (about 1 billion) has now surpassed the number of malnourished people (about 800 million). And a significant part of the growth in obesity occurs in the developing world. For example, the World Health Organization (WHO) estimates that there are 300 million obese adults and 115 million suffering from obesity-related conditions in the developing world" (Steinfeld et al. 2006, 6).

5 Cf. "It is the position of the *American Dietetic Association* that appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases" ("Position of the American Dietetic Association: Vegetarian Diets" 2009, 1266).

6 Cf. "Results from the 2005–2006 National Health and Nutrition Examination Survey (NHANES), using measured heights and weights, indicate that an estimated 32.7 percent of US adults 20 years and older are overweight, 34.3 percent are obese and 5.9 percent are extremely obese" (Centers for Disease Control and Prevention 2008).

7 Cf. Centers for Disease Control and Prevention 2010; Gardner and Halweil 2000, 8.
8 This appropriate heading was used in a recent issue of the *National Geographic* focused on water use (National Geographic 2010).
9 See also, "The extent to which a country is *water stressed* is related to the proportion of the available freshwater supply that is withdrawn for use…" (Houghton 2009, 188).
10 See Houghton 2009, 188 and Steinfeld et al. 2006, 5. According to Pimentel and Pimentel, "in the Western United States, agriculture accounts for 85% of freshwater use" (Pimentel and Pimentel 2003, 662s).
11 Cf. "Livestock also affect the replenishment of freshwater by compacting soil, reducing infiltration, degrading the banks of watercourse, drying up floodplains and lowering water tables. Livestock's contribution to deforestation also increases runoff and reduces dry season flows" (Steinfeld et al. 2006, xxii).
12 This quote continues, "The major sources of pollution are from animal wastes, antibiotics and hormones, chemicals from tanneries, fertilizers and pesticides used for feedcrops, and sediments from eroded pastures."
13 Cf. note 6.
14 Cf. "In simple numeric terms, livestock actually detract more from total food supply than they provide. Livestock now consume more human edible protein than they produce. In fact, livestock consume 77 million tonnes of protein contained in feedstuff that could potentially be used for human nutrition, whereas only 58 million tones of protein are contained in food products that livestock supply" (Steinfeld et al. 2006, 270).
15 Cf. "Desertification…is the degradation of land brought about by climate variations or human activities that have led to decreased vegetation, reduction of available water, reduction of crop yields and erosion of soil" (Houghton 2009, 197).
16 Cf. "The United Nations Convention to Combat Desertification (UNCCD) set up in 1996 estimates that over 70% of these dry lands, covering over 25% of the world's land area, are degraded and therefore affected by desertification" (Houghton 2009, 197).
17 Cf. "We are, quite literally, gambling with the future of our planet—for the sake of hamburgers" (Singer [1975] 2002, 169).
18 Cf. "The total global contribution of agriculture, considering all direct and indirect emissions, is between 8.5–16.5 Pg CO2-eq, which represents between 17 and 32% of all global human-induced GHG emissions, including land use change…" (Bellarby 2008, 5).
19 For a breakdown of methane emission by source, see Houghton 2009, 53, table 32.

20 Although the shorthand of one century is often used for the lifetime of carbon in the atmosphere, the actual lifecycle is more complicated because reservoirs "turnover" at a wide range of timescales, "which range from less than a year to decades (for exchange with the top layers of the ocean and the land biosphere) to millennia (for exchange with the deep ocean or long-lived soil pools)" (Houghton 2009, 37).

21 Cf. "The main process for the removal of methane from the atmosphere is through chemical destruction. It reacts with hydroxyl (OH) radicals, which are present in the atmosphere because of processes involving sunlight, oxygen, ozone and water vapour. The average lifetime of methane in the atmosphere is determined by the rate of this loss process. At about 12 years it is much shorter than the lifetime of carbon dioxide" (Houghton 2009, 50).

22 Cf. "With rising temperatures, rising sea levels, melting icecaps and glaciers, shifting ocean current and weather patterns, climate change is the most serious challenge facing the human race. The livestock sector is a major player, responsible for 18 percent of greenhouse gas emissions measured in CO_2 equivalent. This is a higher share than transport" (Steinfeld et al. 2006, xxi). Pitesky, Stackhouse, and Mitloehner have rightly noted that the FAO's comparison of the livestock and transportation sectors is potentially misleading because it is "based on inappropriate or inaccurate scaling of predictions" (Pitesky et al. 2009, 33). However, Pitesky, Stackhouse, and Mitloehner do *not* dispute that livestock production accounts for 18% of global greenhouse gas emissions. Rather, their claim is first that the FAO's *comparison* of the livestock and transportation sectors is misleading because, whereas both direct and indirect emissions are included for the livestock sector, only direct emissions are counted for the transportation sector. Secondly, they note that while it is true that the livestock sector has a larger footprint than transportation in many developing nations, it is not true of the United States (and most developed nations) where livestock account for only 2.8% of emissions (4). Thus, Pitesky, Stackhouse, and Mitloehner rightly note that a more precise formulation would be to say that "agriculture is considered the largest source of anthropogenic CH_4 and N_2O at the global, national, and state level…while transport is considered the largest anthropogenic source of CO_2 production"(11).

23 For instance, a June 2009 report of the Government Accountability Office (GAO) found that 31 native villages face "imminent threats" from "growing impacts of climate change in Alaska." At least twelve of these villages have elected to relocate entirely (United States Government Accountability Office 2009).

24 The immediate viability of manure management systems is questioned by Fiala, who claims that "this technology is a long way from being used in the US and Europe, let alone the rest of the world, this is not likely to be a solution in the near future" (Fiala 2008, 418).

25 Silvopasture is the practice of combining forestry and animal husbandry to enhance soil preservation and animal welfare. For more on silvopastoralism see Sharrow 1999, 111–126.

26 Cf. "Expansion of livestock production is a key factor in deforestation, especially in Latin America where the greatest amount of deforestation is occurring—70 percent of previous forested land in the Amazon is occupied by pastures, and feedcrops cover a large part of the remainder" (Steinfeld et al. 2006, xxi).

27 In its otherwise comprehensive and detailed analysis, the FAO makes only one brief reference to the role of meat consumption. "While not being addressed in this assessment, it may well be argued that environmental damage by livestock may be significantly reduced by lowering excessive consumption of livestock products amoung wealthy people" (Steinfeld et al. 2006, 269).

28 See, for instance, Schlosser 2001; Schlosser and Wilson 2006; Pollan 2007, 2009; Kingsolver 2007; Petrini 2007; Foer 2009; Fairlie 2010.

29 I will use the phrase "new agrarian movement" to refer to the loose collection of popular writers and scholars who seek to move society away from industrial food production. This phrase is inspired by the book series created by The University of Kentucky Press, *Culture of the Land: A Series in the New Agrarianism*. (See http://www.kentuckypress.com/newsite/pages/series/series_agrarianism.html.) My thanks to Lee McBride for bringing this to my attention.

30 Pollan 2007, 321.

31 On the symbiosis between livestock and humans, see Pollan 2007, 321f.

32 For a more developed defense of this kalocentric or beauty-centered position, see Henning 2005 and 2009.

33 Kingsolver 2007. See also, James E. McWilliams, *Just Food: Where Locavores Get it Wrong and How We Can Truly Eat Responsibly* (Little, Brown and Company 2009).

34 See United States Census Bureau 2010; UN 2011.

35 Contrary to its earlier projections, the United Nations is no longer expecting the human population to stabilize midcentury at nine billion people. According to its most recent estimates, the human population is projected to continue to climb past ten billion people by 2100. See UN 2011.

36 Cf. "Nitrogen is essential to all life forms and is also the most abundant element in the Earth's atmosphere. Atmospheric N, however, exists in a stable form (N_2) inaccessible to most organisms until fixed in a reactive form (N-). The supply of reactive nitrogen plays a pivotal role in controlling the productivity, carbon storage, and species composition of ecosystems… Alteration of the nitrogen cycle has numerous consequences, including increased radiative forcing [i.e., climate change], photochemical smog and acid deposition, and productivity increases leading to ecosystem simplification and biodiversity loss" (Pelletier and Tyedmers 2010a, 1).

37 In 2000 the average American contributed twenty metric tons of carbon dioxide (CDIAC).

38 Net Primary Production (NPP) is defined as "the net flux of carbon from the atmosphere into green plants per unit time.… NPP is a fundamental ecological variable, not only because it measures the energy input to the biosphere and terrestrial carbon dioxide assimilation, but also because of its significance in indicating the condition of the land surface area and status of a wide range of ecological processes" (DAAC 2010).

39 The researchers admit the speculative nature of their models, but also note the conservative nature of the presuppositions made. Cf. "Modeling the future is fraught with uncertainties, and we would be remiss to present our estimates as definitive. We have endeavored to err on the side of caution in developing what we believe to be conservative forecasts of some of the potential future environmental impacts of livestock production. For example, it would be impressive, indeed, were all livestock production globally to achieve resource efficiencies comparable to those reported for the least impactful contemporary systems in industrialized countries, effectively reducing global impacts per unity protein produced by 35% in 2050 relative to 2000—as we have assumed here" (Pelletier and Tyedmers 2010a, 2).

40 For additional discussion of Pitesky et al., see also note 22 and 43.

41 This is in fact the suggestion of the article responding to Pelletier and Tyedmers by Steinfeld and Gerber 2010.

42 This is confirmed by the *American Dietetic Association* (2009): "The results of an evidenced based review showed that a vegetarian diet is associated with a lower risk of death from ischemic heart disease. Vegetarians also appear to have lower low-density lipoprotein cholesterol levels, lower blood pressure, and lower rates of hypertension and type 2 diabetes than nonvegetarians. Furthermore, vegetarians tend to have a lower body mass index and lower overall cancer rates" (1266).

43 Note that this responds to Pitesky, Stackhouse, and Mitloehner's claim that the FAO's report is incomplete because it "does not account for 'default' emissions. Specifically, if domesticated livestock were reduced or even eliminated, the question of what 'substitute' GHGs would be produced in their place has never been estimated" (35). Pelletier and Tyedmers' analysis demonstrates that a plant-based diet is likely to be the only sustainable way of feeding the current and projected human population.

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