Sustaining Soil Productivity in Response to Global Climate Change

Science, Policy, and Ethics

1 Science, Ethics, and the Historical Roots of Our Ecological Crisis

Was White Right?

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1.1 Introduction

Continuing debate and proposed coordinated actions, such as the Endangered Species Act and Clean Water Act in the 1970s, to address global climate change have stimulated a broad, intense public discourse on environmental management. Such debates raise questions about the sacrifices or investment society is willing to make to protect or preserve natural resources. The climate change discussion is the most recent example of a dialogue that has been repeated throughout recorded history; that is, what degree of human exploitation of natural resources is acceptable? A brief essay in *Science* by respected medieval historian Lynn White, Jr., (1967) suggested that values developed and perpetuated by Christian theology permeate western science and technology and are responsible for human's seemingly continuous abuse of the environment. White's assertions have prompted more than 40 years of strident arguments by both passionate critics and defenders, making this paper one of, if not, the most important contributions to the developing field of environmental ethics.

Defenders of White argue that the chronic inability of societies to effectively address pressing environmental challenges is generally not due to a lack of knowledge or resources. Instead, failure to solve problems, such as soil erosion, air and water pollution, deforestation, and now climate change, are due to a deep-seated yet generally tacit belief that humans are ordained to control and dominate, not care for and protect, nature. A broader interpretation of White's argument can easily be extended beyond singling out Christianity as the sole culprit. Several counterarguments include the observation that poor environmental management is not exclusive to western cultures dominated by Christian beliefs, and many other tenets of Christianity (e.g. "love they neighbor") are not universally applied. Recent archaeological evidence suggests that environmentally destructive tendencies of humans predated Christianity by centuries (Eisler 1987). The increasing severity of environmental crises in the second half of the twentieth century that White laments has also been blamed on the powerful economic forces driving materialism and luxury consumption (Kasser 2002; Kaplan 2008). If the failure to recognize or act on environmental crises is indicative of a deficient moral or ethical perspective, then it likely has deep roots in multiple cultural and historical sources, including religious traditions.

Climate change can be seen as a global manifestation of a legacy of poor environmental stewardship over millennia leading to increasing emissions of greenhouse gases (GHGs), especially carbon dioxide (CO_2), through aggressive, unsustainable exploitation of natural resources including soil. Mitigating climate change effects will be an immense

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undertaking on numerous levels, but improving the capacity of soil resources will be a critical component of any meaningful strategy.

1.2 Historical Perspective on Soil Degradation

In his recent bestseller, *Collapse—How Societies Choose to Fail or Succeed*, the geographer Jared Diamond (2005) chronicles how past cultures succumbed to various environmental threats. Notable among these threats was soil degradation by erosion, loss of soil fertility, and land salinization. These key factors contributed to the rapid disintegration of not only the marginal (e.g. the Norse in Greenland) but also some of the most advanced civilizations of their time (e.g. the Maya in Mesoamerica). Diamond proposed four types of failures by societies trying to address their environmental threats: (1) failure to anticipate the problem, (2) failure to recognize the problem after it develops, (3) failure to try and solve the problem, and (4) trying unsuccessfully to solve the problem. He goes on to identify two keys for societal decision making to enable successful mitigation of environmental threats: (1) long-term planning and (2) willingness to reconsider core values. Success stories (i.e. societies choosing to succeed), such as eliminating swine production on the Pacific island Tikopia and reforestation in Japan, are employed as examples of societies making sacrifices to enable long-term sustainability that included difficult, often painful changes to their value systems. Interestingly, even Diamond's definition of success is quite anthropocentric and is based primarily on the sustainability of human cultures, which in many cases resulted in devastating effects on the local ecosystems.

Diamond's popular press account is but a recent addition to a litany of reports cataloging human destruction of natural resources in general and soils in particular (Marsh 1864; Lowdermilk 1948; Hyams 1952; Glacken 1967; Hughes 1975; Hillel 1991; Redman 2001; Hudson & Alcántara-Ayala 2006; Montgomery 2007). Localized, visual assessments of degraded lands presented in early accounts have given way to modern methods of quantitative measurements and global remote sensing (Oldeman et al. 1990; Lal et al. 2004; Bai et al. 2008; Sivakumar 2011). Land degradation, defined as long-term decline in ecosystem productivity and functioning (Bai et al. 2008), includes physical (i.e. wind and water erosion, compaction, waterlogging, and loss of structure), chemical (i.e. nutrient depletion or imbalance, acidification, and salinization), and biological (i.e. loss of organic matter, reduced diversity, and increase in soil pathogens) factors. In the most recent analysis, Bai et al. (2008) concluded that 24% of the global land area, home to 1.5 billion people, was currently degrading. Although many of these areas were in developing countries, some degree of soil degradation is almost universal, as demonstrated by the extent of erosion in developed countries. For example, recent estimates of soil erosion by water in the United States (Fig. 1.1) indicate that 18.2% of cultivated US cropland (22.5 million ha) had annual erosion rates above tolerable levels (US Department of Agriculture 2009). This is consistent with Oldeman et al.'s analysis (1990), which identified extensive areas of the United States and other developed countries as having soils that were highly degraded when compared to their natural condition. The extent and severity of soil degradation, especially in developed countries, appears inconsistent with the current productivity of these regions. This disparity may reflect a growing realization that there is a gradual, insidious loss of inherent soil productivity in areas under intensive cultivation that is obscured by significant improvements in crop genetics and pest control and ready access to nutrients via inorganic fertilizers (Larson et al. 1983; Pimental et al. 1995; Lal 2009).

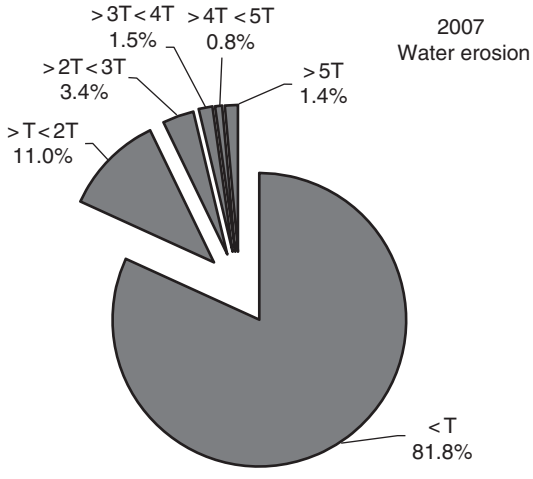

Figure 1.1 Estimated percentages of nonfederal US crop land having sheet and rill erosion rates below tolerable rates (<T) or at various multiples of T up to greater than five times the tolerable erosion rate (>5T).
Data from US Department of Agriculture (2009).

1.3 The New Challenge of Global Climate Change

The causes and consequences of global climate change remain the subjects of intense study. Recent climate trends are likely due to a complex combination of natural cycles and anthropogenic effects acting over multiple overlapping time scales. Increases in atmospheric GHG concentrations include contributions from both fossil fuel combustion and human-induced land-use change, especially cultivation of paddy rice and forest clearing over the last several millennia (Ruddiman 2005). Any successful climate change mitigation strategy will need to include elements that both reduce future GHG emissions *and* current atmospheric GHG concentrations (i.e. reduce GHG sources *and* increase carbon sinks). Although the Kyoto Protocol emphasizes carbon sequestration in forest biomass as a primary land-based carbon sink, even an aggressive global reforestation/afforestation program alone will only be capable of a short-term delay or modest slowing of atmospheric CO_2 concentration increases (Vitousek 1991; Nilsson & Schopfhauser 1995). Any technically or economically viable emission reduction or carbon sequestration strategy will, by necessity, need to include multiple components for GHG emission reduction and carbon sequestration.

With a rapidly increasing world population and expectations for greater affluence in many developing countries, it is prudent to consider whether available soil resources will be capable of producing the food and fiber needed to sustain the global population. This is especially challenging when increased severity and frequency of weather extremes along with shifts in mean temperature and precipitation are predicted (IPCC 2007). The United Nations predicts the world population will increase from 6.8 billion in 2008 to greater than 9 billion in 2050 (United Nations 2008). Because many of the world's best agricultural soils have already been degraded, the prospect for significantly increasing food production to meet rising demand is seriously in doubt (Cassman et al. 2003; Koning & van Ittersum 2009; Godfray et al. 2010). Increasing the intensity of production practices, including increased tillage, nutrient application, and pesticide usage to meet growing demand for agricultural products, will further stress the long-term sustainability of cultivated soils and pose an ever-greater risk to water and air quality and overall ecosystem health.

Restoration of soil functionality and the enhancement of soil productivity are achievable and also provide an opportunity to contribute to climate change mitigation. Carbon sequestration through management practices that increase soil organic matter content tend to make soils much more effective in nutrient cycling and resilient to climatic extremes such as flood and drought, and ultimately, the soils are more productive in the long term (Bot & Benites 2005). All of these benefits can be achieved by employing practices that encourage carbon sequestration in agricultural soils such as reduced tillage, crop rotation, and agroforestry (Sanchez et al. 1997; West & Post 2002; Schoeneberger 2008).

If the multiple benefits of increasing soil organic matter content are well known, why have efforts to increase soil carbon sequestration not met with greater success? Modern agriculture has relied largely on increasing external inputs to maintain or increase productivity. Economic analyses that often exclude deleterious effects on soils favor increased investment in external inputs compared to other practices with greater carbon sequestration potential that may be cheaper to employ but involve greater risk and more management skill. Recent volatility in energy prices and the associated global food crisis was partially driven by diversion of food crops to bioenergy production and may serve as an example of potential future scenarios of food versus energy production. This crisis further reinforces the need for a much more focused, thoughtful assessment of soil management practices.

In June 2009, the Soil Science Society of America sponsored a Bouyoucos Conference on Soil Stewardship in an Era of Climate Change to address some of these scientific and ethical issues of land management from a global climate change perspective. A transdisciplinary group of experts including philosophers, policy analysts, agronomists, and soil scientists explored the recent trends in soil quality, the economic and ethical implications of different land-use options, and strategies to better communicate the challenges and consequences for soil quality in the future. This group drafted a statement that summarized their assessment of the current trend in soil quality and called for greater awareness of the vital role soil resources have and the urgent need to improve soil stewardship (Box 1.1).

Box 1.1 Statement on Soil Stewardship Drafted from the 2009 Bouyoucos Conference on Soil Stewardship in an Era of Global Climate Change

An Urgent Appeal for Soil Stewardship
From the 2009 Bouyoucos Conference on Soil Stewardship in an Era of Global Climate Change

Upon viewing the deforested and eroded landscape near Attica, Greece in the 4th century BC, the philosopher Plato vividly described the loss: "What now remains compared with what then existed is like the skeleton of a sick man, all the fat and soft earth having wasted away, and only the bare framework of the land being left." Plato's observation of soil degradation is no less relevant 2400 years later. If the importance of healthy soils for nutritious food and clean water has been known for millennia, why has an enduring commitment to thoughtful soil stewardship proven so elusive to so many and for so long?

Soil is a fundamental source of life. It plays a critical role in providing water, nutrients, and support for plant growth, recycling organic materials and protecting surface and ground waters from contaminants. Soil is the base of the terrestrial food chain, directly or indirectly

providing over 97% of the calories that now nourish more than six billion people. This modern bounty was enabled by a providential combination of weathering processes that created fertile soils from inert rock and favorable climates suitable for growing a variety of food plants. At the start of the 21st century we express our deep-felt concern that three of the integral resources of agricultural production, soil, water and climate, are increasingly impaired by human actions with potentially serious consequences for global food security.

We are, each of us, people of the soil. Most indigenous peoples and organized religions have oral or written accounts of human origin or experiences that include a deep reverence associated with the life that springs from the soil. Our cultural traditions acknowledge the significance of soil even if our environmental practices do not. The facts about the current condition of global soil resources are sobering. Recent estimates are that one fourth of the earth's inhabitants already depend on degrading lands. Future generations may be forced to obtain ever more sustenance from decreasingly available productive land. Potential changes in rainfall and temperature patterns and their variability as the global climate changes add yet another challenge. There is a long and tragic correlation between cultures that fail to protect the health of their soil and the demise of those same cultures. Life, as we perceive it, exists only on a planet having soil, as we know it. Soil is the interface between lifeless cosmic rock and all terrestrial life. Healthy soil is itself a living community, containing up to four billion microorganisms in each teaspoon. But soil is also a fragile, finite resource requiring care. Destroying soil is the equivalent of destroying the self-renewing capacity of the Earth.

Too often we forget our shared human history and the reality of our dependence on the soil. Too often we fail to enact our historical and rightful commitment to the land, our home place. We are therefore shirking our inherent responsibility to care for the planet. The poor of the world are those most immediately and dramatically affected by both soil degradation and climate change, therefore, soil stewardship is both an environmental and a moral challenge to society.

What is the way forward? What is our task in the face of this reality, this disconnect between the importance and the condition of our soil? We recognize and affirm a cultural and physical link to soil. We assert a shared obligation to soil stewardship that is based on more than purely utilitarian concerns. We acknowledge that soil degradation is an ethical issue, that science and economics alone will not and can not determine a proper course of action. We cannot therefore ignore the mistreatment of our lands and at the same time escape moral denunciation. Encouraging a more broad and thoughtful soil stewardship ethic is not naïve, idealistic, or altruistic but rather perceptive, pragmatic, and essential to our societal response to the challenges posed by global climate change and an increasing human population.

Given that our environmental problems stretch beyond the domain of any particular discipline, genuine solutions to these problems will only be found by engaging all facets of the human mind. **We call for soil scientists to humbly and dutifully work across disciplines – including the humanities and the arts, in efforts to engage in a practice of public scholarship with the goal of building new relationships and networks that advance the soil stewardship ethic. We call for the products of such collaborations to be openly communicated to the public and to policy makers, raising awareness and urging proactive action. Finally, we call for the recognition and celebration of successful soil stewardship stories to serve as examples, to inspire, and to lead us forward**.

Meeting the growing global demand for agricultural products will require greater awareness and commitment to the essential role of healthy soils and clean water to sustainable of food and fiber production. One component of this awareness should be a far greater commitment to ethical discourse on the obligations of the current generation to protect the livelihood and well-being of future generations (Moore & Nelson 2010).

1.4 White

There is a long history of episodic realizations that ethics and values lay at the core of our environmental behaviors. Perhaps one of the most dramatic and reverberating (though ultimately unheeded) came from White (1973, p. 57):

> The artifacts of a society, including its political, social and economic patterns, are shaped primarily by what the mass of individuals in that society believe, at the sub-verbal level, about who they are, about their relation to other people and to the natural environment, and about their destiny.

White locates the origin of our environmental crisis squarely in the realm of philosophy and ethics. Humans do not enter in to an abusive relationship with the nonhuman according to White simply because they can or simply because technologies advance to the point where humans can have massive and detrimental impacts on nature. According to White's analysis, pinning the blame for the environmental crisis on technological advance is as naïve, distracting, and ultimately dangerous as it is common. In addition to acquiring the ability to negatively impact nature, humans have to acquire the philosophical and ethical structures that either allow for, or even sanction, such human-nature interactions. That is, environmental abuse (like any form of abuse) requires *both* an ability and a willingness to abuse.

Specifically, White argues that in the West, Judeo-Christian interpretation of the human-nature relationship is primarily to blame for environmental problems. Humans treat things, according to this interpretation, as they are seen. And Westerners have decided (until perhaps quite recently) to perceive the human-nature relationship in despotic terms: portraying humans as separate from, and in charge of, nature, ordered by God to "dominate and subdue" their charge. Of course, other interpretations of the human-nature relationship are possible. Most recently, and in response to White's challenge (or arguably a misinterpretation of White's challenge), Westerners have offered a "stewardship" interpretation of the human-nature relationship, one in which humans are charged with the care, not despoliation, of God's creation (e.g. Gottlieb 2006). But as White points out, this is a recent, late twentieth-century phenomenon. For literally hundreds and hundreds of years, the world's dominant cultural and religious tradition has instead been actively and righteously engaged in a far more tyrannical relationship with nature:

> In the middle of the fifteenth century the artists of northern France and Burgundy invented a novel iconography for the seven Virtues. For intricate reasons, by that time Temperance (or Moderation) had displaced Charity as the supreme Virtue. In the new iconography Temperance—and she alone—is associated with the new technology. On her head she wears a mechanical clock (invented in the 1330s), the most significant and elaborate recent bit of automation; in her right hand she holds eyeglasses (invented in the 1280s), the greatest boon to the mature intellectual; on her heels she wears rowel spurs (of about 1290), and she stands on a tower windmill (of about 1390), the most spectacular new power machine of the age. *The message could scarcely be more emphatic: technological advance is superlatively virtuous*." (White 1973, pp. 58–58, emphasis added)

The point is, people "commit their lives to what they consider good" (White 1973, p. 59). And people of the Judeo-Christian West believed that employing the ability to impact nature through technology was not only acceptable, but also "superlatively virtuous."

It is easy to react dismissively to White placing the blame for the environmental crisis on the doorstep of Christianity. By far the most common reaction to White's article was, and remains (after anger perhaps), an attempt to suggest that he was wrong because the human-nature relationship in the Biblical tradition should be interpreted as one of stewardship not despotism (see especially Barr 1972; Dobel 1977; Moncrief 1970). Although this response is understandable—maybe even predictable, even White himself offers this interpretation at the end of his original essay—it misses the most important and fundamental point of White's commentary: people's interactions with nature, how they treat one another, and the environment "depends on what they think about themselves in relation to things around them" (White 1967, p. 1205). That is to say, humans abuse the environment not merely because they can or because they possess the technological ability to do so, humans abuse land because they are *willing* to do so and because the philosophical and ethical predisposition toward the land is such that abuse is allowable, even praised.

There is then an important warning here as well as an explanation. To the degree that humans focus efforts at environmental remediation only on technologies and laws that curb their ability to impact nature, and to the degree that humans therefore fail to address the underlying philosophical and ethical issues of willingness, humans will continue to fall desperately short of the approach that is critical to sustainability or whatever word is applied to a proper relationship to nature (Vucetich & Nelson 2010). Aldo Leopold echoes this sentiment when he refers to the development of a land ethic not as a quaint but decadent rumination of an otherwise pacified group, but as an absolute "ecological necessity" (Leopold 1949; see also Flader 2011). In White's words, "more science and more technology are not going to get us out of the present ecologic crisis until we find a new religion, or rethink our old one" (White 1973, p. 57).

At the end of the day, White suggests the task at hand "is to find a viable equivalent to animism" (1973, p. 62). That is, to conceptualize humans' relationship with nature such that humans are not perceived to be separate from nature, and such that nature, like human beings is viewed as imbued with what environmental philosophers later come to call "intrinsic value." Intellectual and value systems that overcome the metaphysical and value dualism between humans and nature will create the possibility for remediation, merely applying more science and more technology—arguably the main, if not sole, thrust of most environmental initiatives—will not.

1.5 Other Views on the Ethics of Land Use: Leopold et al.

Forward thinkers have long been concerned about the deteriorating state of our natural environment. The environmental movement beginning in the mid- to late 1960s and continuing today has created a crescendo of concern. Though previously unpublished in his own lifetime, Leopold, while still in the employ of the US Forest Service, penned an essay in 1923 in which he abstracted outward from his own experience in the Southwest to comment more generally on the state of natural resources in the United States:

> All of our organic resources are in a rundown condition. Under existing methods of management our forests may be expected to improve, but our total possible farm areas are dwindling and our waters and ranges are still deteriorating. In the case of our ranges, deterioration could be easily

> checked by conservative handling, and the original productiveness regained and restored. But the deterioration of our fundamental resources—land and water—is in the nature of permanent destruction, and the process is cumulative and gaining momentum every year. (1979, p. 133)

Leopold's sobering analysis ultimately leads the young land manager to search out and label the root cause of environmental problems: humans' fundamental moral relationship with nature.

Though arguably this call for the inclusion of ethics has not yet been heeded, conservation leaders have, throughout the recent past (and often in the twilight of their careers), returned repeatedly to this realization. After recounting the current land-use problems, Leopold (1979) pointed out that conservation was a "moral issue," likewise warning against conservation's reduction to mere economics,

> Thus far we have considered the problem of conservation of land purely as an economic issue. A false front of exclusively economic determinism is so habitual to Americans in discussing public questions that one must speak in the language of compound interest to get a hearing. In my opinion, however, one can not round out a real understanding … without likewise considering its *moral* aspects (p. 138).

Late in his life, this ethical epiphany becomes a major focus in Leopold's work, a focus that he articulates powerfully in perhaps the most important and celebrated conservation essay ever written, "The Land Ethic" (1949). Building off both the metaphysical realization that humans are "part and parcel" of a biotic community, and the recognition that any given community only hangs together under the auspices of an ethic corresponding to that level of community organization, Leopold implores human to "quit thinking about decent land-use as solely an economic problem." He asks instead to "examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient." In the final analysis, Leopold suggests that humans replace narrowly anthropocentric and utilitarian ethical obsessions with a summary moral maxim suggesting, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1949, pp. 224–225).

Just a few years after Leopold's death in 1948, and the release of *A Sand County Almanac* in 1949, leading wildlife biologist Olaus Murie (1954) called for a similar "big hearted code of ethics." Writing in the *Journal of Wildlife Management*, Murie says,

> Whether we like it or not, we find ourselves in the midst of a struggle. Thoughtful people are trying to understand our place in Nature, trying to build a proper social fabric, groping for a code of ethics toward each other and toward Nature. The current controversies in the diverse field of conservation are an expression of this ethical struggle. We, as wildlife technicians, cannot escape it … we have a responsibility to contribute to the highest thinking in this field" (pp. 289–290).

In the same essay Murie expresses deep concern that humans simply are not training resource professionals to fulfill this responsibility, "Our training in the universities should be such that we do not come out pretty good technicians but philosophical illiterates" (Murie 1954, p. 293).

More recently, retired California fisheries biologist Edwin "Phil" Pister made a similar observation and plea for ethical training. "Lacking adequate exposure to the principles of environmental ethics, most practitioners of conservation (especially those emerging from university resource management programs) quickly become missiles without guidance systems" (quoted in Vucetich & Nelson 2007, p. 1267).

The pedigree of those calling for attention to ethics seems impeccable, their argument for the necessity of ethical discourse in conservation seems sound and valid, so why do we attend so minimally to ethics?

1.6 Ethical Considerations of Strategies for Climate Change Mitigation: An Example

The current concern for climate change and the global economic downturn have some striking parallels with the severe drought in the United States during the 1930s Great Depression. An extended drought, ill-advised cropping practices, and subsequent wind erosion in the Great Plains states (the so-called "Dust Bowl") created a major environmental crisis. The deep economic depression beginning in 1929 produced severe economic and social disruption throughout the country. Desperate to improve bleak conditions in the drought-ravaged plains states, the federal government considered several novel, large-scale programs designed to bring immediate physical and economic relief.

One of the key Dust Bowl relief programs was the Prairie States Forestry Project (PSFP), commonly known as the "Shelterbelt Project." The primary goals of the PSFP were providing jobs for unemployed citizens and alleviating drought conditions by creating multirow tree windbreaks that would arrest wind erosion and create a more favorable microclimate for crops and more comfortable conditions for humans. In seven years (1935–1942), the PSFP program would plant over 217 million trees in almost 30,000 km of shelterbelts in six states (Fig. 1.2) stretching from Canada to Texas (Droze 1977).

By modern standards, the PSFP had several fascinating characteristics. First, it was conceived, designed, and implemented in an amazingly short time. Within a year of President Franklin D. Roosevelt's announcement of the program, a detailed, comprehensive report on the scientific aspects of the project was prepared (US Forest Service 1935), and almost 2 million trees were planted. A crucial factor of the PSFP success was the personal interest and direct involvement of Roosevelt and US Secretary of Agriculture Henry A. Wallace, attention that encouraged project managers to devote extra effort to the project's success.

The PSFP remains the largest single afforestation program in US history. Reforestation, afforestation, and soil carbon sequestration are three land management strategies that are among the best options available for reducing atmospheric CO_2 concentrations (see Eglin et al. 2011; Polglase & Paul 2011; Tonon et al. 2011). Although climate change is a much more complex and global phenomena, there may be important lessons from the PSFP experience that are consistent with Diamond's analysis proposed in *Collapse*. The PSFP fits the profile of a highly successful decision-making process (i.e. long-term planning and willingness to reconsider core values). One of the major criticisms of the PSFP was that the trees would grow too slow to mitigate the drought conditions quickly enough. Proponents countered that although the potential benefits may take longer to reach their full effect, the trees would have greater long-term benefits. In this regard the proponents were proven right because a follow-up survey quantified impressive tree growth and survival rates (Read 1958).

One of the groups most opposed to the original PSFP project plan was the professional foresters. In scathing editorials (Chapman 1934a, 1934b, p. 952), the president of the Society of American Foresters H. H. J. Chapman (one of Leopold's former professors at Yale; see Flader 2011) expressed serious misgivings that the project would fail and "shake the public confidence in our professional integrity." The PSFP also had to overcome intense resistance from politicians and tree nursery operators who believed that it was too expensive, that the trees would not survive, or that it was wrong to use federal resources for plantings on private land.

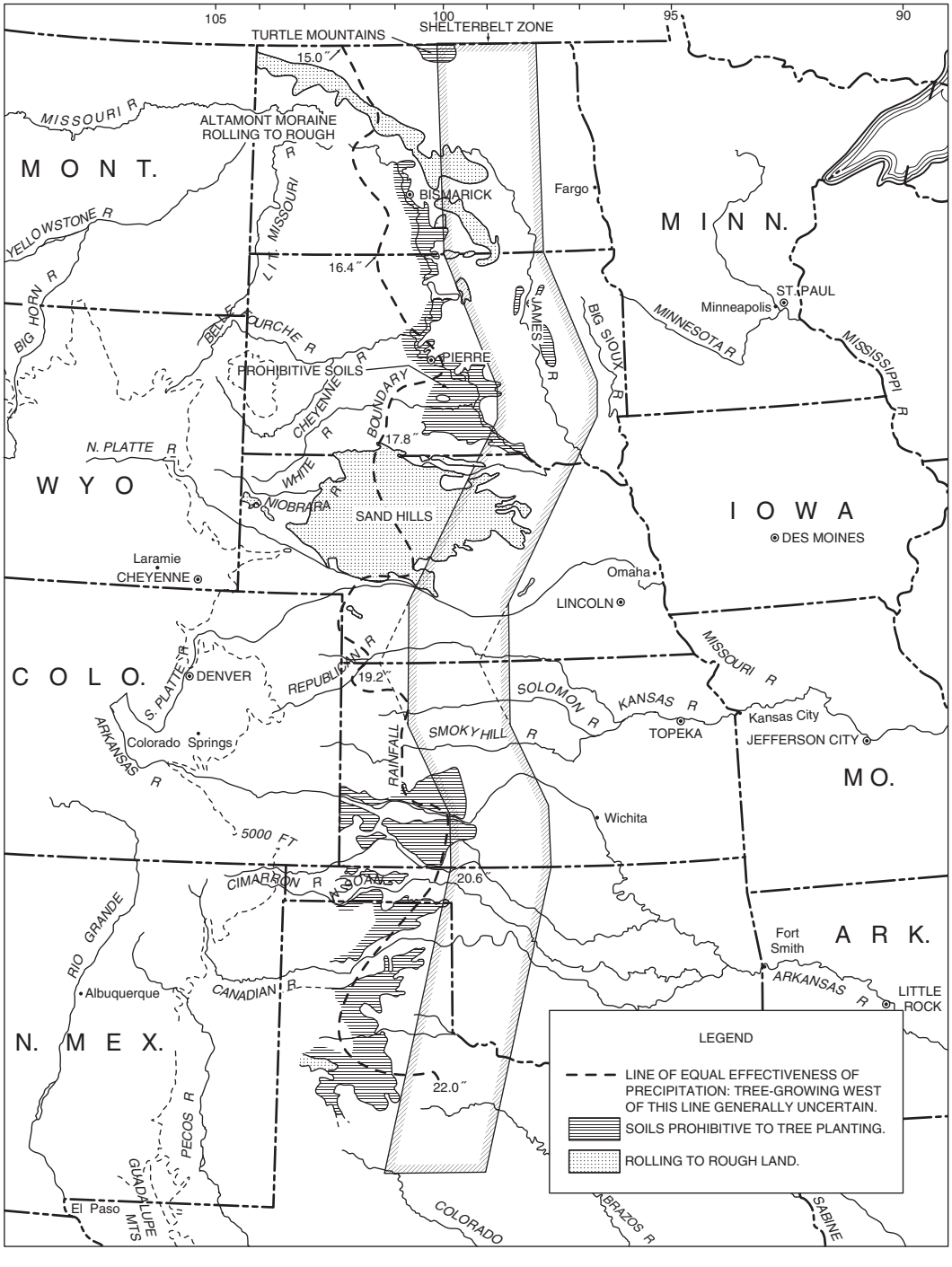

Figure 1.2 Map of the planned tree planting zone for the Prairie States Forestry Project. US Forest Service, 1935.

For the PSFP, it was strongly held beliefs regarding the role of government in relief efforts and whether the government should invest federal resources on private land that had to be overcome. Ultimately it was unwavering belief and confidence in the project by US Forest Service scientists Carlos Bates, Raphael Zon, and Paul Roberts and the personal support of Roosevelt that enabled the project to succeed (Droze 1977).

Successfully addressing global climate change will require similar long-term, holistic strategies but operating on even more extensive spatial scales and longer time horizons. Like the PSFP though, bold and innovative leadership will be needed to enact global measures that reduce net GHG emissions and increase carbon sinks. Any strategies for climate change mitigation or adaption will also have both expected and unintended consequences for the different socioeconomic classes and geographic regions and for future generations. The effects of climate change are likely to have a greater impact on the poor in developing countries than on the affluent in developed countries who are the greatest GHG contributors (Howarth & Monahan 1996; Thomas & Twyman 2005; Paavola & Adger 2006; Stigter 2011; Westra 2011). The challenge now is to engage similar successful decision-making methods as proposed by Diamond and demonstrated by the PSFP of the 1930s to craft effective policies and programs for addressing global climate change today and into the future.

1.7 Conclusions

It seems safe to say that there has long been recognition (as sporadic and ignored as it might be) that issues in natural resource management are fundamentally ethical issues. Likewise, there is a long-standing and widely accepted recognition that humans' well-being is entwined with the well-being of the environment. And finally, there seems to be long-standing recognition that the state of the environmental context is in trouble. It would appear safe to assume, therefore, that there exist all of the elements necessary for profound and rapid reaction to environmental threats. And yet this is not the case. There is instead a failure to appropriately address these issues. Of course there is always some minority voice in opposition to one of these "recognitions": suggesting that humans are not a part of the environment, that the environment is not threatened, or that technology alone will cure what ails. But this does not really explain humans' collective failure to respond. In fact, most humans probably believe they are responding. Humans perhaps all decry the condition of soils, water, and air. According to White (1973), "We deserve [these environmental harms] because, according to our structures of values, so many things have priority over achieving a viable ecology…. [This] gap between our words and our deeds is not hypocrisy, it is something more dangerous: self-deception."

Perhaps one of the most troubling forms of this self-deception is the failure to adequately integrate science and ethics. Scientists often go to great lengths to neglect ethics (Wolpe 2006) and ethicists (even those self-identifying as "applied" or "engaged") seem to go to equally great lengths to avoid doing helpful philosophy (Nelson 2008). This disassociation is both predictable and tragic. But humans might do well to heed White's (1973) words here:

> We shall not cope with our ecologic crisis until scores of millions of us learn to understand more clearly what our real values are, and determine to change our priorities so that we not only wish but also are able to cope effectively with all aspects of [our environmental crisis]" (p. 56).

A solution might be found less in the attempt to train or retrain scientists to be ethicists or ethicists to be scientists (each being such highly expert fields of knowledge), but in creating

overt and intentional modes and opportunities for collaboration, that is, coauthoring papers and grants, sharing graduate students, adding ethicists to science projects, inviting each to the others' meetings. We should not, however, underestimate the obstacles here. There are in fact major challenges for each side: for scientists little or no formal training or expertise in philosophy and ethics and for ethicists there is an almost total lack of familiarity with collaboration and with the recognition of the value of outreach.

So, was White right? If his 1967 *Science* article is interpreted as an indictment of Christianity as the lone or even primary causal factor for poor environmental stewardship, the answer is no. Within Christianity there is such a wide spectrum of views regarding human interaction with nature from humans as nurturer to humans as holding complete dominion. This interpretation is too narrow for such a complex facet of societal decision making. However, if a broader interpretation is taken that the environmental crisis is fundamentally a moral or ethical crisis, and that remediation will only come in the form of values alteration brought forth through ethical discourse, then he was indeed right. Science and technology alone will not lead to a solution to environmental problems such as sustaining soil productivity under the influence of global climate change without the recognition and incorporation of ethical principles in the development of effective and fair policy.

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