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Opportunities and Challenges for Carbon Management on U.S. Public Lands

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1. Introduction

Public lands are important constituents of the U.S. carbon (C) balance because they encompass large areas of forests and rangelands, although whether and how C might be actively managed on public lands is not yet clear. A decision to manage public lands for their C benefits would involve a complex set of interacting drivers and multiple jurisdictions, and would, as they are now, be governed by laws mandating multiple uses of land in the public domain.

As with any lands subject to management, some public lands have significant potential to sequester additional C beyond current levels in vegetation and soils as well as in wood products extracted from the land. However, there is currently no comprehensive assessment of the potential for C sequestration to be enhanced in public lands in particular. An assessment of the potential for increasing the stocks of C in vegetation and soils on public lands above current levels should take into consideration the biological potential to sequester and store additional C (including analysis of risks of reversal from natural disturbances); the economic potential, which reflects the influence of C price on activities; and the social/political potential, such as laws, regulations, and institutional capacity (Failey and Dilling 2010). In this chapter, we review these challenges and the potential for sequestering C on public lands. We first review the institutional context of public land management in the United States, including the federal, state, and local governmental levels. We then evaluate the opportunities for C management given the large acreage of land and vegetation types in the public domain, how decision-making operates, and what has already occurred in terms of agency leadership in the area of C management. We follow with a brief analysis of some of the challenges of deliberately managing C on public lands. We conclude by describing several C-related pilot projects under way and suggest implications for the future of C management on public lands.

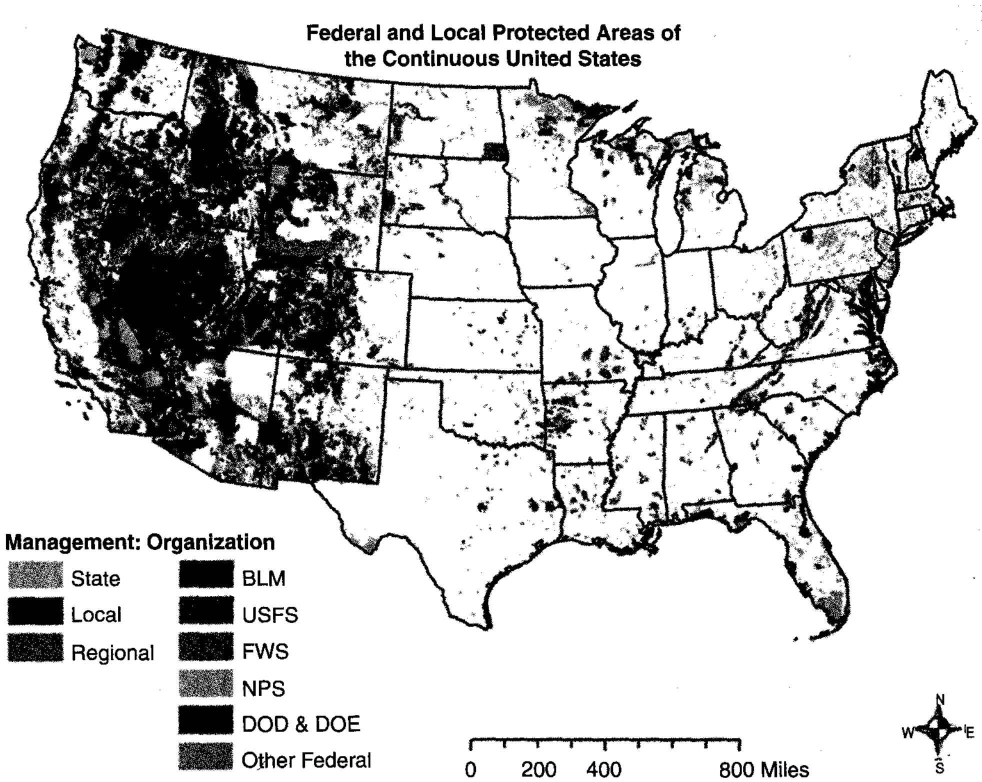

Figure 18.1. Location of land areas of selected public owners. Estimates are derived from the Protected Areas Database of the Conservation Biology Institute (http://consbio.org/what-we-do/protected-areas-database-pad-version-4/). DOE, Department of Energy. (See color plates.)

2. Definition and History of Public Lands in the United States

In general, we can think of public lands as those lands that are held in trust for the people of a country, state, or region by the government. Driven by efforts to utilize, conserve, or preserve natural resources in the public domain, more than one-third of the land area in the United States has now been acquired and is maintained for public use (Figure 18.1). There is a complex system of ownership and management of public lands involving different levels of government and varying mandates. To simplify the discussion, we refer to the management of public lands in this chapter rather than its ownership.

To understand how any new mandate, such as C management, might fit into the institutional context of federal public land management, we must consider the role of history and the guiding forces that shaped not only public lands, but the United States itself. As Charles Wilkinson (1992) eloquently describes:

[N]atural resource policy is dominated by the lords of yesterday, a battery of nineteenth century laws, policies, and ideas that arose under wholly different social and economic conditions but

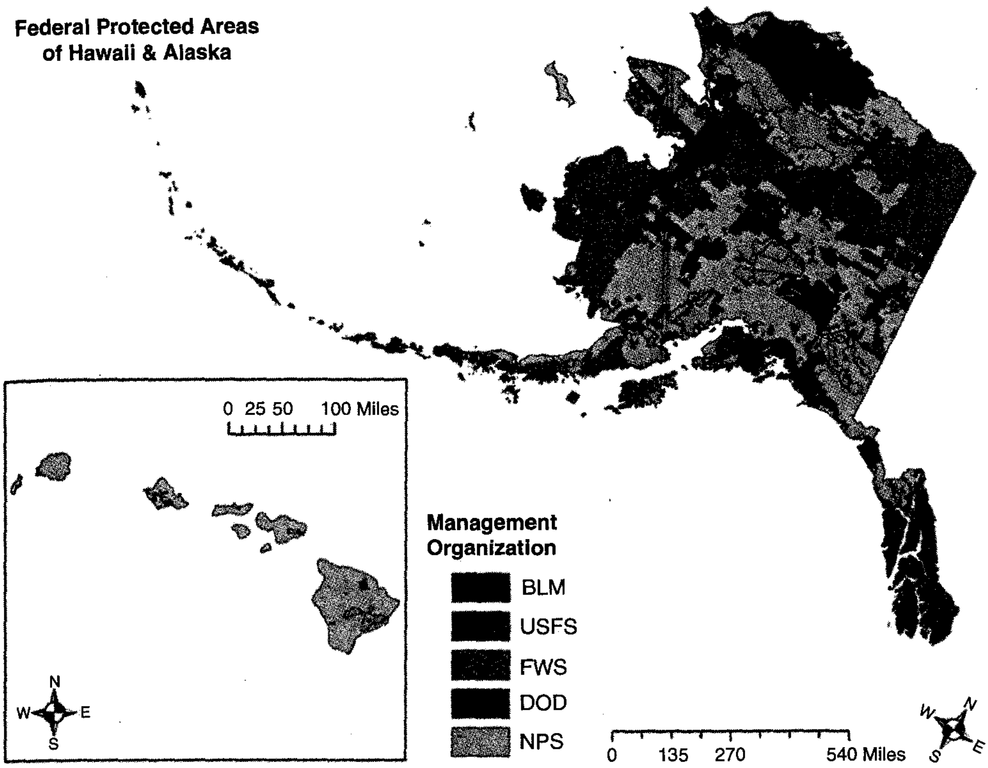

Figure 18.1 (continued) (See color plates.)

that remain in effect due to inertia, powerful lobby forces, and lack of public awareness. (p. 17)

The "lords of yesterday" are the many laws and doctrines of the nineteenth and early twentieth century that have had an enduring impact. Wilkinson describes the lords as (1) the Hardrock Mining Law of 1872; (2) policies involving grazing on public lands and logging as a primary use of forests; and (3) policies involving water in the West, namely, policies promoting dam construction and the Prior Appropriation Doctrine, which allocates water to those who have first claimed rights and allows use of water if put to "beneficial" use (Wilkinson 1992). Whereas modern-day public land management is commonly governed by much newer and broader laws, these lords of yesterday have a significant inertia and set of constituencies that make it difficult to move toward new paradigms of sustainable, multiple-use resource management, including deliberate C management.

Amid growing concerns about the condition of the nation's natural resources and the disposition of the remaining public lands, a strong conservation movement began in the early twentieth century (Fedkiw 1989). National and state parks, forest reserves, and other protections were put in place to secure the lands and improve condition of

Table 18.1. *Area of public land by land-management agency (millions of acres)*

Land-Management Agency[a]	Conterminous U.S. Total[b]	Alaska and Hawaii[c]	U.S. Total	Total U.S. Public Land (%)
BLM	167.9	69.7	237.6	28.7
Bureau of Reclamation	1.6	0.0	1.6	0.2
USFWS	14.8	75.5	90.3	10.9
USFS	171.0	22.2	193.2	23.3
Departments of Defense and Energy	24.2	2.3	26.5	3.2
NPS	25.1	52.9	78.0	9.4
Other federal	0.9	0.0	0.9	0.1
State	91.7	105.8	197.5	23.8
Regional	0.9	0.0	0.9	0.1
Local	1.8	0.0	1.8	0.2
Total	500.0	328.4	828.4	100.0

[a] Agency or department that manages the land. There are some differences between the areas managed and owned by different federal entities (see text for discussion).
[b] Estimates derived from the Protected Areas Database of the Conservation Biology Institute (http://consbio.org/what-we-do/protected-areas-database-pad-version-4/).
[c] Estimates from the National Resources Council of Maine (http://www.nrcm.org/documents/publiclandownership.pdf).

the public domain. Taking preservation a step further, the Wilderness Act of 1964 set land aside to be managed specifically for the preservation of species and habitat, as opposed to extensive recreational or extractive uses. Although this act only applied to a relatively limited number of acres, it reflected a change in the way that public lands were valued at the federal level and demonstrated growing interests that were focused on preservation of the environment for its own sake, in addition to the goods it might provide (Loomis 1993). The Wilderness Act set the stage for more inclusive concepts of land use such as "multiple use," which attempts to balance the need for extraction of resources and preservation of land for wildlife, recreation, and other uses.

2.1. Public Land Management Agencies and Key Legislation

Federal public lands are managed by agencies in the executive branch of the U.S. government (Table 18.1), primarily under the Department of the Interior (Bureau of Land Management [BLM], Fish and Wildlife Service [USFWS], and National Park Service [NPS]) and the Department of Agriculture (USDA; Forest Service [USFS]). In addition, the Department of Defense (DOD) administers a relatively small amount of federal land.

The BLM arose from several agencies, one of which had a fairly narrow mandate focusing on allocating the use of western lands for grazing stock. After much study, a bipartisan commission, and debate through several congressional sessions, the Federal

Land Policy and Management Act (FLPMA) of 1976 was passed to consolidate many separate responsibilities into the BLM and to establish a mandate for multiple-use management of the land that reflected the growing sentiment of the times.[1] "Multiple use" is a concept that is now embedded in the missions of many federal departments and agencies. Much of the BLM land is still used for grazing, along with other multiple uses (approximately 150 million acres; Fedkiw 1989). There are substantial areas used for multiple services such as timber, wildlife habitat, recreation, and water as well as for mineral production.

The USFS was originally established primarily from a perspective of conserving forests for future timber extraction and protecting watersheds in the national interest. Growing recognition of values other than timber production resulted in the passage of the National Forest Management Act (NFMA) of 1976, which established a multiple-use mandate for the USFS. The NFMA mandates assessments of forestlands, development of a management program based on multiple-use, sustained-yield principles, and development and review of forest plans for each management unit in cooperation with the public and other federal and state agencies (Galik, Grinnell, and Cooley 2010). Some of the main uses of USFS lands are timber production, recreation, watershed protection, wildlife habitat, and protected areas (USDA 2007).

The USFWS manages wildlife refuges governed by the National Wildlife Refuge System Administration Act (1966), which provides guidelines and directives for "the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, and waterfowl production areas." About 20 million acres of USFWS-managed lands are designated as wilderness under the Wilderness Act of 1964, which provides additional protections for the land to be administered unimpaired for future use as wilderness.

Because national parks are individually established by acts of Congress, each may have a unique set of management authorities and objectives. However, as a general rule, the NPS mission is to "conserve the scenery and the natural and historic objects and the wild life therein [parks and monuments] and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" originally described in the National Park Service Organic Act of 1916 (NPS).

Policy for management of DOD lands is based on an ecosystem approach (Benton, Ripley, and Powledge 2008) to ensure that military lands support present and future military requirements while preserving, improving, and enhancing ecosystem integrity. In practice, military training takes precedence; however, there are also significant efforts to preserve biodiversity, practice forestry, and provide opportunities for hunting, fishing, and other recreational use.

[1] http://www.blm.gov/flpma/FLPMA.pdf (accessed March 23, 2012).

Two important, overarching laws have had significant influences on public lands management. First, all federal agencies (and work done with federal funding) are subject to the National Environmental Policy Act (NEPA) of 1969, which mandated the evaluation of environmental impacts (through an Environmental Impact Statement, or EIS) and established the Council on Environmental Quality (CEQ), which sets environmental-related policy across the government. Actions subject to the NEPA often include a process, as established by each agency, to gather comments and input from the public and other constituents on actions proposed on public lands. Second, the Endangered Species Act (ESA) of 1973 is focused specifically on protecting species and the "ecosystems upon which they depend." The ESA is administered by the USFWS and the National Oceanic and Atmospheric Administration and requires that agencies take steps to "ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species."[2]

About 200 million acres of public land are held and administered by state governments (Davis 2008). More than three-quarters of this acreage is in the category of "state trust lands," which were allotted to the state (typically at statehood) and generate revenue (often for schools, for historical reasons). State lands represent a much more heterogeneous set of agencies and institutional rules across states compared with the federal government. The structures of state land agencies vary from state to state in several ways, such as in the degree of decentralization and use classifications (e.g., see table 18.4 in Davis 2008). In addition, unlike the federal land agencies, state land agencies do not have an across-the-board, well-defined, multiple-use mandate; about half of the states are mandated to consider multiple use in some way, whereas the other half do not have specific mandates to manage the forest in "any particular way" (Koontz 2007). States have fewer legal constraints on management decision making and do not have the same requirements to involve the public in decision making for public lands as federal agencies do; only seven states have anything resembling the NEPA process for public involvement (Koontz 2007). One study has suggested that decision makers in state land agencies are more likely to hold views that a forest is a source of goods and services, rather than a source of habitat or ecological value (Koontz 2007). Indeed, state public forestlands are proportionately more heavily harvested for timber than federal lands, perhaps partially because of the lack of a legal structure under which state timber-sale decisions can be challenged (Davis 2008).

Since the 1960s, the number of local governments (at the county and municipality scale) that have begun to preserve land through programs, such as open-space planning, have grown dramatically. These lands are a small fraction of the public lands portfolio but can be quite heavily used by local populations for recreation and can play

[2] Text from the Environmental Protection Agency (EPA) Summary of the Endangered Species Act: http://www.epa.gov/lawsregs/laws/esa.html (accessed May 13, 2011).

a role in shaping patterns of urban development. In addition, private trust lands, such as lands managed by the Nature Conservancy, can play an important role in preservation of habitats. These lands are not public lands but are managed for preservation rather than for extractive uses and thus have a narrower mandate than federal public lands.

3. Opportunities for Managing Carbon on Public Lands

3.1. Public Lands Represent a Large Fraction of the U.S. Land Area

Public lands constitute about 37 percent of the land area of the United States, with federally managed lands occupying 76 percent of the total area managed by all public entities (see Table 18.1). Thus, because a significant fraction of the land surface is in the public domain, it is important to consider public lands when evaluating the potential to manage C in the United States. Furthermore, opportunities for management of C lie not only in the vegetation characteristics of the land (e.g., forest type, biomass stocks, current management) but also in the flexibility and constraints of the decision context of the land managers. Therefore, in our analysis of C management in the United States, we must consider how decisions on public lands are made.

Land cover across public lands in the conterminous United States is composed of about one-third forest, one-third shrubland and savanna, and one-third other classifications such as developed land, grassland, and wetlands (Table 18.2). The percentage distribution of land-cover classes on public lands is similar to the distribution of land-cover classes on all nonagricultural lands of the United States (USDA 1989; Lubowski et al. 2006), although the exact percentage distributions depend on definitions.

A large proportion of the land (approximately 50 percent) in the western United States is federally managed (see Figure 18.1). In contrast, federal land management in the East accounts for only about 7 percent of the total land area.

The U.S. BLM manages more public land than any other federal department or agency, followed by the USFS, the USFWS, and the NPS. The BLM is responsible for managing 10 percent of the land area of the United States, or 29 percent of all public lands (see Table 18.1), and was recently designated as the National System of Public Lands. Two-thirds of the BLM-managed land is classified as shrubland, steppe, and savanna (see Table 18.2) and is located in large semicontiguous areas in the western United States (see Figure 18.1). The USFS manages 193 million acres of land, about 9 percent of the land area of the United States or 23 percent of publicly managed lands (see Table 18.1). More than 75 percent of this land is classified as forest (117.4 million acres), with most of the remainder classified as shrubland, steppe, and savanna (see Table 18.2). The USFWS manages the national wildlife refuges, encompassing more than 90 million acres of wildlife habitat in all fifty states and many U.S. territories. The NPS manages the national parks, a portion of the national monuments, and other sites of historical value in the United States. The National Park System encompasses

Table 18.2. *Area of public land by land-management agency and cover type, conterminous United States (millions of acres)*

Land-Management Agency[a]	Cover type[b]								
	Human	Aquatic	Barren	Forest and Woodland	Shrubland, Steppe, and Savanna	Grassland	Disturbed	Riparian and Wetland	Conterminous U.S. Total
BLM	0.9	0.1	13.4	25.2	111.2	7.2	4.6	5.3	167.9
Bureau of Reclamation	0.1	0.2	0.1	0.1	0.8	0.1	0.1	0.2	1.6
USFWS	2.6	1.0	0.7	1.0	4.8	0.8	0.5	3.4	14.8
USFS	1.7	0.7	3.8	117.4	23.0	11.5	6.8	6.2	171.0
Departments of Defense and Energy	1.3	2.1	3.3	3.0	11.1	1.0	1.0	1.4	24.2
NPS	0.5	0.3	5.2	7.9	7.2	0.9	0.7	2.4	25.1
Other federal	0.1	0.0	0.0	0.2	0.3	0.1	0.0	0.2	0.9
State	5.9	2.2	1.4	32.1	21.2	9.6	4.6	14.6	91.7
Regional	0.1	0.0	0.1	0.2	0.4	0.1	0.0	0.1	0.9
Local	0.4	0.1	0.0	0.8	0.2	0.0	0.1	0.2	1.8
Total	13.45	6.87	28.02	187.94	180.21	31.19	18.36	33.96	500.00
Percent of total	2.7%	1.4%	5.6%	37.6%	36.0%	6.2%	3.7%	6.8%	100.0%

[a] Agency or department that manages the land. There are some differences between the areas managed and owned by different federal entities (see text for discussion). Estimates derived from the Protected Areas Database of the Conservation Biology Institute (http://consbio.org/what-we-do/protected-areas-database-pad-version-4/).

[b] Cover-type area estimates from the USGS Gap Analysis Program, level 1 classification. Estimates in this table may not be consistent with other estimates of land cover or use referenced in the main text or in Table 18.3 because the sources of data may be based on different land classification schemes.

Table 18.3. *C stocks and annual changes in C stocks for the United States by land class and management class*

	C Stocks (Pg C)			Changes in C Stocks (Pg C·yr^{-1})		
Land Classification	Private	Public	Total	Private	Public	Total
Forest	31	30	61	0.10	0.10	0.20
Cropland and grazing land			47			0.01
Wetland			64			0.05
All lands			172			0.26

Note: Estimates are not available for blank cells. Estimates are derived from Birdsey and Heath (1995), Heath et al. (2011), Pacala et al. (2007), and USDA (2008a).

about 84 million acres.[3] Finally, the Departments of Defense and Energy manage almost 30 million acres in the United States, spanning a wide range of ecosystems.

Almost all public land that is not managed by the federal government is managed by the states. States manage about 198 million acres, or 9 percent of U.S. lands (see Table 18.1). Alaska has the largest total area of state-owned land (106 million acres, or 53 percent of the total for the United States), whereas New York has the highest percentage of land under state management (11 million acres, or 37 percent of the total state land).

The area of land in county or municipal management is quite small – about 2 million acres of the United States (0.1 percent of land area), or 0.2 percent of the total land area under public management.

3.2. Large Carbon Stocks on Public Lands

Given their areal extent and vegetative cover, public lands contain significant stocks of C and on average are significant C sinks. Inventories of C stocks and changes in C stocks are not individually available for each of the public land management entities. However, greenhouse gas (GHG) inventories and C cycle assessments conducted by the U.S. Environmental Protection Agency (EPA), the USDA, and the U.S. Global Change Research Program provide some information for all lands and for public lands, separately, summarized in Table 18.3. In addition, the U.S. Geological Survey (USGS) has published estimates of soil organic C for Department of the Interior (DOI) lands and individual agencies within the DOI (Bliss 2003), and the USFS has recently estimated C stocks and fluxes for national forests and other public forests by region, including detail about each national forest (Heath et al. 2011).

[3] From National Park Service: http://www.nps.gov/aboutus/index.htm (accessed August 21, 2012).

Total C stocks on U.S. wetlands (see Table 18.3) are estimated to be 64 Pg. Wetlands as C stocks are higher on a per acre basis than other broad land classes because of high amounts of organic soil C (Pacala et al. 2007). However, very little is known about the distribution of wetland C stocks by public and private management classes. Pacala et al. (2007) estimated that C stocks on all U.S. wetlands are increasing at a rate of 0.05 Pg $C{\cdot}yr^{-1}$.

Total C stocks on U.S. cropland and grazing land are estimated to be 47 Pg C (Pacala et al. 2007); however, the estimated rate of change is near zero (see Table 18.3). Data is not available to break these estimates down by public and private ownership classes.

The C stocks and changes in C stocks in U.S. forests are about equal in magnitude for public and private land management classes. Stocks total about 30 Pg C and annual stock changes by about 0.1 Pg $C{\cdot}yr^{-1}$ within each class (see Table 18.3). However, excluding low-density forests of Interior Alaska, the C density of public forestlands is higher, on average, than private lands (Heath et al. 2011), likely reflecting the influence of reduced harvest of public lands compared with private lands during the latter part of the twentieth century. A more in-depth analysis of forest biomass density in New England reached a similar conclusion – the biomass density of public lands there is significantly higher because of a higher proportion of forests that are protected for various reasons: watersheds, conservation values, parks, and so on (Zheng et al. 2010).

Annual changes in C stocks are significantly larger on forestland than other land classes in the United States (Pacala et al. 2007). As with C stock magnitudes, changes in forest C stocks are about equally split between public and private owners (USDA 2008a), indicating that public forestlands currently sequester more atmospheric carbon dioxide (CO_2) per unit of land as compared with private land. Estimated changes in C stocks (see Table 18.3) do not include changes in C stocks of harvested wood products, which are significantly higher from private land management (0.09 vs. 0.01 Pg $C{\cdot}yr^{-1}$), because more timber is harvested from these lands (Heath et al. 2011; Smith et al. 2009). This is an important consideration in comparing management impacts, because accounting for wood products tends to equalize the total sequestration rate (ecosystem plus wood products) per unit of land area between public and private land management.

Although the average biomass density of public forests (excluding Interior Alaska) exceeds that of private forests (Zheng et al. 2010), because of forest type and management history, there is still considerable potential to increase C stocks in some parts of the United States. In many areas of the East, timber was extensively harvested or the land was used for agriculture before the land became public forest, and this land has yet to recover to the maximum potential C stocking (Birdsey, Pregitzer, and Lucier 2006; Pan et al. 2011). In the West, harvesting was much more extensive in the past compared with the present (Smith et al. 2009), and these extensively harvested lands have yet to reach C storage capacity. Smith and Heath (2004) estimated current and projected changes in C stocks for public forests of the conterminous United States, revealing that between 1953 and 2002, C stocks increased from 16.3 to 19.5 Pg C. Projections indicated that this historical increase in C stocks would continue through 2040 under "business as usual" assumptions (i.e., a continuation of current management of public lands). Another study of public forests by Depro et al. (2007) found that eliminating harvest (an unlikely scenario) would result in an annual increase of 17 to 29 Tg C through 2050 compared with business as usual, whereas more intensive harvesting would result in annual losses of sequestered C in the range of 27 to 35 Tg C.

The USGS estimated that the national capacity to increase C stocks on all lands was almost 20 Pg C (Sundquist et al. 2009). Two-thirds of this capacity was on land classified in that report as forests and woodlands.

Actually achieving maximum potential C storage capacity across all public land is probably impossible. At the landscape scale, biological potential is limited by natural disturbances, which periodically release stored C and cannot be easily controlled by land managers (Ryan et al. 2010; see Chapter 14). In addition, because public land is managed for multiple benefits, it is not likely that the use of all areas for maximizing C stocks would be acceptable to the public, as this could require unacceptable trade-offs with provision of other benefits.

A recent study of national forests in California compared business as usual with several alternative management scenarios (Goines and Nechodom 2009). The study concluded that under current management, the national forests would become net emitters of C after several decades because of losses from wildfire and other disturbances. Additional reforestation would extend the period of net sequestration, as would full implementation of the existing management plans (note that current management does not fully implement the existing plans). The study included one scenario entitled "maximum forest resiliency" that was designed to shift the C inventory to larger trees and reduce the risk of wildfire – this scenario produced some long-term C benefits but reduced other services.

3.3. Coordination and Leadership

Although public lands are certainly diverse and managed for several different purposes, the fact that much of the land is linked through the federal agency structure affords the opportunity for a coordinated approach to managing C. The Council on Environmental Quality (CEQ) has the responsibility of overseeing environmental policy across the federal government. As of this writing, the CEQ has promulgated draft guidelines for all agencies, delineating ways in which "federal agencies can improve their consideration of the effects of GHG emissions and climate change in their evaluation of proposals for federal actions under the National Environmental Policy Act (NEPA)" (Sutley 2010, p. 1). The purpose of the draft is to explain how agencies "should analyze the environmental effects of GHG emissions and climate change"

(p. 1) when evaluating potential actions by federal agencies. Also included is the need to analyze the impacts of the changing climate itself on the proposed agency actions (e.g., projecting required water resources under altered precipitation scenarios). The draft is open for public comment (at the date of this writing), and thus the information reported here is subject to change. The guidance suggests that if an action could be "reasonably anticipated to cause direct emissions of 25,000 metric tons [0.025 Tg] or more of CO_2-equivalent GHG emissions on an annual basis" (p. 1), then agencies should consider whether an assessment of the effects would be important for decision making under the NEPA process. For annual amounts less than 25,000 metric tons (0.025 Tg), the guidance does not suggest that impacts are insignificant but rather suggests that agencies should look at long-term effects over longer than a one-year period.

Regarding public land use decision making, the proposed CEQ guidance would not apply to federal land and resource management actions (such as managing the land surface for storing additional C). The guidance states that there is not yet an "established federal protocol" for assessing the effect of land-management techniques "on atmospheric C release and sequestration at the landscape scale" (p. 4). The proposed CEQ guidance specifically asks the public for input on protocols for assessing land-management practices and "their effect on carbon release and sequestration" (p. 4).

The choice of temporal and spatial scales critically influences estimates of environmental impacts and adaptive responses resulting from land-management decisions. Fortunately, the proposed CEQ guidance does begin to recognize the temporal scale problem when it suggests that cumulative emissions could be appropriately considered over the lifetime of the project. On the issue of linking emissions from a single action to an observed climatological impact, the guidance does state that a "direct linkage is difficult to isolate and to understand" (Sutley 2010, p. 3). According to agency decision makers on the ground, models and other tools available are often inadequate for describing how single or localized actions are impacting global climate (Dilling and Failey, in review). The issue of cumulative impacts or aggregating impacts for analysis in an EIS framework is one that will remain a challenge for evaluating the environmental impacts of decisions in a climate context.

Another recent policy that affects all federal agencies is Executive Order 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) signed October 5, 2009, which requires agencies to set targets that would include a focus on sustainability, energy efficiency, reducing the use of fossil fuels, increasing water efficiency, reducing waste, and the like. In addition, the order requires agencies to measure, report, and reduce their GHG emissions from direct and indirect activities, including federal land management practices (Executive Order no. 13514, 2010). This includes requirements on vendors with whom the government does business and thus may have far-reaching consequences beyond the agencies themselves. With this order comes the first attempt to understand the full C footprint of the federal government and to set targets to improve sustainability, which goes beyond previously laudable efforts at improving government efficiency and reducing waste.

Finally, section 712 of the Energy Independence and Security Act (EISA) of 2007 tasked the DOI with developing a methodology and subsequently assessing the storage and flux of three important GHGs from ecosystems, including CO_2, methane, and nitrous oxide. The assessment's goals include determining the processes that control fluxes and the potential for increasing sequestration, as well as identifying adaptation strategies. As of this writing, the USGS of the DOI had published an initial draft of the proposed methodology for public comment (Zhu 2010).

As these policies become clarified and implemented, agencies will have better guidance for GHG management in a consistent manner. Meanwhile, agencies have begun to frame individual policies based on existing regulations, as well as influence from the public and the courts, as management plans and projects are formulated and implemented. The agencies are beginning to develop policy documents and complete reports from pilot studies on C management and responses to climate change.

In 2001, Secretary Babbitt of the U.S. DOI issued a Secretarial Order for all agency units to "consider and analyze potential climate change impacts" in their decision making. This was strengthened by further orders from Secretary Salazar, who also sought to initiate projects in C capture and storage and energy efficiency (Secretarial Order 3289). The BLM, along with other agencies in the DOI and other departments, submitted a report to Congress in 2009 entitled *Framework for Geological C Sequestration on Public Land*. This report responded to the EISA of 2007 and contained recommendations to help reduce GHGs by storing CO_2 emissions in appropriate underground geological formations on public lands (BLM 2009). The report recommends criteria for identifying potential sites for geological C sequestration and addresses related issues such as leasing of public land, environmental protection, public participation, rights-of-way, and federal liability. In a separate, precedent-setting case in 2010, a court in Montana ordered the suspension of sixty-one oil and gas leases in Montana on BLM land because of lack of analysis of GHG emissions. Oil and gas extraction practices will have to undergo review and analysis for determining ways to reduce emissions.

To date, the USFS has explored its role in C management through research activities in C accounting and demonstration projects (see later discussion). USFS land-management plans and projects have also been the subject of appeals in recent years for failing to consider their effects on GHGs and climate.[4] Partly in response to these events, the USFS developed the *Forest Service Strategic Framework for Responding to Climate Change* in 2008, followed by the *National Roadmap for Responding to*

[4] For example, the kanc7 project of the White Mountain National Forest was appealed partially on these grounds. See http://www.fs.fed.us/r9/forests/white_mountain/projects/projects/assessments/kanc_7/kanc_7.htm (accessed July 27, 2010).

Climate Change (USDA 2008b, 2010b). The framework encompasses two components: (1) facilitated adaptation, which refers to actions to adjust to and reduce the negative impacts of climate change on ecological, economic, and social systems, and (2) mitigation to address actions to reduce emissions and enhance sinks of GHGs. The framework also addresses the emissions from agency operations such as vehicle use and emissions from facilities. The *Roadmap* (USDA 2010b) specifically charts some priorities for C sequestration on USFS lands, such as actively managing for C, facilitating demonstration projects, and encouraging the use of biomass for power and materials substitution.

Although the states act on this issue largely independently of the federal level, many states have recently undertaken analyses of climate-change mitigation potential.[5] These analyses have involved both rigorous analysis of data and stakeholder inputs to determine both the biological potential and the likelihood of adoption by various sectors and social groups. Such assessments are targeted to the states' individual circumstances and opportunities. In general, these action plans have focused on emissions reductions from various economic sectors but have not addressed "offsets" that involve C sequestration on the land in lieu of emissions reductions. A few states, such as Pennsylvania, include aggressive land-management actions that are tailored to private landowners but that could also be applied to substantive areas of public lands.

4. Challenges for Managing Carbon on Public Lands

Public lands present particular challenges for land use and managing C stocks and fluxes. Use and management decisions made in a multiple-use context and for a heterogeneous landscape imply that any impetus for C storage management on public lands occurs against a backdrop of other values for the land, and C goals must be understood in terms of other trade-offs that might be made.

4.1. Carbon Management against a Backdrop of Multiple Use

The history and laws supporting the doctrine of multiple use for public lands can be both a curse and a blessing. The ability to consider multiple values and uses of the land is a positive development, as many constituencies' interests can be represented and satisfied to some extent if multiple types of uses are considered valid. On the other hand, allowing multiple uses, some of which can be in direct conflict, can create tension and result in difficult decision spaces for managers tasked with adjudicating between interests.

[5] See the Pew Center map and information: http://www.pewclimate.org/what_s_being_done/in_the_states/action_plan_map.cfm (accessed March 23, 2012).

Public lands currently support a wide variety of uses that correspond to quite different value stances for how public lands should be used, including grazing cattle, harvesting timber, protecting endangered species, providing recreational opportunities, and ensuring the existence of relatively unspoiled wilderness. Within each category, decisions are made every day that must take into account how to best protect the resource while allowing access and use in the public interest. The intersection of public lands with private rural and urban spaces must also be managed, whether for fire mitigation, air quality, wildlife interactions, or even noise and light pollution.

Management of C, therefore, enters into a public land decision landscape that is already fully oversubscribed with multiple competing goals and objectives. Managers who are being tasked with considering C and climate concerns must weigh how these new mandates might intersect or overlay onto their existing portfolio of responsibilities. Moreover, if decisions to preserve C run contrary to some of the long-standing uses for a particular public area, then C management may emerge as a secondary, rather than primary, concern (Failey and Dilling 2010; Ellenwood, Dilling, and Milford 2012).

4.2. Lack of Clear Carbon Management Incentives

As discussed previously, both the DOI and the USFS have taken high-level steps to address C management through strategic planning and Secretarial Orders. How these directives translate into actions at the field-office level remains to be seen. An in-depth case study of one office and a second study on federal offices in one state have indicated that, so far, the most common action for those cases is inventorying C on lands (Ellenwood, Dilling and Milford 2012; Dilling and Failey, in review). A new climate change "Scorecard" initiative by the USFS requires offices to state what they have done on an annual basis to address climate change; one of the reporting elements is to assess C stocks (USDA 2010c). These types of reporting requirements may well serve to raise awareness of C issues throughout federal public land agencies.

Whether land managers are able to prioritize deliberate enhancement of C sequestration or preservation of C stocks as management goals is not yet clear. Anecdotal indicators of the "mood" of the United States toward managing C suggest that at this time, in 2012, there is wavering enthusiasm to enact stronger incentives to encourage increases in domestic land C sequestration, whether on private or public lands. A voluntary market that allowed utilities to purchase C offsets from private farmlands was created, prices of existing shares have dropped to near zero, and new contracts are no longer being issued (Kirkland 2010). In contrast, California has continued to push ahead with implementing the Climate Action Reserve (CAR), which includes forestry projects. National policy to establish a domestic cap-and-trade market for C failed in the 111th Congress, and it is not clear when the issue will be taken up again. Offsets for private lands to enter into C markets were a part of the American Clean Energy and Security Act of 2009 (H.R. 2454), which passed the House of Representatives but did not become law. These examples do not necessarily indicate how public lands will be able to prioritize deliberate C management; however, they do point to some of the difficulties and lack of overall incentives.

4.3. Uncertainty in How Management Actions Affect Carbon

Another factor that will likely be a challenge in adding C management to the portfolio of public land managers is the uncertainty associated with how management actions affect C stocks and fluxes. Although some actions would seem to have fairly obvious C ramifications (e.g., planting trees on barren land), there are actually many questions about how management activities affect the C balance. For example, how the C balance is affected by harvesting timber depends on the fate of the timber, the amount of slash left on the ground, the rotation time of the forest plot, and so on (Harmon and Marks 2002; see Chapter 13).

Another area of active research involves the effect of fire mitigation and fuels reduction activities (see Chapter 14). Although thinning and prescribed burning can result in a forest that is less prone to large, stand-replacing fires – and thus fewer instances of rapid release of C to the atmosphere – there is also some loss of C in the short term simply from the fuels reduction activities themselves (Dore et al. 2010; Reinhardt and Holsinger 2010). The time frame over which C balance is calculated can also make a difference in whether there is a net gain or loss of C from a given forest (North, Hurteau, and Innes 2009; Hurteau and North 2010). Therefore, although managers may be aware of the need to enhance C sequestration on land, they might not know exactly how to manage the lands to accomplish that need (see Chapter 14).

Uncertainty not only plays a role in helping to decide what the right course of action is with respect to C management but also is a factor in defending decisions against potential legal challenges. Challenges of agency management decisions are common, and the courts end up resolving conflicts and setting precedents for land use in the future. Over the past few decades, many different groups have used the court system to challenge agency decision making (Koontz 2007; Davis 2008; Clark 2009). Partly in response, agencies have attempted to make their decision-making process as robust as possible, including relying on "the best available science" to avoid potential court challenges. If science is not available, this is not an obstacle to decision making; however, lack of science may be another reason why managers may be reluctant at the present time to manage C deliberately. The lengthy decision process for public lands has led some to characterize the situation as a "paralysis" (USDA 2002). Lawsuits can serve to block actions that may be seen as necessary for effective land management, such as salvage timber sales in the wake of catastrophic wildfires in the western United States (Martin and Steelman 2004).

4.4. Public Opinion and Constituent Pressure

The role of the public in promoting C management in decision making is not well known; however, there are cases where decisions have been challenged by members of the public on the basis of climate-change goals or maximizing C storage (e.g., see footnote 4). Various public and direct stakeholders play a large role in decision making, from their input into the NEPA process, to lobbying agencies or Congress directly, and instigating court challenges. Whereas public influence has been positive, in that it has opened up decision making to the democratic process (Kasperson 2006), others have claimed that public involvement has prevented effective management because decisions have been delayed, stalled, or reversed, costing extra money and resulting in lost opportunities (USDA 2002). If C management results in more mechanized thinning of forests, for example, there may be constituencies who would oppose such an action because they oppose harvesting of the forest in general (Ellenwood, Dilling and Milford, 2012).

4.5. Lack of Resources

Limited personnel and financial resources are a perennial problem for any agency (or corporation for that matter), thus strategic decisions must be made. The extent to which it would be economically feasible to manage large tracts of public lands for maximization of C storage, whether in forests or grazing lands, is very much in question. The USFS and BLM have the goal of managing for "resiliency" in the environment and promoting sustainable ecosystems. As with other aspects of management, those elements of a C management strategy that are "win-win" with respect to forest health and resiliency will also be higher priorities for other reasons. Given the uncertainty in how management affects C storage at the present time, however, it may be difficult to always identify those win-win strategies.

4.6. Managing Lands across Boundaries

Biomes, ecosystems, and species distributions do not follow political or jurisdictional borders. Similarly, markets for commodities affect supply and demand for ecosystem services across public and private lands alike. Policies that aim to create a consistent approach to C management must therefore consider the role of public lands within the broader context of the natural and socioeconomic landscape.

Managing resources across multiple jurisdictions is a key challenge. Watersheds, airsheds, firesheds (landscape delineation based on fire regime, condition class, fire history, risk, etc.), and landscapes in general simply do not often match the scale of the administrative boundary in place to govern them (Cash and Moser 2000; Dombeck, Williams, and Wood 2004). The USFS has recently recognized this challenge through a proposed new approach to planning called the All-Lands Approach (USDA 2010a).

Similarly, the DOI has proposed Landscape Conservation Cooperatives to work with partners across jurisdictional boundaries for species conservation goals (e.g., USFWS 2010). The BLM has also introduced Rapid Ecoregional Assessments to "look across an ecoregion" and assess trends and opportunities for conservation.[6] The challenge of "leakage" – the displacement of C-releasing activities from one protected area to another nonprotected area – suggests that C management across the landscape will be no different from other cross-boundary management problems (Dilling 2007). Awareness of the C ramifications of decisions across administrative boundaries can perhaps be fostered through new partnerships, coordinating teams and development of compatible policies, such as has occurred for fire management (Dombeck et al. 2004).

5. Activities Under Way – Cases and Examples

In the private sector, experimental offset projects have been under way in several countries for over a decade. In the United States, private landowners were participating from 2003 to 2010 in the voluntary offset market created by the Chicago Climate Exchange (CCX; which ceased active trading in 2010); however, public lands were generally not involved in the CCX except for a few pilot studies. Thus far, using public lands to generate C offsets for C markets has not been official U.S. policy.

There have been a number of demonstration projects to sequester C on public lands, including at the Custer, San Bernadino, and Plumas National Forests,[7] and at several areas managed by the USFWS.[8] These demonstration projects have been achieved through private partnerships with the public agencies, although they are occurring on public lands. The funds used to support the C demonstration activities on national forest land have been raised through selling offset credits on a voluntary basis to the public but are not part of a larger market per se. The USFWS demonstration programs were enabled through partnerships with various nonprofit organizations that either sold credits generated on the voluntary market or were able to sell offsets directly to the public to help fund restoration activities. Further, an effort has been explored by the Delta Institute and the National Forest Foundation to enroll grassland restoration areas at the Midewin National Tallgrass Prairie in northeastern Illinois into the CCX.[9] Such a model for marketing ecosystem services at Midewin would inform neighboring

[6] See more on the BLM approach to Rapid Ecoregional Assessments here: http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html (accessed August 21, 2012).

[7] See examples of demonstration projects for C sequestration on national forests funded by donations to the National Forest Foundation through a C emissions offset portal here: http://www.nationalforests.org/carboncapitalfund/ (accessed July 26, 2010).

[8] See examples of the USFWS's demonstration projects for C sequestration here: http://www.fws.gov/southeast/carbon/ (accessed July 26, 2010).

[9] Presentation: "Restoration and Sustainability of Eastern Forests through Climate Change Mitigation, Adaptation, and Bioenergy" by Logan Lee at the Carbon in Northern Forests Conference, June 10–11, 2009, Traverse City, Michigan. http://forest.mtu.edu/cinf/CiNF_Abstract_Book_Web.pdf (accessed July 26, 2011).

landowners and other USFS units. Funds generated from the sale of C offsets could potentially be used for such purposes as furthering restoration activities, supporting research, educating the public, or maintaining restorations.

These projects have generated some controversy, and a group of U.S. environmental groups have requested that the U.S. Secretary of the Interior and Secretary of Agriculture not allow private contracts for C offsets on public land in the future for a variety of reasons, from concerns over flooding the market to additionality and legal concerns.[10] As of this writing, the issue remains unresolved on federal public lands.

At the state level, following a devastating forest fire, Cuyamaca Rancho State Park in California is the first state public lands reforestation project seeking to generate C offsets through California's new CAR offset registry.[11] Participants in CAR see the C benefits as one part of a larger agenda for restoring habitat and protecting the landscape rather than as the sole goal.[12]

6. Conclusions

In sum, public land managers are not managing the land for C sequestration in a deliberate way, although the impacts of management for other purposes on C is certainly being considered by public agencies and demonstration projects are under way. A complex patchwork of public land agencies with varying mandates, cultures, constituencies, and histories manage a significant portion of the U.S. land surface and, hence, C stocks and potential future sequestration. The ability to enhance the deliberate sequestration of C on land will depend on understanding the complex pattern of public landownership and how C management may fit into existing management expectations and multiple-use considerations. Finally, C management is in a state of flux, and if recent developments are any indication, we can expect to see continuing, rapid evolution of how U.S. public land managers consider C-related goals into the next decade.

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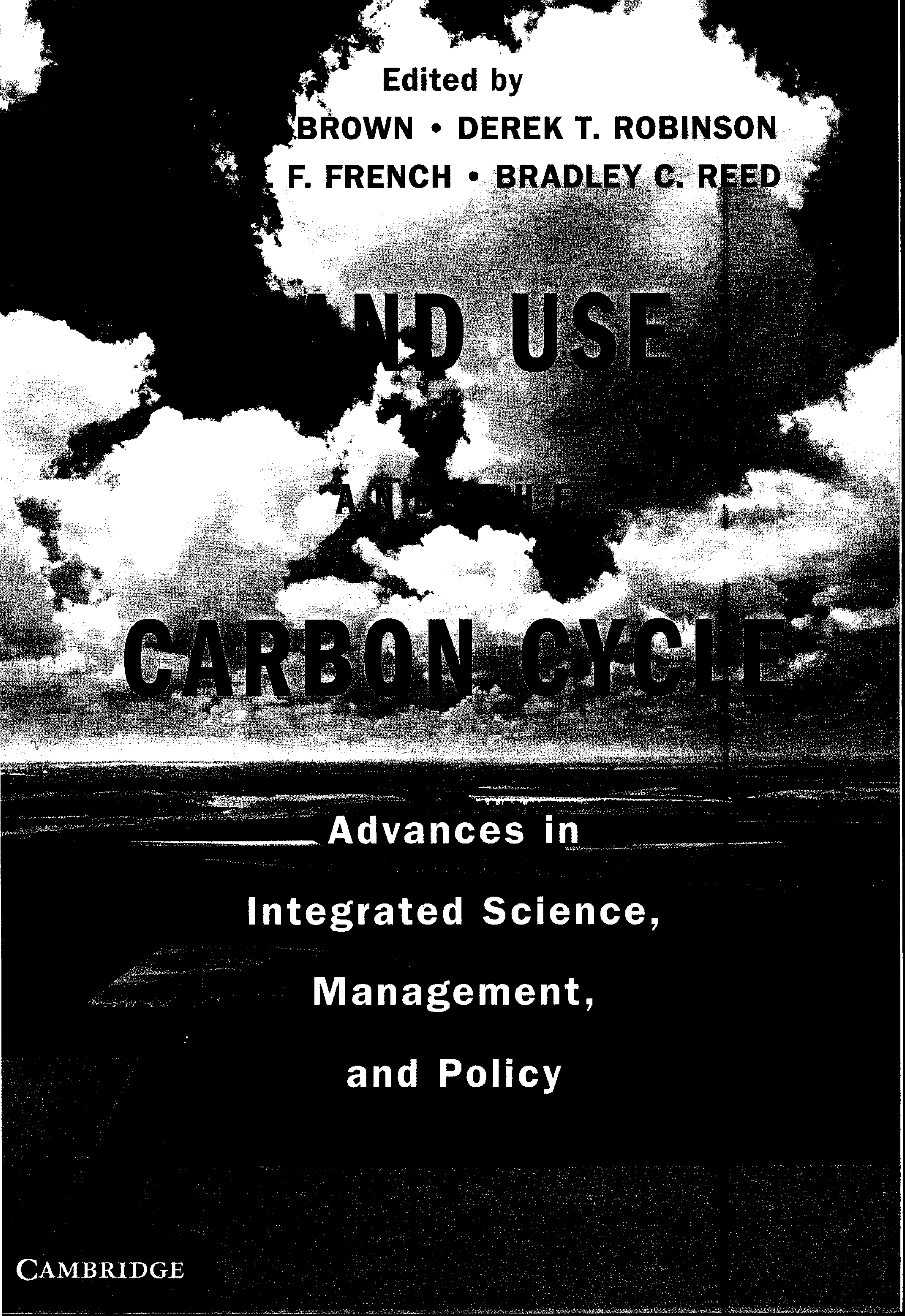

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