The Role of Public Lands in a Low-Carbon Economy

WORKING PAPER

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Executive Summary

Public lands have the potential to make significant contributions to climate mitigation objectives and are likely to play an important role in comprehensive climate policy. Existing legislation and regulations provide broad authority for public lands to contribute to carbon sequestration, emission avoidance, and biomass production objectives. Introducing new climate policy objectives, however, requires balancing with other objectives, such as endangered species preservation, recreation, protection of soil and water resources, grazing, timber harvesting, energy production, and natural resource extraction.

This working paper reviews the role that public lands in general, and federal lands in particular, may play in increasing the supply of greenhouse gas sequestration, renewable energy production, and emission reduction services. We note that activities on federal lands specifically prompted by climate policy must be merged with pre-existing institutional and legal frameworks controlling federal land management. They must also conform and be adaptable to a shifting human environment and changing climatic conditions.

At the present time, ongoing rounds of climate policy debate and development provide a unique opportunity for systematically integrating public lands into comprehensive climate policy. Even absent action on climate legislation in the current Congress, other legislative vehicles, such as energy legislation or a possible public lands omnibus bill, will provide opportunities to address a wide variety of unanswered questions or lingering inefficiencies related to the future of public land management. Accordingly, the paper concludes with a brief discussion of the areas that new policy or revisions to existing policy may help to clarify or address.

Our primary intent throughout this document is not to introduce new science or information, nor is it to advocate the inclusion of any particular provision or provisions in legislation. We likewise note that many of the ideas and concepts discussed herein are hardly new to public land managers, and that significant progress is rapidly being made to tackle these and other issues. Rather, we hope that this collection of off-the-shelf data and compilation of ideas can be used to spur discussion amongst a wider audience of land managers, policymakers, and stakeholders over the exact role that public lands should play in a future low-carbon economy.

Public Lands – Defining the Resource

Public lands sit at the confluence of a changing climate, emerging markets, and the imposition of additional policy objectives. In particular, the potential for comprehensive climate policy in the coming years looms large over the management of public lands in the United States. The sheer magnitude of renewable energy resources and greenhouse gas (GHG) mitigation potential embodied in public lands requires that they be considered as part of any economy-wide climate policy solution. Of course, an increased focus on such low-carbon products and services will require thoughtful deliberation and continual balancing with other long-held, non-GHG policies and objectives. It is this thoughtful deliberation that this working paper attempts to promote.[1]

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[1] As we are discussing the role of public lands in the context of other, existing policy objectives, we largely consider how low-carbon policy objectives can be accomplished within these existing confines and mandates. We do not explicitly consider dramatic shifts in policy, such changes in agency mission, singular carbon management mandates, or large shifts in agency

Defining what we mean by public land is a first step in reviewing the role they may play in a low-carbon economy. At the broadest of levels, public lands can be defined simply as those lands owned by a government.[2] More specifically, public lands can be categorized by level of government ownership (e.g., county, state, federal) and within each level by agency or oversight entity. Within the U.S., over 850 million acres can be classified as public land, with the majority falling under the control of five federal agencies: Bureau of Land Management (BLM), Forest Service (USFS), Fish and Wildlife Service National Wildlife Refuges (FWS-NWR), National Park Service (NPS), and Department of Defense (DOD) (Table 1). It is this federal subset of U.S. public lands on which we will focus throughout this working paper.[3]

Table 1. Breakdown of publicly owned or managed lands in the United States.

	Total Area (million ac)	Percent of Total U.S. Area
Total U.S.	2,261[4]	—
Total Public State Lands	198[5]	8.7%
Bureau of Land Management	264[6]	11.68%
U.S. Forest Service	193[7]	8.54%
U.S. Fish and Wildlife Service National Wildlife Refuge System	93[8]	4.11%
National Park System	84[9]	3.72%
Department of Defense (Army)	15[10]	0.65%
Five-Agency Federal Total	649	28.7%

Low-Carbon Activities and Potential

It is not possible within the confines of this working paper to systematically and comprehensively review the many contributions that public lands may make to a low-carbon economy. A brief review is however warranted of the type and scale of the GHG sequestration, emission reduction, and renewable energy production services that public lands can provide. These potential services are reviewed below, again with a focus on federal lands. Significant policy considerations or tradeoffs are noted when relevant to the continued or expanded use of a particular resource, amenity, or service.

Carbon Sequestration

Public lands provide significant carbon storage benefits, not surprisingly outpacing surrounding private areas in some instances (Zhao et al. 2010). As of 2002, national forest and other public forestlands contained an estimated 10.3 gigatons (Gt[11]) carbon in nonsoil carbon pools, comprising approximately

resources or land holdings.

[2] Merriam-Webster Online Dictionary. Retrieved October 5, 2009, from http://www.merriam-webster.com/dictionary/publicland.

[3] The focus on federal lands is purely for simplicity's sake given the inherent complexity of legal requirements and government institutions that accompany the management of public lands at various levels of government. We do not discount the potential for local and state lands to play significant roles in an emerging low-carbon economy. Indeed, management of public lands at these other levels of government may possess greater flexibility than the federal lands discussed herein, allowing a more rapid adaptation to shifting climate, policy, or market conditions.

[4] Retrieved October 6, 2009, from http://www.ers.usda.gov/StateFacts/US.htm.

[5] Retrieved October 6, 2009, from http://www.nrcm.org/documents/publiclandownership.pdf.

[6] Retrieved October 2, 2009, from http://www.doi.gov/bureaus.html.

[7] Retrieved October 2, 2009, from http://www.fs.fed.us/.

[8] Retrieved October 2, 2009, from http://www.fws.gov/help/about_us.html.

[9] Retrieved October 2, 2009, from http://www.doi.gov/bureaus.html.

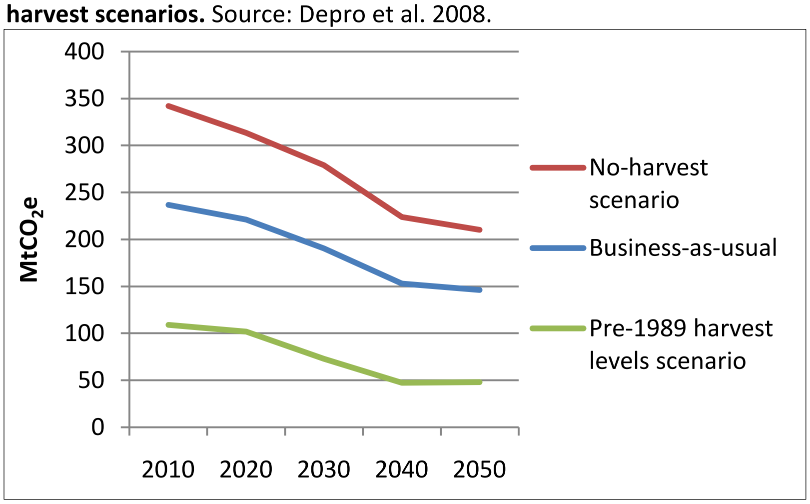
[10] General Services Administration 2004.

[11] The abbreviations *Mt* and *Gt* in this paper refer to megaton (1 million metric tons) and gigaton (1 billion metric tons), respectively. The abbreviation *t* refers to metric ton.

43% of the total U.S. forest nonsoil carbon stock while making up just 37% of the land base (Smith and Heath 2004). It is important to note, however, that sequestration potential can vary dramatically both between land-use types (e.g., forest versus rangeland) and within land-use types (e.g., Pacific Northwest Hemlock-Sitka spruce forest versus Southeastern long leaf/slash pine forest). Furthermore, dramatic increases in sequestration on public lands through active management are likely prohibited by low production capacity, conflicting obligations and priorities, withdrawal for wilderness or other administrative purposes, and public and political opposition to shifts in management (Richards et al. 2006; Tidwell 2009a).

Growth and harvest activity can themselves affect the size of the carbon sink and the rate and direction of change over time. The share of harvests occurring on public lands has fallen significantly over the last few decades (e.g., Powell et al. 1993; Waddell et al. 1989; Smith et al. 2009). Despite this trend, research suggests that a no-harvest approach may result in the greatest rate of annual sequestration on public lands over the coming decades as compared to an increase in harvest activity or even maintenance of status quo (Depro et al. 2008; Figure 1). Extending projections out past 2050 captures the subsequent regrowth associated with increased harvest activity in the early years, decreasing the gap in sequestration between no-harvest and pre-1989 harvest level scenarios (Depro et al. 2008).

Figure 1. Annual public timberland carbon sequestration under various harvest scenarios. Source: Depro et al. 2008.



These estimates are useful in identifying the broad implications of a choice between harvest and no-harvest alternatives, but the full realized sequestration potential on public lands is likely to be influenced by a greater number of factors and management scenarios.[12] For example, reforestation and other management interventions may be appropriate in the wake of massive mountain pine beetle outbreaks in recent years (e.g., Powelson and Osbourne 2008), possibly presenting other opportunities for sequestration.[13] The implications of a broader suite of management options are further borne out in a

[12] It is likewise important to note the tradeoffs that any shift in public-land harvest strategy is likely to require. Reductions in federal timber harvests may generate environmental amenities, benefits, and services besides carbon sequestration in one location, but be offset to some extent by increased harvest activity elsewhere (Wear and Murray 2004). Depending on the manner in which harvests are reduced, renewable energy (i.e., biomass) and product substitution benefits may be forgone as well. There may also be implications for wildfire management if reductions in harvest or other removals are significant (See Emission Reduction, below).

[13] While representing only a single point estimate, evidence from California state park reforestation efforts in the wake of fire suggests that reforestation may hold significant sequestration opportunities: 356,701 tCO_2e over 50 years for a 2,500-acre site, or approximately 2.9 tCO_2e/ac/yr (California Department of Parks and Recreation 2009). This is compared to 0.45–0.77

2009 U.S. Forest Service assessment of National Forest sequestration potential in California (Goines and Nechodom 2009). Though differing in scope and scale with Depro et al. (2008), Goines and Nechodom (2009) find somewhat similar relationships between management and near-term sequestration. Specifically, Goines and Nechodom (2009) find that maximum sequestration rates between 2020 and 2050 may be achieved through full implementation of existing Land and Resource Management Plans or even maintenance of business-as-usual management practices and activities. Over time, however, losses to disease and disturbance outpace growth under these scenarios, suggesting that other, more active management scenarios, such as maximization of forest resiliency through removal of suppressed trees or even intensive even-aged management, could generate the greatest cumulative carbon benefits (Goines and Nechodom 2009).

Apart from forest and timberlands holdings, public lands also contain large amounts of range (256 million acres[14]), wetlands (39.2 million acres[15]), and other land use types. These other landscapes offer potentially significant but highly uncertain GHG mitigation opportunities. Despite this uncertainty, applying a methodology developed under the Chicago Climate Exchange (CCX) to USFS and BLM non-degraded rangeland can be a useful exercise in evaluating rough potential, estimated in Olander et al. (2010) to be roughly 16.6 megatons (Mt) of CO_2e sequestration per year. GHG mitigation in wetland systems is likewise highly uncertain and site-specific. While important to account for the impacts of methane emissions and other radiative forcing components when determining the net climate benefit of wetland restoration efforts (e.g., Bridgham et al. 2006), assessed potential for individual projects suggests that sequestration opportunities can be significant in some situations.[16]

An alternative GHG sequestration strategy—geological carbon capture and storage (CCS)—captures emissions produced during fossil fuel combustion and then subsequently stores them in deep underground geologic formations. The process of injecting CO_2 underground is currently used in the context of enhanced oil recovery (EOR) operations, but also holds enormous potential for GHG mitigation. Total U.S. geologic storage capacity is estimated at over 3,500 $GtCO_2$, or roughly 1,100 years of contemporary domestic stationary-source emissions (U.S. Department of Energy 2008). Federal lands contain between 127 and 374 $GtCO_2$ storage capacity, a small portion of the total resource but significant in its own right.[17]

Existing Policy

Biological carbon sequestration on public land could be recognized and facilitated through several different policy approaches already in place.[18] Most directly, GHG storage benefits could in theory approximate the process by which other mineral sales presently operate, only in reverse. For example, practices that increase the storage of carbon dioxide and other GHGs could generate royalty payments on the value of GHGs stored on public lands, not on the value of resources mined or extracted. Another

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tCO_2e/ac/yr over 40 years estimated in the no-harvest scenario in Depro et al. 2008 ([17–29 MtC/yr * 3.667 tCO_2e/tC]/138 M acres of timberland).

[14] Retrieved February 26, 2010, from http://www.fs.fed.us/rangelands/whoweare/index.shtml and http://www.blm.gov/wo/st/en/prog/grazing.html.

[15] As estimated in Olander et al. 2010 from data retrieved from http://www.fws.gov/wetlands/Data/index.html and http://www.nationalatlas.gov/ (retrieved February 26, 2010).

[16] For example, estimates of sequestration potential for a restored North Carolina pocosin wetland system approach 11 tCO_2e per acre per year, several times the rate of a forested site. Additional research into the actual rates of carbon sequestration, as well as soil respiration and gaseous flux, is planned (Ward 2009).

[17] See U.S. Department of Interior 2009 for a review of ownership issues associated with subsurface storage, particular in situations where ownership of surface and mineral estates is split.

[18] See Olander et al. 2010 for a more detailed review of policy motivations and options for sequestration on federal lands.

option is to pursue direct partnership between public land agencies and private individuals and organizations, an approach that has already been used in USFS and FWS sequestration projects. A third option to facilitate the storage of carbon is the use of new or existing rights-of-way (ROW). Roads, transmission lines, and other activities on public lands typically require some agreement (e.g., easement) or fee simple transfer between a public agency and outside individuals or organizations to authorize project construction, operation, and maintenance. If properly documented in implementation agreements, carbon sequestration benefits that accrue either directly from project operation or through appropriate vegetation management in conjunction with operation of the project could be transferred to the operating party.

Policy analogs likewise exist for CCS, but as with the biological sequestration activities noted above, no laws yet exist that specifically and directly govern geologic CO_2 storage on federal lands (National Energy Technology Laboratory 2009). Existing regulations overseeing the approval and construction of pipelines, leasing of land, and CO_2 injection (currently used in the context of EOR) will likely apply to CCS project development. Issues of ownership and liability will need to be specifically addressed in future policy, however, as these are issues unique to the CO_2 injection and storage process (National Energy Technology Laboratory 2009).

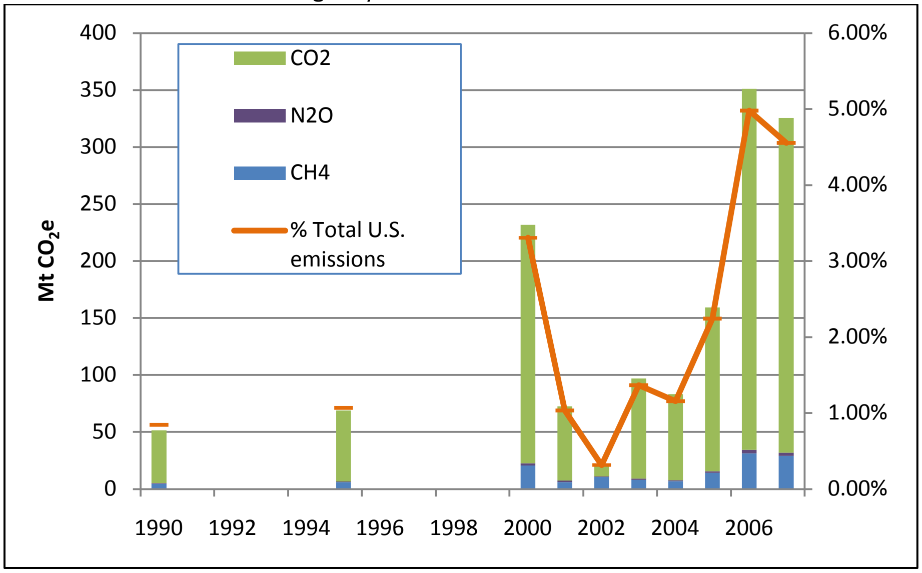
Emission Reduction

A changing climate is expected to bring shifts in the intensity and frequency of extreme weather and other forest disturbance events (IPCC 2007). In extreme instances, individual disturbance events can have significant broad-scale carbon balance implications (Chambers et al. 2007; Kurz et al. 2008; Lindroth et al. 2009). U.S. wildfire emissions in particular are a small but-not-insignificant component of gross emissions (Figure 2). Furthermore, increased wildfire activity (e.g., Westerling et al. 2006) not only implies the release of an extraordinary portion of the aboveground carbon pool but also threatens future ecosystem productivity via direct and indirect losses of soil organic matter, nitrogen, sulfur, and phosphorus (Fisher and Binkley 2000).

Paradoxically, fire suppression efforts throughout most of the past century have led to increasingly dangerous and costly wildfires by fostering greater fuel loads. In particular, an unnaturally high abundance of biomass in the understory of many Western U.S. forests is responsible for the increased fire severity observed in recent wildfires (Peterson et al. 2005). Collectively, up to 90–200 million acres of federal land may be in need of fuels reduction (Government Accountability Office 2003), approximately 16.2 million acres of which is characterized by a high hazard rating (Barbour et al. 2008).

Much as increased fuel loads are associated with increasing risk and severity of fire, fuel removal and thinning could potentially help to reduce the emissions associated with fire should it occur. The extent of these GHG benefits remains the subject of debate within the scientific literature. In particular, uncertainty remains between the tradeoff between fuel-reduction efforts and maximization of net climate benefit. Analysis of recent large western fires suggests that thinning could have reduced individual fire GHG emissions by 75% to 98% (Bonnicksen 2008; Hurteau et al. 2008). Others note, however, the importance of evaluating impacts of fire across entire forest systems, as increased productivity in early successional vegetation and persistence of belowground and dead wood components can help buffer carbon lost from live trees and other aboveground pools (Meigs et al. 2009). Regardless, hazardous fuel-reduction treatments can decrease the area subject to dangerous conflagrations and can improve the efficacy and safety of fire suppression activities if fire fighting authorities are informed of the locations of treatments and their expected effect on wildfire behavior. For instance, prescribed burning and mechanical thinning tend to slow fire spread rates and diminish intensities within and around treated areas (Finney 2001).

Figure 2. Estimated emissions from forest fire in the U.S., as well as the share of gross U.S. emissions attributable to forest fire. Missing data in years 1991–4 and 1996–9 reflect an absence of fire data in surveyed sources rather than an actual absence of fire. Source: U.S. Environmental Protection Agency 2009; U.S. Environmental Protection Agency 2007.



Nonetheless, recent research suggests that fuel-reduction efforts in three Pacific Northwest forest systems generally led to lower fire intensities but also lower levels of mean carbon storage, even when removals were used for energy production (Mitchell et al. 2009). Similar research by Reinhardt and Holsinger (2010) finds that in most cases fuel-reduction treatments in the Northern Rocky mountains could reduce total stand carbon levels for the next 50–100 years. Empirical studies of mechanical thinning and prescribed burning for fuel reduction have found that while these treatments result in initial emissions, they have little to no long-term impact on primary production and carbon sequestration rates (Chiang et al. 2008; Finkral and Evans 2008; Campbell et al. 2009). Yet the time periods of these studies tend to be too short to determine the long-term effects of fuel-reduction treatments on the carbon balance of the fire cycle.

Thinning and emissions reductions efforts should therefore be viewed in the broader context of other management objectives and GHG mitigation activities (Carroll et al. 2007; ONeil 2009). Tradeoffs must specifically be assessed between GHG mitigation benefits and non-GHG policy objectives. For example, increasing stand resiliency to protect against disturbance and loss of stored carbon can have negative impacts on recreation and wildlife habitat (Goines and Nechodom 2009).

Existing Policy

Activities to address emissions from wildland fire or other disturbance on federal lands have direct policy precedent. Multiple tools exist for fuel-reduction activities on public lands, mechanical fuel treatment and prescribed fire being the most prominent. Specifically, the Healthy Forest Restoration Act (HFRA) of 2003 authorized up to $760 million for restoration and fuel-reduction treatments. From some perspectives, however, implementation of HFRA has fallen short.[19] Beyond direct policy intervention, infrastructure availability and investment (Government Accountability Office 2005; Society of American

[19] "Five years after passage, Healthy Forests Restoration Act falls short of goals, critics say." *Landletter*, November 6, 2008. Retrieved October 7, 2009, from http://www.eenews.net/public/Landletter/2008/11/06/1.

Foresters 2005; Western Governors' Association 2006) and the market for removed material are important determinants of removal activity. Funding and program consistency is likewise an important factor in encouraging investment in infrastructure for the processing of removed material.

Renewable Energy Production

Multiple sources of renewable energy are available on or from public lands in the United States. Potential biomass availability, in the form of forest residues and fuel treatment removals, is significant. At present, estimates suggest that approximately 3.5 million dry tons of residues are annually available from public lands (Perlack et al. 2005). The potential availability of biomass from fuel treatment operations is nearly 1,000 times higher (2.9 billion dry tons), but a reasonable estimate of the amount that is actually feasible to acquire is significantly less (17.9 million dry tons) (Perlack et al. 2005). Significant expansion above current removals is therefore possible. Assuming a weight-to-energy conversion factor of 8,500 BTU per dry pound and a heat rate of 13,000 BTU per kilowatt hour, feasible fuel treatment removals translate into approximately 23.4 terawatt hours (TWh) of electricity generation, more than twice the national electric utility sector generation from wood and other biomass in 2007 but still a fraction of the 4,003 TWh of total grid-available generation (Energy Information Administration 2009).[20] Significant potential could likewise exist for the cultivation of energy crops on Conservation Reserve Program land or perhaps even federally owned or managed lands (PCAST 2006), though care must be taken when pursuing such paths so as not to displace native systems with high-yield monocultures.[21]

Public lands also contain significant potential for wind, solar, and other renewable sources of energy production.[22] A technical potential of over 680 gigawatts (GW) has been identified for wind, concentrating solar, and solar photovoltaic on National Forest lands (National Renewable Energy Laboratory 2005). Potential capacity on BLM land is even larger, touted at over 3,100 GW for solar and wind alone.[23] With regard to geothermal energy, over 190 million acres of BLM and Forest Service land were recently allocated for geothermal leasing consideration with a potential developed capacity of over 12,200 megawatts (MW) by 2025 (Bureau of Land Management 2008). Regardless of form, energy production on public lands can also yield rent and royalty payments.[24]

Existing Policy

Policy is already in place to facilitate renewable energy production on public lands. For instance, section 211 of the Energy Policy Act of 2005 established a development goal of at least 10,000 MW of non-hydro renewable energy projects on public lands by 2015. Despite broad authorization, however, permitting of individual projects has lagged. One reason is the complex permitting process, requiring

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[20] Note that these estimates of potential generation do not account for the energy necessary to dry green biomass, nor do they account for a potential loss in generation from current industrial users of biomass should policy or market forces decrease the availability and/or increase the cost of forest resources (See, e.g., Galik et al. 2009, for a brief discussion of the potential supply implications of increased demand for forest biomass). They likewise do not account for any implicit restrictions imposed by distance from end-use facilities and related transportation and processing costs.

[21] Sustainability is also a concern when considering the potential for forest biomass to meet expanded bioenergy goals (e.g., Sample 2010).

[22] The potential noted here is useful in providing a rough indication of the size of the resource, but must be viewed with caution as it far exceeds existing installed or even projected capacity for geothermal, solar, and wind (See, e.g., Energy Information Administration 2009).

[23] Retrieved October 6, 2009, from http://www.blm.gov/wo/st/en/prog/energy/renewable_energy.html.

[24] For example, a July 2009 geothermal lease sale on BLM lands in three western states generated approximately $9 million in county, state, and federal revenue (Retrieved October 6, 2009, from http://www.blm.gov/wo/st/en/info/newsroom/2009/july/NR_0715_2009.html).

compliance with regulations under the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), National Historic Preservation Act (NHPA), and other existing laws, regulations, and orders. Acknowledging the hurdle that the permitting process represents, recent efforts have focused on reducing the turn-around time of renewable energy project and transmission line permits. Renewable Energy Coordination Offices were established in January 2009 to expedite the permitting of renewable energy projects on BLM lands. Review and permitting for both renewable energy project and transmission infrastructure development were likewise the focus of the first Secretarial Order issued by current Interior Secretary Ken Salazar (Department of Interior Secretarial Order 3285; March 11, 2009).

Facilitation of Low-Carbon Infrastructure[25]

Public lands can facilitate renewable energy production and other low-carbon opportunities through electricity transmission and storage support, two recurrent bottlenecks in the development of renewable energy resources. A lack of access to sufficient transmission resources has specifically been identified as a hurdle to the development of the significant wind production capacity that exists in remote areas of the country (Yang et al. 2008). Expanded production of electricity from solar and wind likewise requires that the inherently intermittent, indispatchable nature of both resources somehow be addressed (Yang and Williams 2009).

Existing Policy

The federal government is well suited to take the lead in the development of the most mature energy storage technology—pumped hydro storage (PHS)—being both the largest owner of existing hydroelectric capacity and the owner of the land on which a significant portion of potential PHS sites exist (Yang and Williams 2009). Processes exist for approving storage projects on public lands, but remain difficult and time consuming. The siting and licensing of PHS facilities in particular remains extremely lengthy and costly.[26]

In addition to the provision of storage opportunities, the remote, undeveloped nature of many public lands, combined with a limited number of owners, agencies, or managers overseeing the land, would likewise seem to ease expansion of transmission capacity in support of wind and solar resources. In actuality, however, the use of public lands for expanded transmission capacity may be hampered by the fractured nature of project approval, potentially requiring multiple iterations of approval by multiple stakeholders at local, state, and federal levels (Yang 2009). If proposed transmission lines cross multiple agency jurisdictions, siting and approval may be impeded by a lack of interagency cooperation (Yang 2009). Public opposition to the location of transmission corridors and the adequacy of underlying environmental review may likewise complicate expansion of transmission on public lands.[27] A working group comprised of multiple federal agencies is currently working to develop an integrated policy for the siting and approval of transmission projects to help address these and other related issues.[28]

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[25] Also worth noting is the potential role that public lands may play in uranium mining and the production of nuclear energy (see Spiering 2009). Though not discussed here beyond this singular mention, the specific role of nuclear energy in climate policy is often hotly debated and has yet to be resolved.

[26] Hunt and Hunt 1997 estimate that significant hydropower production (including PHS) is lost as a result of the relicensing process. While recognizing that this particular study is over a decade old, the regulations on which the report's estimates are based are unlikely to have shifted significantly in that time (C-.J. Yang, Duke University, pers. comm., October 8, 2009). See also Adamson 2009.

[27] Galbraith, K. July 22, 2009. "Environmentalists Sue Over Energy Transmission Across Federal Lands." Retrieved October 9, 2009, from http://greeninc.blogs.nytimes.com/2009/07/08/environmentalists-sue-over-energy-transmission-across-federal-lands/.

[28] "Interior Department to Approve Seven Renewable-Energy Projects." The *Wall Street Journal*, September 30, 2009. Retrieved

Adaptation and Other Ecosystem Services[29]

Although not a central focus of this paper, public lands are also integral components to a comprehensive climate change adaptation strategy and key providers of innumerable ecosystem services. For these reasons, climate policy must be mindful of the multiple objectives public lands serve other than those directly related to GHG mitigation. For example, public lands are likely to play a key role in promoting connected landscapes. Landscape connectivity is one mechanism by which the capacity of systems to respond to climate change can be improved (e.g., Millar et al. 2007). The static nature of public land boundaries, however, may complicate protection of targeted systems or species in a changing climate (Burns et al. 2003).

Existing Policy

Existing legislation and associated regulations already reflect the numerous ecosystem services provided by public lands (Table 2). Existing authorities also provide significant latitude to address climate change adaptation concerns through public land management. In November 2009, U.S. Forest Service Chief Tidwell called for the integration of climate change, and in particular the management of water resources, into joint, area-specific action plans (Tidwell 2009b). Adaptation is likewise a central component of the three-point plan adopted by the National Park Service[30] and is encapsulated in the larger, Department-wide strategy established by a Secretarial Order from Interior Secretary Salazar (Department of Interior Secretarial Order 3289; September 14, 2009). In the long term, however, increases in management flexibility or even shifts in agency organization may be warranted (Smith and Travis 2010).

Barriers to Potential

Public lands, especially federal lands, are subject to numerous laws, regulations, and guidance with potential implications for management in a low-carbon economy (Table 2). Indeed, existing legislation and regulations may provide broad authority for public lands to contribute to carbon sequestration, renewable energy production, and emission reduction goals. In some situations (e.g., renewable energy development on federal lands), policy already on the books is directly relevant to the task. Alternatively, active management for carbon sequestration and other ecosystem services may be constrained by overarching single- or primary-use mandates (Ruhl 2010). Even when new or expanded uses are potentially compatible, current law may lack sufficient guidance to properly facilitate the activity.

Regardless of whether directly applicable policy exists, expanded use of public lands to meet low-carbon policy objectives must be tempered by the complexity of public land management. The presence of multiple agencies operating on multiple areas scattered across the landscape and seeking to fulfill multiple missions complicates efforts to streamline the approval and implementation of individual projects or initiatives. New climate policy objectives must also be balanced with other objectives, such as endangered species preservation, recreation, protection of soil and water resources, grazing, timber harvesting, energy production, and natural resource extraction.

October 19, 2009, from http://online.wsj.com/article/SB125434790460153875.html.

[29] See also U.S. Climate Change Science Program, 2008 for an expanded discussion of the adaptation options available to U.S. National Forests, National Parks, National Wildlife Refuges, and other public lands and areas.

[30] "NPS director pledges major role in tackling global warming effects." *Energy and Environment Daily*, October 29, 2009. Retrieved December 1, 2009, from http://www.eenews.net/EEDaily/rss/2009/10/29/8.

Table 2. Select examples of existing policy affecting the management of public lands in a low-carbon economy.

Legislation/Provision	Description and Application
The American Antiquities Act of 1906, 16 U.S.C. 431-433	Provides presidential authority to declare objects of historic or scientific interest as national monuments
National Park Service Organic Act of 1916, 16 U.S.C. 1	Calls for the conservation of scenery, as well as the conservation of natural and historic objects and wildlife, and to leave them unimpaired for the enjoyment of future generations
Migratory Bird Treaty Act (MBTA) of 1918, 16 U.S.C. 703-712	Implements four migratory bird protection treaties and prohibits the taking of migratory birds except when specifically authorized
Multiple-Use Sustained-Yield Act (MUSYA) of 1960, 16 U.S.C. 528-531	Mandates that national forests be administered for multiple use and sustained yield of the several products and services, including outdoor recreation, range, timber, watershed, and wildlife and fish
Wilderness Act of 1964, 16 U.S.C 1131-36	Established the National Wilderness Preservation System, giving Congress the authority to designate public land as "wilderness" under which nearly all uses are restricted
National Historic Preservation Act (NHPA) of 1966, 16 U.S.C 470 et seq.	Requires federal agencies to evaluate the effects of proposed developments built, funded, licensed or permitted by them on sites listed or eligible for listing in the National Register
National Wildlife Refuge System Administration Act of 1966, 16 U.S.C. 668dd-668ee	Established a National Wildlife Refuge System with the mission of conserving wildlife, but permits the use of system lands for other uses if compatible with the purpose for which those areas were established
Wild and Scenic Rivers Act of 1968, 16 U.S.C. 1271 et seq.	Prohibits federal support of activities that threaten to negatively impact the free-flowing condition or other natural, cultural, and recreational values of designated rivers; includes a specific prohibition against the licensing of hydropower projects that would occur on or directly affect designated rivers
National Environmental Policy Act (NEPA) of 1969, 42 U.S.C. 4321-4347	Requires that major federal actions that are likely to have an adverse impact on the human environment report the potential environmental impacts and those of reasoned alternatives that could be pursued instead
Endangered Species Act (ESA) of 1973, 16 U.S.C. 1531-1543	Requires federal agencies, in consultation with the Fish and Wildlife Service and/or National Oceanic and Atmospheric Administration (NOAA) Fisheries, to consider the effect of any proposed action on threatened or endangered species or its habitat
National Forest Management Act (NFMA) of 1976, 16 U.S.C 1604-14	Directs the Forest Service to follow a host of substantive standards in its activities, to formulate and review national, regional, and forest plans in cooperation with the public and local, state, and other federal agencies
Federal Land Policy and Management Act of 1976, 43 U.S.C. 1701-1785	Consolidated and articulated the agency's responsibilities similar to the National Forest Management Act, including the first multiple-use mandate on Bureau of Land Management (BLM) land
Energy Security Act of 1980, 42 U.S.C. 8854 et seq.	Directs the Secretary of Agriculture to process applications for leases and permits to explore, drill, and develop resources on National Forest System land, notwithstanding the status of a National Forest's Land and Resource Management Plan
Energy Policy Act (EPAct) of 2005, 42 U.S.C. 15801	Establishes a development goal of at least 10,000 MW of non-hydro renewable energy projects on public lands by 2015; amends the Geothermal Steam Act of 1970, providing new guidelines for geothermal development of BLM and Forest Service lands
Energy Independence and Security Act (EISA) of 2007, 42 U.S.C. 17001 et seq.	Requires study of GHG flux from ecosystems and methods to reduce emissions/increase sequestration, and recommendations for framework of geological storage on public lands

It is also likely that an increased focus on low-carbon services will only add to other pressures already faced by public lands. Against a backdrop of restricted budgets, public land managers must also contend with demands of a growing population and a shifting climate (e.g., Government Accountability Office 2007). Natural disturbance events such as wildfire, pest outbreaks, drought, and storms are expected to increase in frequency and intensity under a changing climate (IPCC 2007). A shifting climate can also impact the ability of public lands to meet conservation objectives as the historic range of species begin to diverge from the largely static boundaries of parks, refuges, and other projected areas (Halpin 1997; Burns et al. 2003). Finally, non-defense discretionary spending as a percentage of GDP is expected to fall to recent historical lows over the coming decade (Congressional Budget Office 2009), potentially introducing additional budget constraints or exacerbating existing ones.

These overarching concerns can be further distilled into several distinct issue areas that are likely to permeate policymaking and implementation. Whether maximizing the amount of low-carbon services and the efficiency in which they are provided, balancing an increasing list of policy objectives, or some combination thereof, issues of access and ownership, cost-effectiveness, competing objectives and tradeoffs, and uncertainty will need to be addressed:

- **Access and ownership.** Access to resources can restrict both public and private activities on public lands, affecting net climate mitigation and adaptation potential in the process. Limitations can be as a result of restrictions on access or specific uses, such as those imposed by the Wild and Scenic Rivers Act of 1968 and the Wilderness Act of 1964. Limitations can also occur in the form of restrictions on areas or tree sizes that can be acted upon by stewardship contracts. Limitations on contract length can also implicitly restrict access by increasing transaction costs or reducing potential returns to the point where investment is not feasible. The same holds true for renewable energy projects. Even when access is not an issue, however, ownership of resources may be. This is especially true in the case of emerging markets or practices. Biological and geological sequestration of GHGs achieved on public lands may or may not be eligible for sale by private parties, for example.[31]

- **Cost-effectiveness.** Cost-effectiveness is a recurrent barrier to private-entity activity on public lands and can exacerbate other hurdles noted here. For example, permitting complexities associated with multiple-agency jurisdiction can impede development of electricity transmission capacity on public lands, by extension impeding development of remote solar and wind resources. Permitting time and upfront capital costs also present perennial obstacles to the construction of PHS projects (Adamson 2009). Forests with large accumulations of understory biomass may require both mechanical thinning and prescribed burning, which is more expensive unless the harvested biomass has a high enough market value to balance the cost of the thinning (Carroll et al. 2007). The proximity of processing infrastructure likewise has strong implications for the cost-effectiveness of biomass harvesting and removal (Becker et al. 2009). Alternatively, other activities, such as offset projects, may actually be more cost-effective to implement on public lands than private because of lower opportunity costs and large economies of scale.

- **Competing objectives and tradeoffs.** Public lands serve multiple objectives at multiple scales across varying timelines.[32] At times, satisfaction of these myriad objectives will present direct

[31] See Olander et al. 2010 for a detailed discussion of the issues surrounding offset project implementation on public lands.
[32] See Ruhl 2010 for a review of the various types of tradeoffs potentially faced by federal agencies in the context of management for ecosystem services.

conflicts with larger GHG mitigation goals. For example, significant amounts of coal, oil, and natural gas are extracted from federal lands,[33] and the production and consumption of these resources have direct GHG emissions implications. The multiple objectives for which public lands are managed can also dictate the location and manner in which GHG mitigation activities operate. The HFRA of 2003 mandates that at least 50% of appropriated funds be spent on projects in the Wildland-Urban Interface (WUI) rather than the forestland with the largest stable carbon pools at risk.[34] The NHPA can impede wind energy development if wind turbines within the viewshed of such a site are thought to diminish its historic value. Development of wind resources on DOD lands must also be weighed against potential conflicts with base operations.[35] Regardless of whether direct conflicts exist on public lands themselves, public land management has implications for private markets. Limiting public harvests may indirectly reduce the financial incentive for private forestland owners to engage in carbon-targeted management activities as timber supply is constrained and a corresponding price signal is sent through the market.[36]

- **Uncertainty.** Uncertainty exists in multiple forms (regulatory uncertainty, implementation uncertainty, scientific uncertainty, etc.). The scale of many of the activities discussed throughout this paper (if not the actual activities themselves) will likely be new to public land managers. Furthermore, emerging markets and practices face tremendous uncertainty. This is especially true for CCS projects on federal lands, where issues of long-term ownership and liability still need to be addressed (National Energy Technology Laboratory 2009). In addition to basic questions surrounding the likelihood of a federal compliance market for GHGs, determination of if and how documented increases in sequestration on public lands can be marketed is a complicated legal and practical question.[37]

  Activities that have been part of agency culture for quite some time, such as biomass harvest and utilization, also face uncertainty due to policy revision, litigation, or expanding focus.[38] For example, the definition of renewable biomass in energy legislation will determine the eligibility of certain sources for compliance purposes. Conflicting definitions in the 2007 Energy Bill and 2008 Farm Bill over which feedstocks qualify for various biofuel and renewable energy grants, programs, and mandates have been a particular source of concern from both environmental and renewable energy development perspectives. Increased demand for renewable energy and affiliated transmission infrastructure is also creating permitting and oversight issues (disclosure, for example) that are just now being explored further.[39] Perhaps most importantly, climate change may present land managers with an operating environment without historical analogue, and one to which proven management strategies do not necessarily apply.

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[33] The Department of Interior reports that 39%, 35%, and 42% of domestic natural gas, oil, and coal production, respectively, is generated from federally managed lands. Note that these estimates also include offshore areas not otherwise addressed in this paper (Retrieved January 14, 2010, from http://www.doi.gov/facts.html).

[34] In practice, however, research suggests that treatments are not necessarily being targeted to the WUI, and that an increased focus on areas in and around communities may be warranted in light of National Fire Plan objectives (Schoennagel et al. 2009).

[35] e.g., http://www.sandia.gov/LabNews/080509.html (Retrieved October 19, 2009).

[36] For a review of the economic foundations of this sort of activity, termed “leakage,” see Jenkins et al. 2009.

[37] Again, see Olander et al. 2010 for a more detailed review of offset project implementation on public lands.

[38] Also noted by one reviewer was the issue of permit durability, whether permits held by energy facilities operating on federal lands may be renewed should they expire or should agency priorities change.

[39] “Industry rushes to claim Calif. land for projects.” Greenwire, June 1, 2009. Retrieved October 6, 2009, from http://www.eenews.net/Greenwire/rss/2009/06/01/9. See also “Interior Department to Approve Seven Renewable-Energy Projects.” The *Wall Street Journal*, September 30, 2009. Retrieved October 19, 2009, from http://online.wsj.com/article/SB125434790460153875.html.

Select Policy Options to Address Barriers

An increasing focus on the role that public lands play in a low-carbon economy will likely mean some shift in policy and/or implementation. Federal land managers are already equipped with a variety of policy tools to promote carbon sequestration, renewable energy production, emission reduction, and adaptation and other ecosystem services. Balancing multiple objectives, a recurrent part of public land management for decades, will be of even greater importance. Such is already evident in a growing tension between energy development and conservation (e.g., Woody 2009).

Accordingly, refinement of both legislation and regulation is likely necessary to take advantage of the full suite of low-carbon services provided by public lands, especially for those involving emerging markets or practices. A variety of climate-specific programs and initiatives are already under way on public lands across the country. For example, the Energy Policy Act of 2007 (P.L. 110-140) established multiple efforts to gauge federal land mitigation capacity and management processes, requiring both a national assessment of ecosystem sequestration and emissions (Sec. 712) and a recommended framework for managing geological carbon sequestration activities on public land (Sec. 714). From an implementation perspective, the California-based Climate Action Reserve included guidelines for offset projects conducted on public lands in the latest version of its forest project protocol (Climate Action Reserve 2009).

Despite these policy endeavors, recent Congressional hearings,[40] and a growing number of assessments of impacts (e.g., Government Accountability Office 2007), needs (e.g., National Energy Technology Laboratory 2009), and potential (e.g., Sundquist et al. 2009), a full and substantive debate on the role that public lands should play in a low-carbon economy has yet to be held. Fortunately, ongoing rounds of climate policy development provide a unique opportunity for such debate and discussion. Even absent additional movement on climate policy in this Congress, the wide-ranging debate and discussion that it has already spurred creates opportunities for addressing the issue in other comprehensive legislation, such as energy and/or public lands omnibus bills.

To this end, the list below highlights a few outstanding issues that comprehensive public land management policy, be it climate-related or otherwise, may help to address. As mentioned at the beginning of the paper, we do not consider a dramatic paradigm shift in public lands management, and note that such a transition would obviously entail a different list of issues and options than the ones detailed below. The present list is likewise not intended to be exhaustive or to advocate any particular course of action, but rather to further discussion on the role that public lands are to play in an expected future low-carbon economy:

- **Prioritization:** Public land management requires the balancing of multiple objectives, some of which may directly compete with GHG mitigation goals. The introduction or expansion of low-carbon policy objectives could benefit from agency-, interagency-, or Congressional-level guidance on the relative priority of actions, or at the very least a process for evaluating the priority of individual objectives, should new or novel conflicts emerge.
- **Role in offsets markets:** As discussed further in Olander et al. 2010 the ability of public lands to participate in the production and sale of carbon storage or GHG emission reduction credits (i.e., offsets), either directly or indirectly, remains at issue. Clarification is necessary as to the

[40] United States Senate Committee on Energy and Natural Resources, Subcommittee on Public Lands and Forests: Management of Federal Forests in Response to Climate Change, November 18, 2009; United States House of Representatives Committee on Natural Resources, Subcommittee on National Parks, Forests, and Public Lands: The Role of Federal Lands in Combating Climate Change, March 3, 2009.

eligibility of public lands for the production of offset credits. Insight into the indirect role that public lands may play (as a buffer to hedge against reversal risk or as a mechanism to moderate potential leakage, for example) is also warranted.

- **ROWs and ownership:** Related to some extent to the role that public lands may play in a federal compliance offsets market, the ownership of carbon and other ecosystem services produced by individuals and entities operating on federal or other public rights-of-ways requires clarification.
- **Establishment of CCS regulations:** Existing policy frameworks may be sufficient to guide early implementation of CCS on public lands, but federal policy may be helpful in resolving issues of ownership and liability for reversals.
- **Data acquisition:** A recurrent theme throughout the existing literature and commentary on the subject of public lands and climate change is the need for accurate data from which to base management decisions (e.g., Government Accountability Office 2007; Brunello 2009). Regardless of whether public lands themselves are to play an active role in climate mitigation or adaptation activities, increased measurement and monitoring activities can assist in planning and gauging the impact of climate change on the nation's ecosystems, as well as providing a strong scientific basis for those mitigation and adaptation activities taking place elsewhere.
- **Biomass definition and cultivation:** The definition of what is included within the category of "renewable biomass" will strongly influence the role that public lands play in meeting renewable energy objectives. As noted above, conflicting definitions in the 2007 Energy Bill and 2008 Farm Bill have been a source of concern from both environmental and renewable energy development perspectives. A related issue is the use of federally owned or managed lands to be used for biomass and other energy crop cultivation, as well as the environmental protections necessary for such a program to be implemented.
- **Streamlining of public land transmission projects:** Although currently limited to congestion relief, provision of federal siting authority under the National Interest Electric Transmission Corridors (NIETC) process as created by the Energy Policy Act of 2005 presents one model to potentially address process barriers that hinder the expansion of transmission capacity in support of renewables.
- **Role of environmental review:** The jurisdiction of environmental legislation, such as NEPA and the ESA, in offsets program development and implementation is somewhat unclear, but would more than likely apply to projects implemented on public lands. Mechanisms exist to ease compliance with environmental review provisions for projects that are unlikely to have significant impacts, and consideration could be given as to whether such exemptions would facilitate implementation of offsets and other low-carbon projects.

Again, our objective is to spur discussion amongst a wider audience of land managers, policymakers, and stakeholders rather than to advocate for a particular policy or approach. While it is true that public lands have the potential to make significant contributions to climate mitigation objectives and are likely to play an important role in comprehensive climate policy, activities on federal lands specifically prompted by such climate policy must be thoughtfully merged with pre-existing institutional and legal frameworks controlling public land management.

Path Forward

Facing increasing pressures from a changing climate, the emergence of new markets, and the imposition of additional policy objectives, the future of public land management will surely require thoughtful deliberation, as well as a continual balancing with other, long-held and non-GHG objectives. Should climate policy fail to advance this Congress, the immediate drivers and incentives for private-market GHG reductions may be diminished somewhat, placing even more onus on public lands and public land management to provide climate mitigation benefits in the near term. In that regard, attention should be paid to the full suite of services provided by public lands in the United States so that a comprehensive strategy may be defined and appropriate tools and mechanisms brought to bear.

As noted at the outset of this working paper, the information and concepts discussed herein are not new and should not come as a surprise to those already working tirelessly on public lands issues. The wide range of sources cited in the preparation of this paper indicates, however, that this information often exists in scattered form and is more often than not issue- or agency-specific. It is hoped that this working paper can begin to bridge those traditional divides, and provide a basis for analysis and debate by land managers, policymakers, and stakeholders on the role that public lands are to serve in a future low-carbon economy.

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Overview: A growing Low Carbon Economy Key findings Low carbon technology: Taking off the training wheels Four front-runners stand out among low carbon technologies Winning low carbon technologies benefit from a mix of policy, scale and technologyâ€¦ â€¦and are shaping the low carbon economy, 2015-25 LEDs: Transforming the global lighting industry Onshore wind & solar PV: Rewiring the global power sector Grid. connected vehicles: A driver of change in automotives Low carbon regulation: Tipping the scales Policy pressure to cut emissions remains a secular trendâ€¦ â€¦but we expect global rules to r Request PDF | This paper considers the prerequisites for implementing a competitive low-carbon economy in the European Union from the point of view of firmsâ€™ incentives, the role of policy and the contribution of public research. It suggests that the reduction of the environmental impact...Â This paper considers the prerequisites for implementing a competitive low-carbon economy in the European Union from the point of view of firmsâ€™ incentives, the role of policy and the contribution of public research. It suggests that the reduction of the environmental impact of energy can be a new competitiveness factor. Rather than being treated as a constraint and cost-aggravating factor, addressing climate change can offer economic opportunity and contribute to growth.