



Steven G. Hall

Raising Food for Thought

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Food is essential for life, but food also encompasses many ethically challenging aspects with both scientific and theological implications. This article invites further dialogue on these matters. With rising world population and wealth, the need for food is escalating. This article explores various concerns as to where food comes from, how food is distributed and processed, how food consumption may be healthy or unhealthy, and encourages consideration of a more sustainable, just, and sound food system.

Agriculture provides a fascinating and important intersection point to explore issues that have both theological and practical implications. We all eat; thus we depend on agriculture to survive. What do science and theology have to say about agriculture, food, and human flourishing? This article questions a broad overview of the food system, with focus on areas of interest and conflict to be addressed throughout this theme issue. It is also an invitation to address some of these problem areas in a deeper fashion, drawing on scientific and theological bases to provide vision to move forward toward a more sustainable food system.¹

Food is a fundamental of life. We all eat and could benefit by learning more about how our food is raised: where it comes from; who grows it; how it is grown, treated, distributed, processed, and consumed; and what effects this may have on our health, society, and planet. Water is also fundamental to most food production. Only oxygen is more physically critical for our survival.

Despite amazing improvements in food production in the last century, hundreds of millions are still hungry, and world population continues to rise, with predictions of 9 billion or more people by 2050.² At the same time, extreme weather events such as droughts, floods, powerful storm systems, and temperature extremes are making sustainable food production more difficult, while biological chal-

lenges such as diseases of food crops and humans continue to hamper food production and health.

How can we produce sufficient, safe, healthy food and fiber while reducing inputs, and minimizing impacts on local and global ecosystems? Our agricultural and related systems must become more robust and adaptable in changing times. A sustainable food system should provide this food and fiber while also enhancing human flourishing, farming communities, and society in general; protecting and restoring God's creation; and moving food systems toward economic and environmental sustainability. This is a grand challenge, an opportunity to stand in the gap, a call to both prayer and humility, and an opportunity to consider what the Bible has to say about food and water, the culture of plants and animals, and how God sees humans, the earth, and his other creatures.

Biblical Background

A'dam, the man created from dust (the earth-ling) was placed in the garden to *sh'mar* and *a'bad* the garden (work and keep; cultivate and guard, Gen. 2:15, ESV; GNT).³ So we were originally made of

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“the earth”—elements common in the earth’s crust, oceans, and atmosphere (hydrogen, oxygen, nitrogen, carbon ...). “For dust you are, and to dust you shall return” (Gen. 3:19b). In the interim, we have spirit in that physical “earthy” body. It is this intersection that helps define what it is to be human. In ways healthy or unhealthy, this also influences our approach to raising and preparing food. One could argue, in both “secular” history and in biblical history, that our first foods were “wild”—God provided fruit trees in the garden and we were gatherers. In our traditional understanding, humans were hunter-gatherers before developing agriculture, which itself allowed more “permanent” civilization to emerge.

In the Bible, the “people of God” were seen as primarily nomadic, living in tents (even the ark of God was kept in a tent or tabernacle). Cain and Abel, the first children of Adam and Eve, brought “nomadic” animal sacrifices and “settled” grain sacrifices; and we see tension both there and later in conflicts between the more-settled Canaanites and Philistines and the more-nomadic Israelites. Similar tensions continue today in some parts of the world and in food supply, for example, in tensions between wild caught fishers and settled aquaculture practitioners;⁴ or between nomadic tribes, such as the Fulani in Nigeria, with nearby settled cultures. Thus, tensions in our food system have had and continue to have social or even spiritual aspects.

Jesus addresses and interacts with food in at least two ways:

1. Food is a real physical aspect of our human experience and Jesus enjoys it, eating “regular food” with his disciples and also with unexpected peoples and in unexpected (boundary pushing) ways or times (for example, on the Sabbath). He also uses food and agricultural images to share visions of God’s transformative kingdom. He eats normal food such as bread, wine, and water, but makes it special. What makes such food special or celebratory? The night of the last supper, Jesus shared bread, a very simple food, and used it to remind his disciples of their personal and spiritual lives; after supper he poured wine, probably produced from local fruit, and said, “This cup is the new covenant in my blood, poured out for you” (Luke 22:20), comparing himself to traditional animal sacrifices. After his resurrection, he appeared to the disciples and broke bread and ate

fish with them (John 21:9–13). Again, these simple foods remind us that he too became an “earthling.” Some even conjecture that Jesus took his earthly body to heaven and that heaven will have “earthly” qualities. Addressing both the physical and spiritual aspects of food and agriculture is critically important. A Christian approach is thus critical to this conversation.

2. Food is not the ultimate point. Jesus initially resists Mary’s request to turn water into wine, but then acquiesces and produces a very good wine (John 2:1–10). He was tempted by the devil to turn a stone into needed bread, but resisted. Even though “after fasting forty days and forty nights, he was hungry” (Matt 4:2), he replied, “Man does not live on bread alone, but on every word that comes from the mouth of God” (Matt. 4:4). Thus, a true theological discussion of food should not be constrained to purely physical aspects, but it should also consider social, ethical, and spiritual implications of the food system.

There are many unique images of food in the Bible. Starting early, God creates *ex nihilo*, an unfolding cosmos over periods of time, with the development of the heavens, the production of plants and animals on Earth, and eventually Adam and Eve, the earthlings. And God saw that it was good. Adam is given the responsibility of naming all the creatures. Surely, this accepting of God’s handiwork and the naming implies a knowledge that humans should have of the other creatures. God creates the “beasts of the earth” and creatures of water and sky, and he places Adam in “dominion” over them. God blessed the animals and told Adam and Eve to “be fruitful and multiply” (Gen. 1:24–30, ESV). That we have done.

As of the early twenty-first century, human dominion has expanded, dominating even the large carnivores, fishing out the oceans,⁵ toppling the great forests, and feeding more people than ever before. We have a moral obligation to allow humans to provide for themselves, but we are having a much harder time of caring for other creatures and keeping species alive. Is this our responsibility and how does this link with a responsible Christian view of agriculture? Human fruitfulness is tied to the fruitfulness of creation.

In our day we are blessed to live with the largest population the planet has ever hosted, but also challenged in how to care for creation and each other with limited resources. Agriculture uses the most

land and may be the largest total contributor to environmental degradation,⁶ but Christians cannot in good conscience allow people to starve. In fact, we are called to care for “the least of these” (Matt. 25:40). How can we raise food and provide water and other basic necessities in a way that honors God and provides for the present population, but that also allows for a sustainable future for those who come after us? This too is a moral imperative, as it could be argued that the unsustainable way we are using resources is actually stealing food and water from our children and grandchildren. In this light, we should consider our place in history and some of the immense transitions that have taken place and will continue, as well as the need for Christian thought and action in these realms. But to consider these, we need to explore the where, who, why, when, and how of our food system.

Agricultural Challenges

Where does our food come from? Clearly, the land, water, human, and biological inputs to the agricultural system are essential to the enterprise and are critical considerations. The environment at large is of interest: agriculture is practiced around the world in varying ways, but always with the growth of plants and animals, and always with the need of soil or other media and water. Biblically, both soil and water have theological implications. Adam was taken from the dust, as were all other creatures—we are literally earthlings. Both practical stories, such as Boaz and Ruth harvesting and sharing in fruitfulness (Ruth 2–4), and parables, such as that of the sower, speak of “good soil” (Matt. 13:8). Yet many forms of agriculture encourage erosion of soil, reduce nutrient content in soil, and otherwise have negative effects on soil. Aldo Leopold suggested a “Land Ethic” in the last century,⁷ and many of his ideas have been beneficial when put into practice, with conservation tillage, low-till or no-till practices, organic farming, and other techniques intended to conserve and enhance soil. What is good soil? How can we reduce negative effects on our soil? Are there types of agriculture that can conserve or even restore soil?

Similar things can be said of water. Water is essential for all forms of agriculture. “Soil-less” agriculture is totally dependent on water. Sometimes plants can flourish with natural rainfall, but many areas use various forms of irrigation. There are numerous

challenges with water, and water problems will continue to contribute to both environmental and social stresses around the world. In the American southwest, laws are based on “riparian rights,”⁸ which imply limits to water supplies. Ongoing tensions between urban users and agricultural needs are serious there, but water tensions are even more severe in other parts of the world. How are we to address these questions? How can we have a fruitful agriculture while also allowing both the natural environment and other humans sufficient water? These questions are not only local but also global in scope.

Food itself is now grown and shipped, frequently traveling thousands of miles, essentially shipping water and resources to other areas.⁹ While global trade has many positives, what are the limits? Should agriculture be encouraged at a more local level? And what are the implications for the rich and the poor? Jesus said, “The poor you will always have with you” (Matt. 26:11), but he did not condemn the poor to remain poor. How are we to care for our local and global neighbors? How do agriculture and the food system play into this? Such questions have implications for food production and consumption.

In Genesis 2:15, NRSV, Adam is told to till and keep the garden of Eden. We are instructed not only to take an active role (the tillage interpretation), but also to “keep” or “protect,” implying that we are not to destroy entire species or ecosystems. In Exodus, food was provided in the desert in the form of manna, and later, birds sacrificed themselves, but the Israelites in both cases were instructed not to “store up” too much but to trust God to provide. This contrasts with Joseph’s exploits in storing up during good years (Genesis 41), and other instructions which allow for a “Sabbath for the land” (Lev. 25:2–4), but we are told that the land will still provide (there does appear to be some allowance for storage) and the “tillers” are to become something closer to hunter/gatherers during these “rest” times. Also in Leviticus, we are told *not* to harvest grain to the edge of the field but to leave some for gleaners (Lev. 23:22). This directive is not very “efficient” by modern standards, but it does have a strong social aspect, both providing for the poor and allowing the poor to work for their food. This idea of differentiation of labor and of some kind of social net, which still allows active participation, appears to be a template for a modern version of sustainable agriculture.

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What should be the working conditions for agricultural laborers? Agriculture is and has been hard work. After the Fall, Adam was told that he would work “by the sweat of his brow” (Gen. 3:19). Are there ways to reduce the labor demands of agriculture? Is it good physically and spiritually to work? What are the implications for transient laborers? Are there biblical examples? Boaz greeted his workers and they greeted him back (Ruth 2:4). How could fair treatment of laborers and mutual respect be instilled in the modern context? Whom or what else should we treat well? Surely, water, air, and land must be cared for better than we are currently doing.

Many specific challenges have been noted, including unsustainable use of fresh water (rivers dammed, aquifers and waters dramatically reduced, geographic tensions over water); degradation and erosion of arable land; eutrophication of water bodies, including oceanic waters by excess nutrient runoff; excess use of fossil fuel in food production and thus air pollution and carbon dioxide changes in the atmosphere.¹⁰ It is now recognized that atmospheric changes are leading to various other events, including more-extreme tropical storms, melting of glaciers and polar ice, rising sea levels, and changes in precipitation. Clearly, each of these could ultimately result in significant harm for agriculture and civilization itself.

What does modern science have to say about these questions? Are there fundamental limits to resource use or to biology? Have we reached or exceeded some limits? What are other ways we might provide for people’s caloric needs while still allowing other species to flourish? Are there ways we can minimize degradation of the environment as we pursue agricultural goals? Are there methods by which we can help restore habitats and species while also providing sufficient food for humans?¹¹ How and why might we pursue these methods? What are the physical or spiritual reasons why we might not pursue them?

Land Use and Practices

How do we farm, and who does the farming? This varies dramatically around the globe. In Africa, most growing of crops is done by women. Water is often carried by women and children. In America, the image of a strong male farmer is often presented, although the actual participants in agriculture are

quite diverse. What is the relationship between owners of land and workers on the land? Can land be “owned” in the biblical sense? The psalmist tells us, “The Earth is the Lord’s, and everything in it” (Ps. 24:1). Some societies have practiced various forms of communal land ownership, while others have allowed individuals to claim rights to land. What are the advantages and disadvantages of each approach? The US, in practice, has a mixed approach, with substantial amounts of land owned by private individuals or families, companies, and industries such as timber, paper, and integrated farming operations; in addition, massive tracts of land are managed by state and federal government entities such as the Bureau of Land Management that leases land for timber harvest, grazing, and other activities.¹² Some moderately large areas are owned or managed by nongovernmental organizations (NGOs), including environmental and church groups. Is there a “best” or “biblical” approach? The Bible speaks of long-term ownership, with concepts such as Sabbath rest for the land once every seven years, and Jubilee every fifty years – at which time the land reverts to a more distributed ownership model.

How should we treat the land? What do we plant? A very limited number of crops, and a limited biological diversity of these crops, is now planted.¹³ The implication is that high yields of “selected” crops are expected. Chickens grow bigger and faster, cows give over 100 pounds of milk per day, and yields of corn and soybeans are higher than ever. However, this is a precarious system in which a disease or other disaster can decimate large areas of crops. Should we care about “heirloom” varieties of vegetables, fruit trees, or other crops? The US government has developed several National Germplasm Repositories (for plants in New York State and for animals in Colorado) to “save,” often in the form of seeds or sperm, genetic diversity.¹⁴ Should our farming systems preserve living strains of more diverse organisms? How should this be funded or managed?

What do we add to the land? Plants tend to remove nutrients, requiring additional applications of fertilizers, either natural such as manure and compost or artificial such as phosphorus or nitrogen, often at a cost both in the process of mining or manufacturing and in loss from excess. The hypoxic zone in the Gulf of Mexico¹⁵ and similar eutrophic areas elsewhere, such as Lake Erie (freshwater) or red tide areas

(marine/estuarine saltwater), are the result of nutrients that run off and encourage the growth of algae and bacteria; these can reduce oxygen in the water column, often killing other species. These are relatively benign chemicals, generally helpful in plant growth.

What damage is created by the more-toxic chemicals that we add to the environment? Synthetic pesticides and herbicides, antibiotics administered to animals, and other chemicals have left a mark. DDT famously killed insects but also affected the health of animals such as predatory birds, almost driving the national symbol of the US, the bald eagle, to extinction. DDT inspired Rachel Carson's *Silent Spring*¹⁶ and ushered in laws in the 1960s and 1970s that helped protect the environment in the US. Internationally, many toxic chemicals are still used. More recently, the herbicide glyphosate has been used extensively on "roundup ready" crops, in concert with "genetically modified" (GM) crops.

Genetically modified organisms (GMOs) or GM crops are generally animals or plants whose DNAs have been modified using genetic engineering techniques. This may involve inserting or deleting genetic information to change the organism. These traits may be taken from other plants, animals, or microorganisms. There are currently ten GM crop species, including corn, cotton, and soy. In the US, more than 75% of the crop land used to cultivate these species is now GM.¹⁷ GM crops may be more drought tolerant or resistant to disease organisms, potentially reducing inputs, including water, fertilizer, and energy. In some cases, GM crops may be resistant to herbicides, thus encouraging heavier use of those herbicides in a tension with reduced tillage and erosion, since land does not need to be cultivated as much to reduce weeds. In the US, a very high percentage of plant crops are now GM crops (94% of the corn cultivation areas since 2014 grow GM corn varieties),¹⁸ and many other parts of the world are growing them. Some researchers note that adding these traits can reduce the need for expensive pesticides and may result in enhanced yields. Others argue that, in many cases, these create new challenges, such as excess use of certain chemicals that "match" the GM traits (for example, herbicide-resistant crops). Still others worry about the effects of current or future chemicals on both the environment and human health. Some chemicals seem relatively benign, but their degradation products may have unexpected harmful results.

This could include various medical and pharmaceutical products that may end up in water systems and affect wildlife and humans.

Technological Problems

Our technological innovations can cause unintended consequences. Items from our consumptive lifestyle that we do not always think of as affecting food or ecologies can range from fuels to components to transportation to industrial systems to packaging. Microplastics are now seen as cause for concern in many ecological and agricultural systems. These may come from textiles, packaging, or consumer goods that end up in water, soil, and almost certainly, in food.

What are we to think about new technologies—biological, chemical, or otherwise? Do we "play God" too much? How much intervention in the natural system is helpful? Are there limits? It could be argued that agriculture itself is a technological innovation, and is a part of the conditions that have allowed high human densities in the first place. The plow, fossil-fueled farm equipment, artificial fertilizers, genetically modified organisms (GMOs) as food, pesticides, and antibiotics are each a technological advance that can enhance food growth, but each also has potentially damaging side effects. The dust bowl and, more recently, desertification in the Mediterranean Basin and other areas, were partially the result of excess soil tillage. Fossil fuels have increased CO₂ in the atmosphere, contributing to climate change. Too much fertilizer has led to eutrophication in both fresh and ocean waters: for example, consider the hypoxic zone in the Gulf of Mexico.¹⁹ GMOs are a much broader description of many kinds of plants and animals whose genetic editing has been much faster than the genetic selection used since biblical times, but at a much slower rate of selection. These "new technologies" raise questions, as do other methods of agriculture that may affect the surrounding environment or genetics. Pesticides can kill selected pests but they may have unintended consequences, and while antibiotics kill microbes, they may thus select for resistant bacteria or weeds. Is selection of genetic traits by traditional or GM technologies a good thing, leading to better producers that are possibly resistant to temperature extremes or biological impacts, or is selection encouraging excess use of antibiotics or pesticides a bad thing?

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Other technologies are more physical, traditionally including tractors and other implements, but more recently including electronic and geographic information systems. Automation and robotics is another area of both interest and controversy. Automation is increasing with artificial intelligence, automated tractor and processing systems, remote sensing to identify problems in fields early, and, on the horizon, even larger, more automated farming systems,²⁰ ultimately reducing the contact between humans and the land even further. Is this a good thing?

Moral Considerations

Can thoughtful approaches to automation enhance our understanding of the land, reducing environmental impact while improving yield? Are there moral imperatives in the Bible or Christian thought that apply here? As God sent Adam and Eve from the garden, he said that humans would work “by the sweat of your brow” (Gen. 3:19). The Puritans, Amish, and other Christian groups have seen work as something good for both the human body and soul. Can an approach such as co-robotics in which robots enable humans to be involved and make “high-level” control decisions, possibly enhance our connections with the land? Could virtual farm tours help educate the general public?

Moral treatment of animals in agriculture has some basis in the Bible. The Mosaic law places limits on working animals (Exod. 20:10). Jesus asks a hypothetical question that assumes helping an animal, in his response to a theological question about the Sabbath (Luke 14:5). He suggests that it is normal and good to treat animals well. “Animal rights,” by contrast, is fairly modern terminology,²¹ but the Bible does address the requirement for moral treatment of working and food animals. As animal agriculture has become more concentrated, with “feedlots” and confined animal feeding operations (CAFOs), a number of physical as well as moral issues have been raised.²² The excess concentration of nutrients is one challenge, and the actual treatment of the animals is another. What is acceptable treatment of animals in agriculture? Should Christians seek to treat animals better than the usual “minimum acceptable” level? Are there technologies that can reduce reliance on animals or enhance animal welfare? Will we move to a primarily or totally vegetarian food system?

Thus, there are moral aspects to biotechnology, animal agriculture, food technology, and related practices. Each possible technology or practice has benefits, but also possibly dangerous side effects, both direct and indirect. Is there a moral or even a “Christian” way of vetting such technologies and practices? Could we learn from groups such as the Amish, who abstain from many technologies but do have a technique for vetting new technologies, and are more likely to adopt new technologies “partially,” rather than “full scale,” such as the use of electricity in barns but not in houses? Is there a logical and moral approach to these questions?

Jesus speaks in metaphorical and physical terms about food and water, animals, and even the technologies of the day, often placing himself in the story. At the beginning of his ministry, Jesus is tempted by the devil. After forty days of fasting, Jesus was hungry. The devil urges him to “tell these stones to become bread” (Matt. 4:3). Interestingly, given that Jesus not only turns water into wine but also heals and raises people from the dead, he would have been able to do this, but he declines. This is instructive for our modern world: just because we can, does not mean we should. By extension, one should be careful as to why one is “playing God”: is it for good purposes or for sinful reasons, including pride, fear, and greed? Jesus, instead, replies, “Man shall not live on bread alone, but on every word that comes from the mouth of God” (Matt. 4:4, citing Deut. 8:3).

Jesus’s next temptation was to take a risk: “throw yourself from the pinnacle of the temple.” Again, this is something he could have done, and the devil even tempts him by citing scripture, “He will command his angels concerning you to guard you carefully; they will lift you up in their hands, so that you will not strike your foot against a stone” (Luke 4:10–11, citing Ps. 91:11–12). Jesus’s response is parallel to the first, and equally useful in our current context: “Do not put the Lord your God to the test” (Luke 4:12, citing Deut. 6:16). This has a secular parallel called the “precautionary principle.”²³ Interestingly, this environmental principle has health-related implications, which are often linked to environmental chemicals or risks.²⁴ This, of course, is among the limits of human existence: we are not God, and we do not know all. We would be wise to follow a kind of biblical “precautionary principle” and “not test

the Lord.” The theology and science behind this is complex and invites further discussion and writing. It also leads us humbly back to Jesus, whom Christians acknowledge as “my Lord and my God” (John 20:28), and it guides us to observe his actions and words with regard to the environment, people, and human flourishing.

Human flourishing as well as the flourishing of God’s good creation are both objectives that seem consistent with a Christian worldview. This leads to issues of food safety and food security.²⁵ How is food distributed and processed? What techniques for distributing food globally are feeding people in need with excess from other areas or are diversifying the diet to enhance human health? What are the food safety issues involving disease or pesticide residue? How good is food security in our current system?

Food Processing

Food processing has historically been a way of preserving food. Drying and salting were two ancient techniques. Grain was harvested, dried, and stored. Meat was often salted or smoked. In the last century, a number of additional techniques have been developed to process and preserve food, while a very large number of techniques have been used to enhance value.²⁶ Many of these techniques, such as refrigeration and processing to separate out valuable products, have been helpful, but many have also led to concerns in the realm of food safety.

Food processing can help provide sufficient quantities of food during times of low food availability, and keep food safe by reducing microbial spoilage. However, modern food has often been processed to the point at which many native antioxidants and other healthy components have been removed, leaving empty calories. We enjoy sugary drinks and processed salty snacks, but they make us fatter and less healthy. Many of these foods also have substantial loadings of food preservatives that allow products to sit on shelves longer, but that also degrade their healthy aspects. Should the food processing industry be involved not only in food microbial safety, but also in food quality for better nutrition? Are there techniques in processing food that can keep nutrients in, while also providing food safety? Are we too married to “convenient” food, fast food, and rich food? Are we addicted to unhealthy foods?

Food Consumption

How is food consumed? The health effects of food are significant. Food is God’s way of providing for us, and sharing it is a blessing. However, there may be types of food or ways of consuming food that can be harmful. Obviously, food that is laden with unwanted chemicals, or which contains toxins such as botulism from natural processes, can be a problem. In the twenty-first century, the form and amount of food consumed may constitute the biggest harm. Specifically, more food is available in processed forms which likely exclude many needed nutrients; this leads to sufficient calories, but the food is deficient in micronutrients, antioxidants, and other food components that are present in more-raw forms of food. In other cases, salts and flavor compounds are provided at excessively high levels in processed foods, leading to other health problems such as high blood pressure due to excess sodium.

Is it the fault of the food growers that individuals may choose to eat cereals made largely of processed grains and sugars, or choose to eat excess calories, salt, or fats? While individuals make choices, it is clear that many in the US, and now many in other developed and developing countries, consume excess calories and have significant health concerns related to these excess calories—calories from nutrient-deficient food and beverages. Is there a biblical approach to food consumption that could help reduce these man-made results of bad producing? While there are still hundreds of millions hungry people,²⁷ more people are being fed more calories than ever before, but not with uniform enhancements to health. How can we move toward healthier approaches to food, enjoying the fruitfulness God has provided while not exceeding the limits of the land or the human body, and, indeed, treating the body as “the temple of the Holy Spirit” (1 Cor. 6:19)? Biblically, we are called to “fasting and prayer” (1 Cor. 7:5, NKJV). Is fasting also a healthy practice for the body and soul? Could limited fasting have positive effects on our views and practices in the food system?

How we treat ourselves may be linked to how we treat the land and other people and creatures. For example, both per capita and total consumption of animal products have risen in recent decades. Chicken, pork, and fish are at all-time record levels of consumption. Beef consumption has not increased in recent years, but it still accounts for a substantial

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stress on the planet. Feed conversion ratios (FCRs) of these animals mean that raising animals, in most cases, is less efficient and uses more resources than eating primarily plant-based products. For example, cows require about 25 kg of feed to produce one kg of meat; pork, about 5 kg; poultry, 2–3 kg; whereas eggs, milk, and fish are generally more efficient.²⁸

Interestingly, the books of Genesis and Daniel both seem to suggest that a vegetarian diet can be a godly diet. On the other hand, Jesus ate fish and Peter was told to eat what the Gentiles eat (Acts 10:13), including many kinds of animals. The early Christians who came from non-Jewish backgrounds or lived in these communities were instructed to “abstain from food sacrificed to idols, and from blood” (Acts 15:29, ESV). This teaching leaves the door open to eat with and fellowship with a wide variety of individuals, reflecting the inclusive nature of the worldwide Christian community. This is also instructive for our interactions with others.

Food as a Social and Spiritual Principle

We should be understanding of individual choices, while acknowledging Christian freedom in the realm of food, beverages, and diet. Jesus too links food with social and spiritual action, often using images of food and beverages. His first miracle recorded in John was at the urging of his mother: he turned water into wine at a wedding. This provision was not only a necessity but a celebration as well. Jesus does celebration food. In fact, on further consideration, almost all of Jesus’s food-related stories and miracles have a celebration aspect, while many of them also earnestly seek to share provision at both a basic and a much deeper level. He famously shared meals both with “good” people and with “tax collectors and prostitutes.” Here the focus was not on the food but on the social aspects of food, often with a sense of sharing. He did talk about himself as both food and drink: “I am the bread of life. Whoever comes to me will never go hungry, and whoever believes in me will never be thirsty” (John 6:35).

Jesus modeled and encouraged transformations. How would Jesus suggest we transform from twisted to redeemed ways of relating to food, not selfish but selfless? The Bible speaks to healthy and unhealthy ways to enjoy and share food. There are numerous examples of both in the Old and New Testaments.

Excess consumption of wine led to drunkenness and other immoral behavior. Gluttony, the excess consumption of food as well as drink, is understood as a moral failure in the New Testament. However, celebration with food and drink appears not just acceptable but even central to biblical community. For example, the biblical tithe (Lev. 27:30–33) included a portion of food produced, offered to the Lord. It was to be eaten in community at the temple (Deut. 12:18). There was also a tithe intended for the foreigner, the fatherless, and the widow (Deut. 26:12) who would eat in community with the people of God in a kind of celebration. In fact, food in the Bible is frequently portrayed as having special meaning: feast days, sacrifice of special plants or animals, and many examples from Jesus’s life, including his ultimate sacrifice, the substitution of himself. In 1 Corinthians 11:23–26, he speaks of his body and blood as not just physical, but also spiritual, and parallels this with food items (bread and wine).

Many types of food are mentioned in the Bible, including wine (Ezra 6:9; numerous times in the New Testament), olive oil (Deut. 8:8), bread (in both the Old and New Testaments), honey (Exod. 33:3; Judg. 14:8–9), eggs (Job 6:6, NKJV; Luke 11:12), grape juice (Num. 6:3), vinegar (Ruth 2:14; John 19:29), and vegetables (Dan. 1:12). “Plants are good” (Gen. 1:11–12, 29–30; Dan. 1:12–16; Rev. 22:2) may even be considered a biblical food principle; and, by extension, a plant-based diet, low on the trophic order, may be a wise diet. Plant-based foods appear to be good for health. Modern medicine more and more is confirming this. While a modest amount of protein is a good thing for health, many of our modern illnesses may be exacerbated by excess consumption of meat, especially processed red meat.²⁹ This is an area in which modern science and ancient scripture largely agree, and further detail could be added to this area to enrich our understanding of both science and theology.

Food Security While Minimizing Damage to the Ecosystem

Considering ways to minimize damage to the ecosystem while providing healthy food for humans is important in this era of fossil fuel, growing populations, and more-consumptive attitudes. We also need to wisely use wastes that are often nutrients in the wrong places, possibly to grow healthy and valu-

able plants, algae, or other green products. Moving down the trophic levels, to a more plant-based diet for people and food animals, can be both environmentally beneficial and healthier. Since plants in general are more efficient at producing food calories, this could be a wise way to increase food production harmlessly.

Demographic trends suggest that, over the next few decades, overall demand for food will rise, dramatically in some areas: The Food and Agriculture Organization of the United Nations (FAO) projections are that there will be 2-3 billion additional people in the next thirty years.³⁰ In addition, as people in developing countries gain wealth, they tend to eat “richer” animal-based foods, so, at this point, it appears that more food must be produced. Two fundamental approaches, or a combination of them, will likely be needed. One is to be more efficient with our land, growing more crops on less land, possibly by more inputs such as fertilizer, chemicals, and water or more-efficient use of inputs or technology. A second approach is to alter our consumption, reducing instead of increasing meat consumption, especially in the middle class and wealthy areas of the world. A more plant-based diet might be healthier in many developed areas, and it would allow us to feed more people. Paired with this might be considering ways to reduce environmental damage from distribution, packaging, and other aspects of the overall food system. The protein we do use could include more-efficient protein, such as milk, eggs, and fish.

This brings up another area of interest, namely, aquaculture: the culture of fish, shellfish, and seaweed in water. Some authors suggest that aquaculture may do damage or at least not improve wild fisheries as much as had been hoped.³¹ However, with aquaculture now producing more seafood than the total of wild fisheries in our stressed oceans, we may have to go forward with more-sustainable aquaculture.³² How do we develop an even more productive aquaculture (possibly largely in coastal or oceanic waters), while minimizing or even reversing damage to bodies of water and to the coast?

Did Jesus favor fish? Interestingly, Jesus rarely is seen eating meat. Perhaps this simply showed the food availability of the day. Bread was a basic staple; water or wine were basic beverages. He did cook fish, and there are other images of aquatic foods. Does this reflect on our overfishing of wild fish

stocks? Should we abandon aquaculture because we have damaged our oceans? Or should we do more (but more-sustainable) aquaculture to take some pressure off wild fish stocks? While fish is an animal protein, it is arguably one of the most efficient animal proteins. Fish have excellent feed conversion ratios, partially because fish do not have to grow large supportive skeletons: they are supported by the water. Can alternative food sources such as aquaculture help take pressure off other land and water resources, or will we simply continue to damage the waters further?

Human Flourishing

Whether foods of the future include more plants, animals, or aquatic products, there is another question to consider: What is human flourishing? Our ultimate goal is to have healthy people living in communities on a healthy planet where focus on the spiritual life is integrated into our lives. Can a consumer culture allow for true human flourishing, or must we encourage a new kind of lifestyle that is more service oriented, caring for other humans, and providing for wild creatures? A biblical lifestyle is characterized by serving. How then do we explain the current seeming antipathy between many conservative Christians and conservation? What parts of agreeing or disagreeing with current leaders are prophetic and where are we deceiving ourselves?

Prophets such as Daniel acted out and followed tenets of the faith despite persecution as they witnessed not only to their fellow believers but also to their captors. Daniel actually put less, not more strain on the food system of his day by refusing meat and wine in favor of plant foods. Whether powerful or powerless by earthly standards, our conduct can be influential. Daniel was a healthy young man who showed “aptitude for every kind of learning, [was] well informed, quick to understand ...” (Dan. 1:4), and who was selected to be trained to be a cross-cultural leader. He was provided with rich food, including meat and alcohol. He declined these, resolving “not to defile himself” and went lower on the trophic level to a plant-based diet, “nothing but vegetables to eat and water to drink” (Dan. 1:12). He “looked healthier and better nourished” (Dan. 1:15) than others. This too is a hint and a reflection back to Genesis where God gives you “every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for

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food" (Gen. 1:29). These biblical precedents suggest that our agriculture and food choices can have either negative or positive influences on the world and on our health.

Proposals to Minimize Environmental Damage

What are the benefits that agriculture does or could have on the land, water, and air? How can we minimize environmental changes caused by agriculture and food? Excess nutrients pollute downstream water bodies, excess chemicals kill other creatures, and excess consumption puts our very health and lives at risk. At the same time, modern agriculture has allowed the largest human population the earth has known. More people are able to hear the good news of Jesus than ever before. Is this system sustainable? If not, what limits on chemistry and biology are appropriate? How should biblical ethical concerns be considered in the food system?

There are those who argue that eating animals that can convert feed that humans cannot consume, such as grass, trees, and saltwater algae, is a way of harvesting human food without excessively changing the environment. One could argue that some of these cultivation activities are a kind of agriculture that is actually closer to wild food harvest, a kind of cultured hunter-gatherer approach. There are, in fact, a number of agricultural activities of this sort, including various permaculture and tree or bush types of cultivation that we see in cranberries, nuts, and fruit trees, as well as some types of animal husbandry among nomads or range-type cultivation of grazing cows or goats. Other examples include some unique hybrid wild-cultivation techniques such as the biculture of rice and crayfish (~200,000 acres cultivated in Louisiana³³), which encourages wild crayfish to harvest the standing biomass of the rice after harvest, producing a crayfish crop harvested by traps and providing a diversified income over a longer period of the year. This practice is enabling a native species to flourish, while providing a stable income. This might be considered "extensive" or low-intensity agriculture or aquaculture.

By contrast, some argue for "highly intensive" agriculture to focus the consequences of agriculture on smaller surface areas of the planet. Specifically, some argue for very intensive agriculture on lands that are extremely fertile, allowing less-fertile or optimal land

to be held or restored to a wild state. The regrowth of forests on former marginal agricultural lands has been cited as having a positive effect by sequestering carbon in forests growing back on otherwise marginal lands.³⁴ Large swaths of undisturbed habitat may allow conservation of flora and fauna, and some charismatic megafauna may, in fact, require large and wild areas of habitat. Again, how can we care for and protect the biodiversity of God's creation while still providing for human flourishing?

There may be danger in focusing solely on extremely intensive agriculture. The Bible suggests that absolute harvest quantity is not the objective. It is said that the "land shall have rest," but also that the "beasts of the field" will be able to graze on the excess; the plants that grow during the Sabbath year, perhaps including legumes or other nitrogen-fixing plants, will be your food (Lev. 25:2-7). In Ezekiel 34:18, the prophet warns against abusing the environment: "Is it not enough ... must you also muddy the rest" in reference to not caring for the land. God's response through John's vision includes this warning: God will destroy "those who destroy the earth" (Rev. 11:18). The underlying sins in both the Old and New Testaments appear to be greed and violence, still common in our day. Conflicts abound, but scientists and theologians of good will must consider these challenges to our food system, and seek a vision for a more sustainable future.

A Faith-Based Approach to Sustainability

How can we move toward a more sustainable food system? Does the Bible give advice on how to treat the land, other creatures, and each other? How can we use this to enhance our food system and lives? Are there ways to consider eternity as we thank God for our food? Are there ways in which we could manage, sustain, or even restore land, the environment, human lives, and the overall food system?

While much focus has rightfully been placed on reducing environmental damage while still producing food, a faith-based approach will seek a way that others do not see. Could we go beyond just reducing ill effects, and actively work on restoration of degraded lands, perhaps by reducing agricultural damage, but possibly by a dramatic reconsideration of agriculture itself? Could we move from management or conservation to restoration? Is this not what

Jesus does with us? He finds us in a degraded state, accepts us as we are, but then guides us toward holiness, cleanness, joy, and fruitfulness. Can we move from an exploitative approach to the land to a view of wise use and stewardship? What will this take in terms of attitude, technology, and even a philosophical or spiritual approach? Are there already examples, and could these examples be expanded or used in other contexts?

A biblical approach to food means we need to go beyond just reducing damage to our ecosystems to actually restoring them. Our food system could be part of this process. Perennial plants and trees could be harvested, while minimizing changes to the soil. Some of these plants may be native to their respective locations and could enhance the environment. In coastal waters, growth of shellfish could protect valuable coastal land while, at the same time, growing food for us. Since most shellfish are filter feeders, this process could clean coastal waters. With some creativity, what other agricultural techniques could enhance the environment, mimic natural systems, and possibly even restore local and global ecosystems?

Are there current examples of agriculture that “cultivate and guard” (Gen. 2:15, GNT)? In what ways or places are Christian values and Christian persons encouraging conservation, restoration, and care for creation? This article and this journal can help to share these stories, documenting both the biophysical and the human spiritual aspects of these efforts. Alternatively, are there non-Christian approaches that demonstrate truly excellent stewardship? Can and should Christians work together with these groups, and what limits are there to such partnerships? Perhaps even more challenging are partnerships between different strains of Christianity. Can those Christians who focus on telling about Jesus, partner with more-service-oriented groups, and are there ways to coexist and even work together to share God’s word and God’s love in real and tangible ways?

In summary, food and water are essential for life. Agriculture ostensibly has the largest effect on Earth’s land area and some of the largest net effects on the planet. Yet it does not seem moral to allow people to starve. Are there techniques or approaches that can enhance sustainability, while still producing healthy food? How are the environment and human

health linked? How much of the food system is food, and how much is distribution, packaging, processing, and other often-harmful aspects? How do we approach new technologies? And, as we look toward Christ’s eventual return and see images of “the river of the water of life ...” and “... leaves for the healing of the nations” (Rev. 22:1–2), how can we imitate God’s agriculture, enjoy “edible landscapes,” exercise restorative agriculture and aquaculture, and, in all things, demonstrate dominion over God’s good creation with a grace-filled approach to agriculture, working in harmony and allowing for fruitfulness of both humans and other creatures? ■

Notes

¹Dorothy Boorse, “New Findings in Environmental Science and Their Implications for Christians,” *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 194–202. Boorse reviewed a number of environmental issues, some related to food production, including fisheries, population growth, irrigation, antibiotic resistance, “playing God,” water stresses in agriculture, climate change, soil health, and heavy metals.

²The Food and Agriculture Organization of the United Nations (www.fao.org) tracks demographic, food production, and related information and projections. “The Future of Food and Agriculture: Trends and Challenges,” published in Rome, 2017, is available at <http://www.fao.org/3/a-i6583e.pdf>. This publication notes “world population is expected to grow to almost 10 billion by 2050.” Their “medium” prediction is 9.7 billion in 2050. They also note that “income growth in low- and middle-income countries would hasten a dietary transition towards higher consumption of meat ... requiring commensurate shifts in output and adding pressure on natural resources” (p. x).

³All references are taken from the New International Version unless otherwise noted. ESV is the English Standard Version; GNT is the Good News Translation; NRSV is the New Revised Standard Version; and NKJV is the New King James Version.

⁴Trond Bjørndal and Jordi Guillen, “Market Competition between Farmed and Wild Fish: A Literature Survey,” Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Center, Rome, 2016, <http://www.fao.org/3/a-i5700e.pdf>.

⁵Rosamond L. Naylor et al., “Effect of Aquaculture on World Fish Supplies,” *Nature* 405 (June 2000): 1017–24. This article warned against excess “appropriation of net aquatic primary production” — using small wild fish to feed to aquaculture, thus potentially damaging wild fish stocks. This article encouraged reducing the use of fish to feed aquacultured fish by using algae, plant materials, or other byproducts to encourage environmentally sound aquaculture and to allow natural fish stocks to recover. This article also noted the “increasing scarcity of freshwater resources,” hinting at future expansion of marine (ocean/coastal) aquaculture.

⁶David Tilman, “Global Environmental Impacts of Agricultural Expansion: The Need for Sustainable and Efficient Practices,” *PNAS* 96, no. 11 (1999): 5995–6000. This article notes not only that agriculture already has massive

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consequences, but also that intensification of agriculture is expected to increase those effects unless substantial improvements in technique are made.

- ⁷Aldo Leopold, *A Sand County Almanac* (New York: Oxford University Press, 1949). Leopold used a series of nonfiction chapters to present the concept of a Land Ethic, a kind of contract or relationship between humans and the land. This has been influential in environmental theory and practice.
- ⁸Brett A. Boisjolie et al., "Legal Ecotones: A Comparative Analysis of Riparian Policy Protection in the Oregon Coast Range, USA," *Journal of Environmental Management* 197 (2017): 206–20.
- ⁹Christopher Weber and H. Scott Matthews, "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," *Environmental Science and Technology* 42, no. 10 (2008): 3508–13. This article claims 1640 km delivery distance for food in the US, but also notes additional impacts of the food system, with a focus on greenhouse gas emissions.
- ¹⁰Boorse, "New Findings in Environmental Science," addresses a number of environmental problems that overlap with agricultural practices and production, pp. 195–200.
- ¹¹Alex Saturday, "Restoration of Degraded Agricultural Land: A Review," *Journal of Environment and Health Science* 4, no. 2 (2018): 44–51. This review article addresses a number of problems concerning the loss of agricultural land due to unsustainable practices. These are diverse, but include salinity issues, fertility loss, and erosion. Consideration of techniques for reducing these harmful effects, while still farming, and ways to restore land that is no longer productive, are discussed. While this article does not explicitly address Christian morals, it would appear that these techniques and approaches could be considered within a biblical context.
- ¹²Bureau of Land Management General Land Office Records (<https://gloreCORDS.blm.gov/>) includes many documents related to BLM and government land ownership, primarily in the western parts of the US.
- ¹³Gero Benckiser and Sylvia Schnell, eds., *Biodiversity in Agricultural Production Systems* (Boca Raton, FL: CRC Press, 2007). This book discusses soil and plant biodiversity, and a number of techniques used to address genetic problems in agriculture.
- ¹⁴The National Animal Germplasm Program (NAGP), https://nrrc.ars.usda.gov/A-GRIN/main_webpage_dev/ars?record_source=US, is run by the United States Department of Agriculture (USDA), and has objectives to "develop and expand a scientifically based germplasm and DNA/tissue collection" ... "develop methods for population regeneration," and "improve cryopreservation methods." The National Plant Germplasm System (NPGS) "acquires, conserves, evaluates, documents, and distributes crop germplasm." Both the NAGP and the NPGS are funded by USDA; they acknowledge that "intensification (of agriculture) has relied heavily on producing crops with increasing genetic uniformity," <https://data.nal.usda.gov/dataset/national-plant-germplasm-system>.
- ¹⁵Mary Caperton Morton, "Gulf Dead Zone Looms Large in 2019," *Eos: Science News by AGU* (July 11, 2019), <https://eos.org/articles/gulf-dead-zone-looms-large-in-2019>, notes that "a new forecast predicts widespread hypoxia after a wet Midwest spring." This article defines the hypoxic zone as having oxygen levels of less than 2 parts per million, and is predicted to be over 22,000 square kilometers in 2019. The so called "dead zone" reduces survival of aquatic life and is driven significantly by fertilizer runoff of nitrogen and phosphorus.
- ¹⁶Rachel Carson, *Silent Spring* (New York: Houghton Mifflin, 1962). This classic book, written by the late Rachel Carson, focused on addressing now-confirmed disastrous results involving widespread chemical use, including the pesticide DDT that was later banned. This book was influential in both agricultural and environmental fields.
- ¹⁷USDA ARS, "Recent Trends in Genetically Engineered Crop Adoption," summarizes data from 1996–2018, showing that soy, cotton, and corn are each planted on very high acreages, and it explains more about the specific traits that are most common in genetically engineered crops, <https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx>.
- ¹⁸Ibid.
- ¹⁹Nancy N. Rabalais et al., "Global Change and Eutrophication of Coastal Waters," *ICES Journal of Marine Science* 66, no. 7 (2009): 1528–37. This article addresses both "local" Gulf of Mexico eutrophication and the hypoxic or "dead zone," as well as implications for worldwide eutrophication driven by both agricultural and other impacts. They argue that "nutrient loadings to coastal waters need to be reduced now, so that further water quality degradation is prevented."
- ²⁰Wouter H. Maes and Kathy Steppe, "Perspectives for Remote Sensing with Unmanned Aerial Vehicles in Precision Agriculture," *Trends in Plant Science* 24, no. 2 (2019): 152–64. This article discusses use of UAVs to assess and manage agricultural issues, including drought stress (and irrigation), pathogen detection, weed detection, and nutrient status (and fertilization).
- ²¹Peter Singer is well known for his sometimes controversial philosophical views, espoused in books such as *The Ethics of What We Eat: Why Our Food Choices Matter*, with Jim Mason (Emmaus, PA: Rodale Press, 2007), which addresses a number of ethical issues in the food system; and *Animal Liberation: The Definitive Classic of the Animal Movement*, rev. ed. (New York: HarperCollins, 2009), which specifically addresses morality in the production of food animals. Singer says he and his wife gave up eating meat in 1971.
- ²²Dana Cole, Lori Todd, and Steve Wing, "Concentrated Swine Feeding Operations and Public Health: A Review of Occupational and Community Health Effects," *Environmental Health Perspectives* 108, no. 8 (2000): 685–99, reviews over 250 previous studies, providing a broad context for confined animal feeding operations (CAFOs) and considers animal and human health perspectives.
- ²³David Kriebel et al., "The Precautionary Principle in Environmental Science," *Environmental Health Perspectives* 109, no. 9 (2001): 871–76. This article is written from a scientific perspective and acknowledges a number of ethical concerns in environmental areas, including implications for agriculture.
- ²⁴Joel D. Kaufman and Cynthia L. Curl, "Environmental Health Sciences in a Translational Research Framework: More Than Benches and Bedsides," *Environmental Health Perspectives* 127, no. 4 (2019): 045001, <https://ehp.niehs.nih.gov/doi/10.1289/EHP4067>. This article acknowledges that health practice may have more complexity, including elements of human care and communication, as well as ethical and policy implications.

- ²⁵Food security, as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. International Food Policy Research Institute, <https://www.ifpri.org/topic/food-security>.
- ²⁶Xin-li Ran et al., "Novel Technologies Applied for Recovery and Value Addition of High Value Compounds from Plant Byproducts: A Review," *Critical Reviews in Food Science and Nutrition* 59, no. 3 (2017): 450–61. This article reviews a number of other studies on value added technologies, and acknowledges both difficulties and opportunities in food storage and quality.
- ²⁷Food and Agriculture Organization of the United Nations, "Hunger and Food Insecurity," accessed at <http://www.fao.org/hunger/en/>, estimates 820 million undernourished people in 2017, estimated at 10.7% of world population. This site clarifies terms and how these estimates were made.
- ²⁸Alon Shepon et al., "Energy and Protein Feed-to-Food Conversion Efficiencies in the US and Potential Food Security Gains from Dietary Changes," *Environmental Research Letters* 11, no. 10 (2016): 105002. This article estimates "efficiency" for a variety of animal protein sources, finding eggs and dairy the best at 17% efficiency; poultry, at 13%; pork, at 9%; and beef at 3% efficiency (implying a 97% loss of energy calories). They do imply that feed for beef is largely from pasture and "processed roughage," both largely inedible to humans.
- ²⁹Saeed Mastour Alshahrani et al., "Red and Processed Meat and Mortality in a Low Meat Intake Population," *Nutrients* 11, no. 3 (2019): 622, <http://dx.doi.org/10.3390/nu11030622>; Daniel Demeyer et al., "Mechanisms Linking Colorectal Cancer to the Consumption of Processed Red Meat: A Review," *Critical Reviews in Food Science and Nutrition* 56, no. 16 (2016): 2747–66; and Adam M. Bernstein et al., "Processed and Unprocessed Red Meat and Risk of Colorectal Cancer: Analysis by Tumor Location and Modification by Time," *PLoS One* 10, no. 8 (2015): e0135959.
- ³⁰FAO, *The Future of Food and Agriculture: Trends and Challenges* (Rome, Italy: Food and Agriculture Organization of the United Nations, 2017), <http://www.fao.org/3/a-i6583e.pdf>.
- ³¹Rosamond L. Naylor et al., "Effect of Aquaculture on World Fish Supplies," *Nature* 405 (June 2000): 1017–24. It should be noted that although this group questioned the sustainability of aquaculture at the time, they laid out a plan to enhance aquacultural sustainability, and many of the better operators now practice many or all of the suggested BMPs, leaving room for hope; and Stefano B. Longo et al., "Aquaculture and the Displacement of Fisheries Captures," *Conservation Biology* 33, no. 4 (2019): 832–41. Longo et al. modeled a hopeful case: aquaculture might displace wild fisheries enough to allow wild stocks to recover. Their findings suggest that although aquaculture now produces as much seafood as all wild fish capture in the world, it is not sufficient, and further increases in aquaculture in a sustainable manner may be needed.
- ³²Bjørndal and Guillen, "Market Competition between Farmed and Wild Fish: A Literature Survey."
- ³³W. Ray McClain and Robert P. Romaine, "Crawfish Culture: A Louisiana Aquaculture Success Story," *World Aquaculture* 35, no. 4 (2004): 31–35. This article gives the

history of how this system developed into an ecologically friendly, robust system, in which, when either production or prices are down for one commodity, the other often makes up for it; and also allows a semi-intensive culture that can allow native species to thrive while still providing valuable food products.

- ³⁴Thomas A. M. Pugh et al., "Role of Forest Regrowth in Global Carbon Sink Dynamics," *Proceedings of the National Academy of Sciences* 116, no. 10 (2019): 4382–87, <http://dx.doi.org/10.1073/pnas.1810512116>. This is one of a number of articles that acknowledge the role of forests in sequestering large amounts of carbon dioxide.

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