# 10. ADDITIONAL CONSIDERATIONS

In our final chapter, we discuss a *non*-climatic catastrophe that a cadre of particularly insightful researchers have found to be looming ominously on the horizon, but about which much less is typically said or written, although it represents a more *realistic*, more *immediate*, and more *dangerous* threat to the well-being of man and nature alike than that of speculative $CO_2$-induced global warming. And ironically, what many people believe to be the *source* of current global warming – rising anthropogenic $CO_2$ emissions – is actually our *last best hope* to avoid this very real threat.

## *10.1. Feeding Humanity and Saving Nature*

*How much land can ten billion people spare for nature?* This provocative question was first posed by America's Paul Waggoner in the title of an insightful 1995 essay, wherein he explored the dynamic tension that exists between the need for land to support the agricultural enterprises that sustain mankind, and the need for land to support the natural ecosystems that sustain all other creatures (Waggoner, 1995). This challenge of meeting our future food needs – and not decimating the rest of the biosphere in the process – was stressed even more strongly in the 8 August 2002 issue of *Nature* (Huang *et al*., 2002), where Jikun Huang of the Chinese Academy of Sciences and two US colleagues wrote that we humans "have encroached on almost all of the world's frontiers, leaving little new land that is cultivatable." And in consequence of humanity's ongoing usurpation of this most basic of natural resources, Peter H. Raven stated in his Presidential Address to the American Association for the Advancement of Science – which was published in *Science* (Raven, 2002) just one day after Huang *et al*.'s report appeared in *Nature* – that "species-area relationships, taken worldwide in relation to habitat destruction, lead to projections of the loss of fully two-thirds of all species on earth by the end of this century."

If one were to pick the most significant threat currently facing the biosphere, this would likely be it: a single species of life, *Homo sapiens*, is on course to *completely annihilat*e fully two-thirds of the ten million or so other species with which we share the planet, and to do so within less than a century, simply by appropriating the land and water resources that support all other species and using it to sustain ourselves.

In comparison, the predicted dire consequences of potential $CO_2$-induced global warming fade into insignificance, in terms of both magnitude and immediacy, as well as in their likelihood of occurrence. Also, as shown in the preceding chapters, the root cause of 20$^{th}$-century global warming is hotly debated; and plans to thwart its continuance are incredibly difficult, if not impossible, to define and implement. In addition, what many people believe to be the *source* of current global warming – rising anthropogenic $CO_2$ emissions – is actually our *last best hope* to preserve land for nature, a point to which we shall return shortly.

In a more detailed analysis of the impending "global land-grab" catastrophe – which moved it closer to the present by a full half-century – ten highly-respected researchers led by the University of Minnesota's David Tilman wrote in the 13 April 2001 issue of *Science* (Tilman *et al*., 2001) that the task of meeting the doubled global food demand*,* which they calculated would exist in the year 2050, would likely exact a toll that "may rival climate change in environmental and societal impacts." But how could something so catastrophic manifest itself so soon?

Tilman and his nine collaborators shed some light on this question by noting that at the end of the last century mankind was already appropriating "more than a third of the production of terrestrial ecosystems and about half of usable freshwaters." Now, think of *doubling* those figures, in order to meet the doubled global food demand Tilman *et al*. predict for the year 2050. The results suggest that a mere four decades from now mankind will be appropriating *more than two thirds* of terrestrial ecosystem production and essentially *all of the usable freshwater on the face of the planet*, a point that has also been discussed in depth by the UK's J.S. Wallace (Wallace, 2000).

In terms of *land* devoted to agriculture, Tilman *et al*. calculate a much less ominous 18% increase by the year 2050. However, because most developed countries are projected to withdraw large areas of land from farming over the next fifty years, the loss of natural ecosystems to crops and pastures in developing countries will amount to about half of their remaining suitable land, which would, in the words of the Tilman team, "represent the worldwide loss of natural ecosystems larger than the United States." What is more, they say that these land usurpations "could lead to the loss of about a third of remaining tropical and temperate forests, savannas, and grasslands." And in a worrisome reflection upon the consequences of these land-use changes, they remind us that "species extinction is an irreversible impact of habitat destruction."

What, if anything, can be done to avoid this horrific situation? In a subsequent analysis that was published in the 8 August 2002 issue of *Nature* (Tilman *et al*., 2002), Tilman and a second set of collaborators introduced a few more facts before suggesting some solutions. They noted, for example, that by 2050 the human population of the globe is projected to be 50% larger than it was just prior to the time of their writing, and that global grain demand by 2050 could well double, due to expected increases in per capita real income and dietary shifts toward a higher proportion of meat. Hence, they but stated the obvious when they concluded that "raising yields on existing farmland is essential for 'saving land for nature'."

So how can this readily-defined but Herculean task be accomplished? Tilman *et al*. proposed a strategy that focuses on three essential efforts: (1) increasing crop yield per unit of *land area*, (2) increasing crop yield per unit of *nutrients applied*, and (3) increasing crop yield per unit of *water used*.

With respect to the first of these efforts – increasing crop yield per unit of land area – the researchers note that in many parts of the world the historical rate-of-increase in crop yield is declining, as the genetic ceiling for maximal yield potential is being approached. This observation, in their estimation, "highlights the need for efforts to steadily increase the yield potential ceiling." With respect to the second effort – increasing crop yield per unit of nutrients applied – they note that "without the use of synthetic fertilizers, world food production could not have increased at the rate [that it did in the past] and more natural ecosystems would have been converted to agriculture." Hence, they say that the ultimate solution "will require significant increases in nutrient use efficiency, that is, in cereal production per unit of added nitrogen." Finally, with respect to the third effort – increasing crop yield per unit of water used – Tilman *et al*. note that "water is regionally scarce," and that "many countries in a band from China through India and Pakistan, and the Middle East to North Africa either currently or will soon fail to have adequate water to maintain per capita food production from irrigated land." Increasing crop water use efficiency, therefore, is also a must.

Although the impending *humanity vs. nature* crisis and several important elements of its potential solution are thus well defined, Tilman and his first set of collaborators concluded that "even the best available technologies, fully deployed, cannot prevent many of the forecasted problems." This was also the finding of a study we conducted a few years ago (Idso and Idso, 2000), wherein we concluded that although "expected advances in agricultural technology and expertise will significantly increase the food production potential of many countries and regions," these advances "will not increase production fast enough to meet the demands of the even faster-growing human population of the planet."

So how can we prevent this unthinkable catastrophe from occurring, especially when it has been concluded by highly adept individuals that the earth possesses insufficient land and freshwater resources to forestall it, while simultaneously retaining any semblance of the natural world and its myriad animate creations? Although the task may appear next to impossible to accomplish, *it can be done*; for we have a powerful ally in the ongoing rise in the atmosphere's $CO_2$ concentration, which *can provide* what we can't.

Since atmospheric $CO_2$ is the basic "food" of nearly all plants, the more of it there is in the air, the better they function and the more productive they become. As discussed in Chapter 6, for a 300-ppm (part per million) increase in the atmosphere's $CO_2$ concentration above the planet's current base level of slightly less than 400 ppm, for example, the productivity of earth's herbaceous plants rises by 30 to 50% (Kimball, 1983; Idso and Idso, 1994), while the productivity of its woody plants rises by 50 to 80% (Saxe et al., 1998; Idso and Kimball, 2001). Consequently, as the air's $CO_2$ content continues to rise, so too will the productive capacity or *land-use efficiency* of the planet continue to rise, as the aerial fertilization effect of the upward-trending atmospheric $CO_2$ concentration boosts the growth rates and biomass production of nearly all plants in nearly all places. In addition, elevated concentrations of atmospheric $CO_2$ typically increase plant *nutrient-use efficiency* in general – and all-important *nitrogen-use efficiency* in particular – as well as plant *water-use efficiency*. Consequently, with respect to fostering all three of the major efforts Tilman *et al*. (2002) say are needed to prevent the catastrophic consequences they foresee for the planet just a few decades from now, a continuation of the historical upward trend in the air's $CO_2$ content would appear to be, in common parlance, "just what the doctor ordered."

In the specific case we are considering here, the degree of crop yield enhancement likely to be provided by the increase in atmospheric $CO_2$ concentration expected to occur between 2000 and 2050 has been calculated by Idso and Idso (2000) to be sufficient – but just barely – to compensate for the huge differential expected to otherwise prevail between the supply and demand for food some four decades from now. Consequently, letting the evolution of technology take its *natural* course, with respect to anthropogenic $CO_2$ emissions, would appear to be the only way we will ever be able to grow enough food to support ourselves in the year 2050 without taking unconscionable amounts of land and freshwater resources from nature and decimating the biosphere in the process.

In spite of the dilemma described above, many have called for the implementation of strict measures to reduce anthropogenic $CO_2$ emissions. So, how does society proceed in this situation – positioned (as we are) between (as it were) *a rock and a hard place*? We believe that the logical route to take is to carefully consider the *relative reliabilities* of the predictive techniques that are used to derive the two very different catastrophes the two sides of the debate are claiming will occur if the measures they propose are not adopted.

In the case of catastrophic $CO_2$-induced global warming, the end result is derived from mathematical models of earth's global climate system, as it is currently understood. In the case of the catastrophic imbalance between global food supply and demand, the end result is derived from mathematical models of human population growth and projected increases in agricultural productivity, as these phenomena are currently understood. In thinking about these different models, and the subsets of component processes that comprise them, it is our belief that projections of human population growth and agricultural productivity just four decades into the future are *far* more likely to be correct than are predictions of earth's climatic state over the next several centuries. In addition to the obvious time differential between the two sets of predictions, human population growth and agricultural productivity are much better-understood processes than is global climate change, which involves a host of complex phenomena that span a spatial scale of fully *fourteen orders of magnitude*, ranging from the planetary scale of $10^7$ meters to the cloud microphysical scale of $10^{-6}$ meter. What is more, many of the component processes that comprise today's state-of-the art climate models are far from adequately understood (see Chapter 2), even to the extent that the very *signs* of their impacts on global temperature change (whether positive or negative) are in many cases *not yet known*. Consequently, in light of the much greater confidence that can realistically be vested in demographic and agricultural production models, it would seem that much greater credence can be placed in their predictions than in the predictions of climate models.

Additional information on this topic, including reviews of newer publications as they become available, can be found at http://www.co2science.org/subject/f/food.php.

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## ***10.2. Biofuels: A Solution or a Problem?***

In an interview that he gave to *Physics Today*, which was published in the magazine's September 2007 issue (Feder, 2007), Sir John Houghton declared that "we need very large growth in renewable energy sources," among which he listed *biomass* -- as in *biofuels* -- in second place after *solar*. Already, however, it has become abundantly clear to researchers around the world that meeting this so-called "need" is not without potential problems of its own.

In a study published online in the journal *Climatic Change* on 15 February 2007, two scientists (Johansson and Azar, 2007) analyzed what they called the "food-fuel competition for bio-productive land," developing in the process "a long-term economic optimization model of the U.S. agricultural and energy system," wherein they found that the competition for land to grow crops for both food and fuel production leads to a situation where, in their words, "prices for all crops as well as animal products increase substantially." In fact, in the May/June 2007 issue of *Foreign Affairs*, two other researchers (Runge and Senauer, 2007) reported that the production of corn-based ethanol in the United States *already*, as they describe it, "takes so much supply to keep ethanol production going that the price of corn -- and those of other food staples -- is shooting up around the world." And to put the situation in a perspective to which most Americans can readily relate, they noted that "filling the 25-gallon tank of an SUV with pure ethanol requires over 450 pounds of corn -- which contains enough calories to feed one person for a year."

But not only does biofuel production reduce the ability of the world's poor to purchase the food they so desperately need to sustain themselves, it also does *irreparable harm* to what we could call "wild nature," as native plants and animals lose ever more habitat and freshwater resources to the biofuels industry, which is rapidly advancing the time of their ultimate disappearance from the face of the earth, as they are inexorably driven to extinction.

Additional support for this view is provided by an article in the 17 August 2007 issue of *Science*, where another pair of researchers (Righelato and Spracklen, 2007) wrote that using ethanol derived from crops as a substitute for gasoline and vegetable oils in place of diesel fuel "would require very large areas of land in order to make a significant contribution to mitigation of fossil fuel emissions and would, directly or indirectly, put further pressure on natural forests and grasslands." As an example of this unfortunate fact, the two British scientists calculated that a 10% substitution of biofuels for petrol and diesel fuel would require "43% and 38% of current cropland area in the United States and Europe, respectively," and that "even this low substitution level cannot be met from existing arable land." Hence, they conclude that "forests and grasslands would need to be cleared to enable production of the energy crops."

Adding insult to injury, the two scientists hastened to add that the required land clearance would result in "the rapid oxidation of carbon stores in the vegetation and soil, creating a large up-front emissions cost that would, in all cases examined, out-weigh the avoided emissions." Furthermore, even *without* the large up-front carbon emissions, they report that individual life-cycle analyses of the conversion of sugar cane, sugar beet, wheat and corn to ethanol, as well as the conversion of rapeseed and woody biomass to diesel, indicate that "forestation of an equivalent area of land would sequester two to nine times more carbon over a 30-year period than the emissions avoided by the use of the biofuel." As a result, they rightly conclude that "the emissions cost of liquid biofuels exceeds that of fossil fuels."

Coming to much the same conclusion in an article in the 27 September 2007 issue of *Nature* was yet another prominent researcher (Laurance, 2007), who discussed the ability of forests to reduce catastrophic flooding. In addition to this important virtue, he wrote that "tropical forests, in particular, are crucial for combating global warming, because of their high capacity to store carbon and their ability to promote sunlight-reflecting clouds via large-scale evapotranspiration," which led him to conclude that "such features are key reasons why preserving and restoring tropical forests could be a better strategy for mitigating the effects of carbon dioxide than dramatically expanding global biofuel production."

Yet another important reason for not taking the biofuel route was explained by Nobel Prize-Winner Paul Crutzen and three collaborators in a paper published on 1 August 2007 in *Atmospheric Chemistry and Physics Discussions* (Crutzen *et al*., 2007), where they calculated the amount of nitrous oxide or $N_2O$ that would be released to the atmosphere as a result of using nitrogen fertilizer to produce the crops used for biofuels. As they describe it, this work revealed that "all past studies have severely underestimated the release rates of $N_2O$ to the atmosphere, with great potential impact on climate warming." And why would greater $N_2O$ emission rates have a tendency to cause the climate to warm? Because, as they report, $N_2O$ "is a 'greenhouse gas' with a 100-year average global warming potential 296 times larger than an equal mass of $CO_2$."

The ultimate consequence of this phenomenon -- as best the four researchers could evaluate it -- *is*, in their words, that "when the extra $N_2O$ emission from biofuel production is calculated in '$CO_2$-equivalent' global warming terms, and compared with the quasi-cooling effect of 'saving' emissions of $CO_2$ derived from fossil fuel, the outcome is that the production of commonly used biofuels, such as biodiesel from rapeseed and bioethanol from corn, can contribute as much or more to global warming by $N_2O$ emissions than cooling by fossil fuel savings." As a result of these observations, Crutzen and his co-workers concluded that "on a globally averaged basis the use of agricultural crops for energy production … can readily be detrimental for climate due to the accompanying $N_2O$ emissions."

Thus, in considering the findings of the researchers above, it would seem that growth in biofuel production to combat global warming not only does not do any *good* in this regard, it is actually *counterproductive*. Clearly, such facts must be considered in any attempt to regulate $CO_2$.

Additional information on this topic, including reviews of newer publications as they become available, can be found at http://www.co2science.org/subject/b/biofuels.php.

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