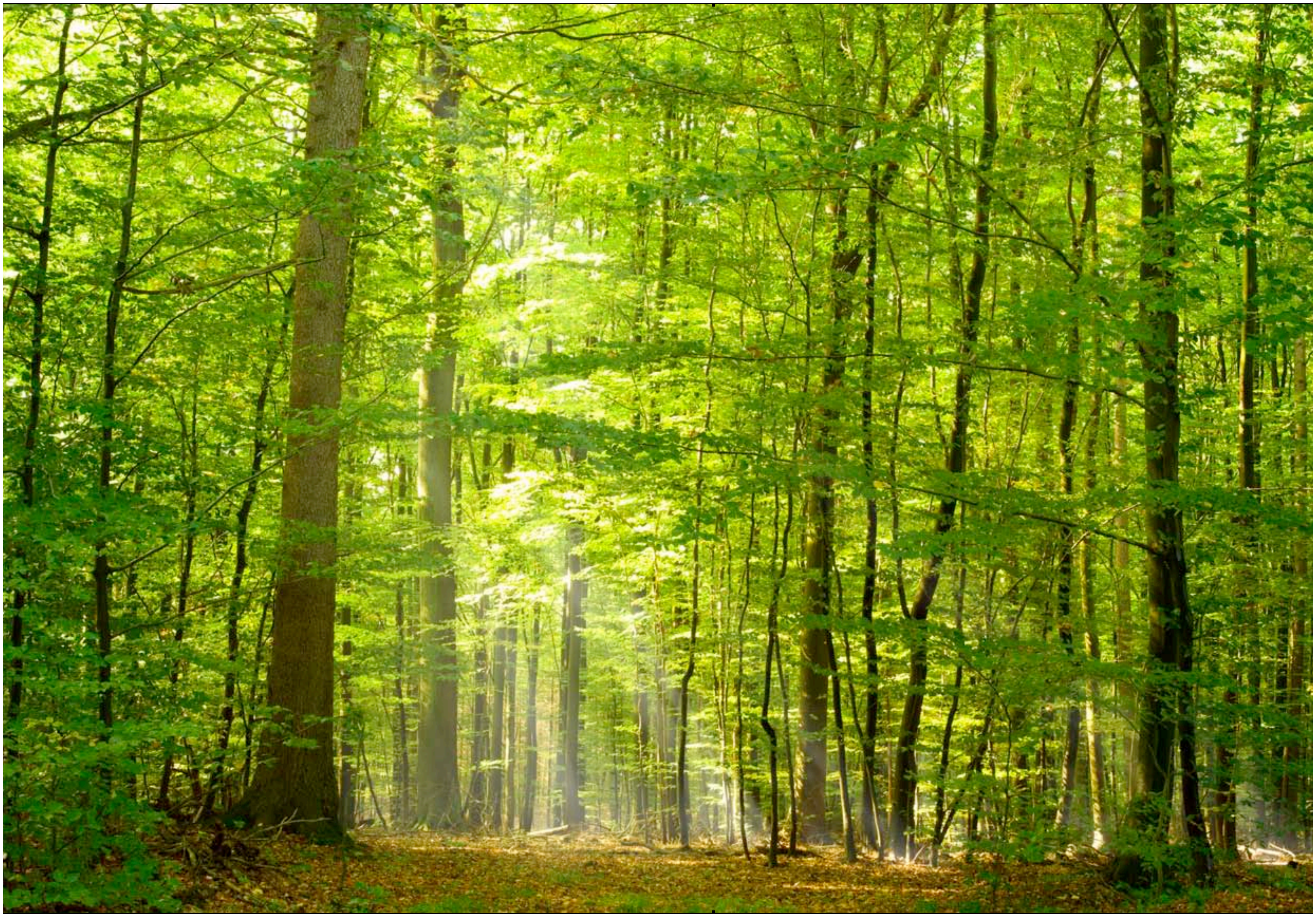
WORKING PAPER



Forest Carbon Incentives

Options for Landowner Incentives to Increase Forest Carbon Sequestration

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Pinchot Institute for Conservation

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1. INTRODUCTION

U.S. forests play an important role in the nation's effort to address climate change; they are vital terrestrial carbon sinks. These ecosystems also provide vital services like drinking water and wildlife habitat, and enjoyment to millions of Americans. The majority of the nation's forests are in private ownership, so it is critical that private forest landowners are encouraged to improve and secure the emissions reductions they can provide, while helping these ecosystems adapt to climate change. Failing to engage private landowners at the broadest scale possible not only limits the role of the nation's forests in increased climate change mitigation, but also risks increased forest-based emissions and declines in the health and richness of forest ecosystems over the coming decades.

Globally, forest carbon stocks represent around 1.2 million TgC (4.4 million Tg CO_2)(Roy et al. 2001, Dixon et al. 1994), which is equivalent to the total cumulative carbon emitted for the highest IPCC emissions scenario by year 2060 (IPCC 2000). However, fossil fuel emissions could exceed the magnitude of even the most ambitious plans for *additional* forest carbon sequestration by 5-10 times (Malhi et al. 2005). This means that while adequate climate change mitigation cannot be achieved with land-based sequestration *alone*, it certainly cannot be achieved without it. These figures underscore the indispensable role of maintaining and enhancing vital forest carbon stocks in any strategy addressing climate change.

In the United States, forests comprise about a third of the land area (USDA Forest Service 2009), representing a total carbon stock of roughly 191 Tg C (699 Tg CO_2) (FIA 2010, *forthcoming*). Along with carbon stored in wood products, forests offset about 12 to 19 percent of national greenhouse gas emissions (Ryan et al. 2010). Conversion of forests to other land uses is on the rise in many regions of the country (FIA 2009). For example, forest area in the eastern US—which sequesters 93 TgC per year (341 CO2 eq per year (FIA 2010)—has been reduced in recent decades by urbanization and other competing land uses (Drummond and Loveland 2010). In addition, invasive pests and diseases have left many forests in stress and susceptible to destructive wildfires. Forest lost to agriculture may return to forest again as commodity prices or policy settings change; but forest lost to development is most often permanent. Using Forest Service Carbon Accounting Tools, Talberth and Yonavjek (2010) estimated that 21 million acres of forest in the United States will be lost to development in the next two decades alone. This loss of carbon stored in forests, *plus* the loss of sequestration that otherwise would have been provided by that forest area if not converted, amounts to at least 40 million TgC per year in emissions.

Results from the National Woodland Owner Survey (Butler 2008a) indicate that the trend of forest loss could accelerate in the future. Of the 751 million acres of forest in the United States, more than half is privately owned. Two-thirds of private forest land is held by 10 million families and individuals most of whom own between one and nine acres. While effective stewardship of private forests is clearly of national importance, only five percent of all private forest landowners have developed a written management plan. Adding to the uncertainty of private forest management in the coming decades is the fact that over a third of these landowners are over 75 years of age; and fourteen percent of family forest owners plan to sell or transfer their land in the next five years.

Regulating carbon emissions and/or establishing a domestic carbon market could clearly change the way forests are conserved and managed and encourage practices that demonstrate potential for enhanced carbon sequestration and emissions reduction benefits. Carbon offsets present private forest landowners a window of opportunity for increasing revenue from forest land use. The now-closed

Chicago Climate Exchange (CCX), the Regional Greenhouse Gas Initiative (RGGI), the Climate Action Reserve (CAR), the American Carbon Registry (ACR) and the Voluntary Carbon Standard (VCS) protocols all include rules for forest-based emissions offsets. However, the transaction costs and accounting measures required for producing forest offsets through the Climate Action Reserve or the American Carbon Registry, among others, represent considerable barriers for small nonindustrial private forest owners in climate change mitigation. Incremental gains in carbon stocks through enhanced forest management (of standing forests) are modest per unit area but potentially significant at scale. Forests managed to conserve carbon can also produce other vital ecosystem services, like clean drinking water. Incentives to help reduce emissions through forest management could be designed to enhance these other services, and should limit/prohibit degradation occurring as a result of emissions reduction projects. Included in these services can still be timber and other harvested wood products for paper, building, and energy. Most critically, forests managed for carbon need also be managed to enhance their resilience and function as wildlife habitat, especially in the face of climate change.

Creating incentives for forest-based carbon management offers the opportunity to reach significant forest land ownerships that may be unable to participate in compliance-based markets due to offset project requirements, parcel size, or transaction costs. Whereas offset payments for forestry projects are directly tied to the tons of carbon sequestered, an incentives-based approach could further the adoption of silvicultural approaches (systems and practices) that have proven carbon benefits. A Carbon Conservation Program was included in the Clean Energy Partnerships Act of 2009 (S.2729) signaling interest in this type of program. During legislative debates, this kind of "supplemental incentives" approach (i.e. "supplemental" in being outside any regulatory cap or requirement) garnered broad-based support.

In Fall 2010, following the debate on federal climate legislation, the US Forest Service gathered a number of organizations together who were participating in these discussions with interest in the supplemental incentives approach. The US Forest Service contracted with the Pinchot Institute for Conservation (PIC) to host a series of workshops aimed at further evaluating the feasibility of the incentive approach and guide the development of an incentive program to protect and enhance carbon sequestered by the forests in the U.S.

Summary of Proposed Forest Carbon Incentives

The ultimate goal of forest carbon conservation incentives (FCI)[1] would be to reduce private forest loss in the United States, for the main purpose of climate change mitigation. A voluntary incentive program can encourage private forest landowners to (a) keep their land forested and (b) engage in land management activities that mitigate climate change.

As proposed, Forest Carbon Incentives would complement existing programs--working with agencies and private sector consultants already engaged in similar activities, and with landowners in ways in which they are familiar. For example, Forest Carbon Incentives would rely on the same basic eligibility requirements (e.g. EQIP) and would be administered by state agencies in coordination with federal

[1] For simplicity, throughout this and other documents associated with this process, the phrase "Forest Carbon Incentives" is used and abbreviated FCI. Initially, the participants in the workshop had referred to this concept as the Forest Carbon Incentives Program. However, to some participants, the use of the word "program" suggested too strongly that adoption of the concept described in this paper would require the creation of a new program, when instead it would also be possible to incorporate this concept in existing USDA programs. The Clean Energy Partnerships Act of 2009 (S.2729) calls for a supplemental incentives program, but this document and process is not meant to be a description of that legislative title or its intent.

agencies. The approach also includes a Carbon Benefits Index that, like EBI, will use existing data to prioritize applications. Much like EQIP, the proposed approach is practice-based, so that troublesome calculations of baselines and additionality are unnecessary—yet program-wide adoption will be reportable "in tons" and demonstrably result in emissions reductions. The initial research that would be required to select a suite of eligible silvicultural systems would use USFS Forest Inventory and Analysis data and the USFS-developed FVS model—robust datasets and tools familiar to researchers at agencies and universities throughout the country.

The silvicultural systems established through some additional research and selected by state-level committees would rely on a suite of management activities, practices, or treatments. Practices could include, depending on the region and design, activities like artificial regeneration, thinning, fertilization, pest-control, etc. Landowners would be eligible for payments to help cover the expense of implementing those practices which are cost-prohibitive. The level of payment for an individual landowner will not be linked to total carbon stocks, but to the amount of land committed to the program and the cost of practice implementation. Landowners will not be required to report in "tons of carbon," yet program-wide analyses will be able to show reduced emissions resulting from program enrollment. As such, carbon benefits resulting from FCI would be supplemental to any [potential] cap and could not be sold as offsets for compliance with voluntary or regulatory markets.

The FCI approach offers many advantages. It simplifies participation in forest-based climate mitigation and lowers transaction costs to better engage the ten million small private forest landowners in the US (Butler 2008b). The program would help keep forests as forests and contribute to sustainable forest stewardship by incentivizing forest management plans and practices through term contracts which would result in short term positive impacts, while in aggregate reducing emissions through sequestration in forests and wood products. Through implementation on farms and forests across the country in many different ecosystem and socioeconomic contexts, this approach would spur innovation and ongoing advancements and adjustments in land management practices that offer carbon benefits. Further, FCI would contribute to rural development. Every one-thousand acres of private working forest generates an average of eight jobs according to a study across 29 states using 2006 census results (Forest2Market 2009). More investment in this sector will help grow and sustain these jobs over the long-term.

Widespread implementation of forestry oriented to enhancing carbon benefits would promote much broader understanding of the role of land management in mitigating climate change. What we propose resembles aspects of programs suggested in legislative proposals of recent years, and mirrors the increased attention to carbon storage and sequestration in existing land conservation programs implemented by the US Forest Service (USFS), Natural Resources Conservation Service (NRCS) and USDA Farm Service Agency (FSA). The principal aim of this report is to propose and explain options for the design of an incentive-based approach to climate change mitigation through forest carbon management—from landowner eligibility, to program administration, to a technical framework for refining suggested forest management practices.

2. BACKGROUND: DEVELOPING RECOMMENDATIONS

Recommendations on how to design a Forest Carbon Incentives, which are the focus of this report, were developed in large part in two full-day workshops involving a dozen organizations and more individuals (Appendix A). Prior to the workshops participants were provided with a background paper which included information on climate-related legislation and existing programs that incentivize the adoption of conservation practices. The background paper also included an overview of the rationale for using an incentives-based approach to enhance and maintain carbon benefits and other ecosystem services generated by private forest land uses. Much of the thinking in the background paper had come from discussions at the Forest Service earlier that year.

In the Fall of 2010, conference planning discussions served to better refine the scope and structure of the workshop process. A key decision made during these discussions was the focus on improved forest management, as broadly defined. Although a "climate change mitigation incentives" program could include a variety of practices and land uses, participants decided to focus explicitly on developing a program for incentives that improve management and conservation actions in private forests that also provide climate mitigation benefits.

The justification for this narrower focus was based on several reasons. First, technical protocols and a wealth of implementation experience already exist for tree-planting of non-forested or cleared lands (i.e. afforestation and reforestation) whereas there is less methodological guidance for improving management to enhance carbon storage or reduce long-term emissions, on lands that are presently forested. Second, the Natural Resource Conservation Service, Farm Services Agency, and other entities already provide landowner incentives for regulatory compliance, recovery of erodible lands, and maintaining working agricultural lands. Lastly, no incentive program exists at scale for climate benefits resulting from changes in forest management. For many landowners, marginal gains in carbon stores and sequestration rates from forest management are unprofitable per se. Even forest-related offset opportunities under a strict cap may not reach many private forest acres. Yet the overall carbon benefits of retaining forests on private lands at the national scale is critical to mitigating climate change.

Workshop participants also decided to separate discussions into two parts. The first workshop focused on the structure and function of a program, and the second workshop focused on the actual projects and practices that would be incentivized. Participants also recognized that many of the ways in which to design a program, from an administrative perspective, are evident in other landowner incentive programs administered by USDA, providing perspective that was invaluable in discussions. In this way, the workshop discussions used the experience gained in these programs as models for incentives explicitly dealing with climate mitigation through forest management.

The goal of the first workshop was to lay the foundation for an incentive program framework, including overall program design and requirements for participation. Central questions included: Who can enroll? How should enrollment occur? What are the eligibility requirements? What agencies and institutions will oversee implementation and what will their respective roles be? The second workshop defined the practices the program could incentivize, how they would fit into a silvicultural system or management planning process, and the related issue of how these practices are identified, modified, delivered, tracked, quantified, etc. This discussion did not explore the scientific basis of potential sequestration rates or identify exactly how these may differ between regions. The purpose and desired outcome was to decide and justify what activities should constitute a carbon conservation program.

3. DESIGNING FOREST CARBON INCENTIVES

The principal aim of a Forest Carbon Incentives program is to support landowners who are willing to adopt management strategies, or silvicultural systems," which would include a suite forest management practices proven to increase and maintain forest carbon stocks. Incentivizing forest carbon management encompasses both avoided conversion of forest to non-forest land uses, as well as forest management activities that sequester carbon and reduce emissions. Within this scope lies a wide range of silvicultural possibilities that vary by region and forest type. In some parts of the country long-term emissions reductions can result from removals that mitigate disturbance-driven emissions such as wildfire outbreaks, or simply speed to accumulation of carbon by focusing growth in longer-lived carbon pools In other parts of the country sequestration may be best enhanced by reserving carbon stocks onsite, such as forests containing deep soil carbon pools. The program should be designed to encompass and support a range of strategies and activities that conserve and enhance carbon stocks and/or practices that reduce CO^2 emissions from forest land use in the long run.

This Section 3 of the report describes options for program design that encompass two main areas: (3.1) Administrative Options, Payments and Accountability; and (3.2) Carbon Conservation Activities. **Section 4** of this Report describes in more detail the program "as it would appear to landowners"—i.e. eligibility, ranking, and technical requirements. To set the context for Section 3, a brief summary of program design recommendations follows.

In general most non-industrial private landowners would be eligible to participate. Qualified applicants would be ranked based on a carbon benefits index framed at the national level, but augmented by state priorities. Applicants should be offered several tiers of incentives representing increasing levels of commitment and associated incentives and payments:

I. An incentive for adopting a **silvicultural system** documented in a Forest Stewardship Plan, or equivalent plan (base-payment plus management planning cost-share or full payment)

II. Payments for carrying out **silvicultural practices** scheduled within an approved forest management plan (cost-shared or full payment, based on cost of implementation)

III. Additional incentives for commitment to **independent third-party certification systems** (American Tree Farm System (ATFS), Forest Stewardship Council, and/or Sustainable Forestry Initiative).

Tier I. The first level is the adoption of a Forest Stewardship Program plan that incorporates **silvicultural systems,** which represent a form of land management likely to promote carbon conservation benefits. These systems would be defined by ecoregion and forest type[2], and designed based on supporting

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[2] Defining an appropriate ecoregional/forest type hierarchy will require some initial analyses. A number of different classification schemes exist (Shantz and Zon 1924, Kuchler 1964, Daubenmire 1978, Bailey 1983), and continue to evolve through studies using remote sensing datasets. The group recommended using classifications standardized in FIA sampling. How silvicultural systems are selected regionally will depend on how modeling is carried out. If states perform modeling, then eligible systems would be defined by forest types for portions of ecoregions occurring in each state. For example, to estimate mean carbon stocks for forest types in California, the Climate Action Reserve aggregated multiple forest types, into 12 types across the state. Were this sort of procedure to be used, the modeling exercise would consider the carbon benefits of alternative silviculture systems for each of these 12 forest types, and manipulating the types, timing, and intensity of treatments and removals to evaluate alternative carbon balances. State-level modeling would have the benefit of being able to use wood products removal data which is sometimes tracked at the state-level. Another option would be to model

research to enhance and maintain carbon stocks at an optimal level. The carbon accounting used to enumerate eligible silvicultural systems would include removals (e.g. wood products), decay, and emissions and emissions-reductions associated with operations, and alternate CO_2 balances for systems [3]commonly used (should they be different). In many cases the system would perform better than conventional practice for that setting, but is not necessarily expected to do so. In other words, some landowners may already be employing the silvicultural systems that optimize carbon benefits. By adopting and committing to a silvicultural system, and an associated plan that includes a schedule of treatments in that system, the landowner would be eligible for incentives for the length of the contract.

The intent of Level I is to create a pathway for landowners to receive specialized professional advice from practitioners who have necessary credentials related to understanding forest carbon dynamics and their relationship to silvicultural systems. The scientific basis for carbon management is rapidly evolving and it is not expected that forest management professionals without specialized training or continuing education should possess this current knowledge. A base payment for Level 1 management planning and maintenance of current carbon stocks can serve to reward prior and continued good management and put forests on a trajectory that provides long-term benefits in terms of reduced carbon emissions and increased on-site carbon storage. Landowners, working with trained forestry professionals would be required to submit their plan, which would include a map delineating stands, a description of eligible silvicultural systems assigned to each, and a treatment schedule.

Tier II. The second level is a payment for the implementation of specific **silvicultural practices** within a defined silvicultural system that are introduced based on field conditions and expert judgment by a qualified forester. The practices would be pre-defined based on existing knowledge and reviewed and adjusted by an administrative body working in consultation with an advisory committee. Practices that are not financially viable within existing market conditions would be eligible for a payment, set by the cost of implementation. Level II payments support carbon-beneficial practices to implement the silvicultural system that would otherwise be cost-prohibitive to implement, but are critical to move a forest or stand along a carbon trajectory. The practices would be specified under the approved silvicultural system plan.

Tier III. The third level is an additional payment or incentive for landowners who have become certified by ATFS, FSC, or SFI, and meet Level 1 and Level 2 requirements. Their certification should be conducted, or have been re-assessed, once Forest Carbon Incentives commitments are in place. Certification audit reports should therefore include verification of conformance with the schedule of activities and commitments associated with the incentives program. Level III payments are intended to provide monitoring and verification services on participating forestlands. Audits performed to show conformance with certification schemes will provide more rigorous reporting on program implementation, and therefore leverage program investments.

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silvicultural systems for forest types within ecoregions heedless of state boundaries. In the same example, CAR used FIA datasets to determine the high/low carbon stocks ($MtCO^2$/acre) of more than 350 assessment areas, defined by forest types, in 97 "supersections" or eco-regional groupings occurring nationwide.

[3] "Alternate CO^2 balances for the systems" refers to the net emissions and emissions reductions (including sequestration) for different combinations of management treatments that compose a silvicultural system (e.g.. type, timing, intensity, removals, etc.).

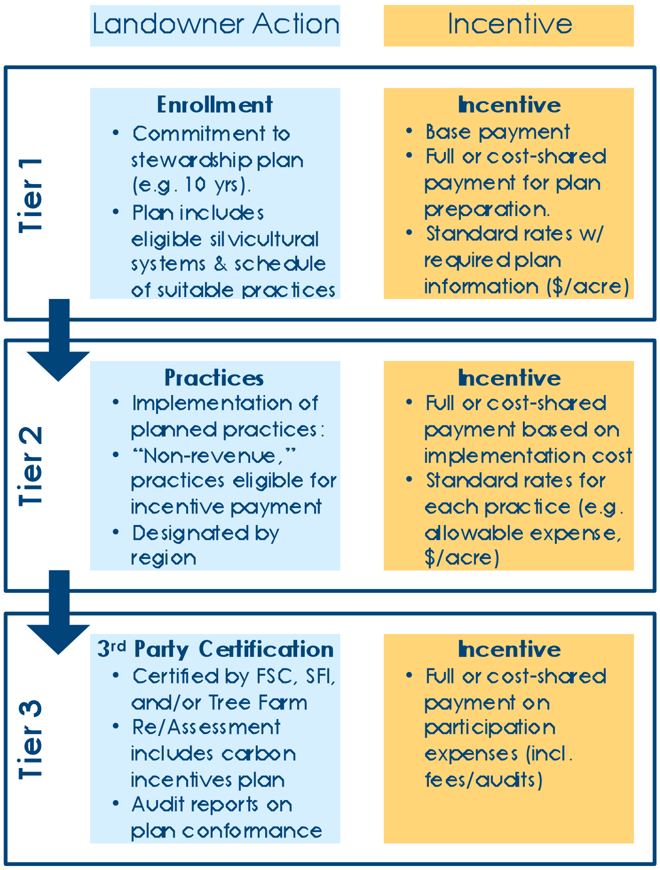

Figure 1. Landowner actions/commitments and associated types of incentives proposed for Tiers I, II, & III for FCI

Overall, participants felt that the development, delivery, and oversight for the program should be shared by federal and state organizations and complemented by extensive cooperation with private forestry professionals. For example, one possible implementation method is to defer to state-level technical committees to identify silvicultural systems and associated practices in each state that would qualify for incentives. In turn, in many states the program would be delivered by a combination of agency and consulting foresters and resource professionals.

3.1 ADMINISTRATIVE OPTIONS

FCI could potentially operate through established USDA and state forest offices. Forest carbon management could require three types of financial and technical program support: (1) the payments and incentives provided to landowners rewarding program commitment and reimbursing landowners for the implementation of non-revenue generating practices (which may vary by region and depend on starting condition); (2) support for state forestry agencies to develop and operate a training and certification program for qualified professionals, and (3) technical resources and guidance for carrying out science-based assessment and modeling of land management systems and practices that are the basis for FCI.

3.1.1. Payment and Incentives for Landowners

Participants identified several types of payments and incentives for landowners. There are payments and incentives for each of the types of activities described above—i.e. commitment to an FCI-eligible Forest Stewardship Plan, implementation of practices which are part of these plans, and participation in a third party certification scheme. These are stepwise requirements corresponding to different levels of participation.

Base Carbon Conservation Payment. Landowners who have been approved for receiving FCI have completed the associated plan, would receive a base carbon conservation payment or other form of incentive. These payments would be a flat rate with an established floor and a ceiling (potentially by state level technical committees) based on planning and implementation cost estimates for an appropriate system and suite of practices for the area. National guidelines could suggest a sliding scale depending on the average sequestration rates of the silvicultural systems in certain eco regions, the relative threat of conversion, and net gains in carbon considering the regional average for carbon stocks, which represent an estimate of starting conditions for the area of implementation.

As a retention strategy, payments for FCI enrollment should be annualized for the duration of the contract. Participants felt it would be important to establish a connection with the landowner on a regular basis. If the landowner stops receiving a payment, it will be very hard to monitor continued behavior. Incentive payments could also be adjusted based on contract length. Higher payments could be made for longer commitment periods. To this end, it may be desirable to increase the payment based on the risk of conversion following a methodology for avoided conversion incorporated in the Carbon Benefits Index (CBI, *described in Section 4*). The federal program should include guidance helping to set payment levels based on the CBI, and how to incorporate yield of the system, risks of conversion and, carbon intensity of practices, etc.

Practice incentives. While they are committed to implement practices identified in an FCI plan, there is no guarantee of cost-share funding for implementation. Cost-share payments to the landowner should be calibrated to assist with the non-revenue practices involved in the implementation. These might include cost-sharing for exceptional practices such as use of high-quality seedling stock, some expenses associated with certification, non-commercial thinning, delayed harvesting or increased basal area retention (cost-shared at time of harvest). Rankings for cost-share should reflect the carbon benefits associated with FCI enrollment. Cost-share could be allocated to cover 50-100% of non-revenue generating practice implementation costs to the landowner. Where cost-share payments do apply the amount could be considered as investment rather than counting as landowner income for tax purposes.

Participants in the workshop also considered the possibility of adopting a reverse auction approach such as that tested in the Conservation Reserve and EQIP Programs. Here, landowners submit a bid representing the payment they would accept for implementation of the proposed management plan. The advantage with reverse auctioning is that the landowner (or a consulting resource professional) must consider practice implementation costs, opportunity costs, and expected revenues in submitting a bid.   Auctions have the benefit of reducing the total cost and increasing the outcomes produced per dollar spent.

Certification. The third category of payment would provide increased incentive for commitment to third-party certification. This commitment also does not guarantee cost-share assistance, which would only be available on a competitive basis, but could be included in ranking. Certification will add assurance to implementation, strengthen reporting, and help promote other environmental benefits.

3.1.2 Professional Expertise and Program Implementation

Professional expertise and service provision. USFS and state forestry agencies could each play a role in developing training curricula as well as certifying carbon management plan writers in each state. Qualified professionals—either state forestry personnel or other providers that meet the requirements—would write FCI-eligible plans. Participants felt that technical assistance should be available through any certified, qualified professional, including NRCS-approved technical service providers. Some existing consultants and technical service providers (TSPs) offering FCI enrollment to landowners would likely need training to incorporate eligible silvicultural systems and practices in Forest Stewardship Plans. In addition, a group or body playing an "advisory role" may be useful in refining requirements for carbon management plans over time. As a consequence FCI could require seed funding to sponsor the development of educational tools and certification procedures. In the end, increased cost-share assistance to landowners participating in FCI would potentially encourage foresters to obtain certification.

Plan types and practice delivery. As a planning process for forest carbon management, the existing Forest Stewardship Program (FSP) may present the most viable option since FCI could potentially fit within the administration of existing programs, a notion that is compatible with current FSP efforts to move toward an outcomes-based approach. Funding for FCI-qualified plans could be delivered through the FSP, but also link with forest practices that are already incentivized. For example, tree-planting activities required by an FCI silvicultural strategy could be accomplished through NRCS tree planting practices, whereas any provision for cost-share arrangements through the Forest Stewardship Program will be a new administrative function. An alternative to embedding FCI-practices within the Forest Stewardship Program would be to augment and prioritize forest carbon management as practices within existing FSA or NRCS programs. However participants noted that the drawback of the latter is that existing USDA programs are more oriented to "agricultural" outcomes and delivery systems and may not reach landowners most suited for FCI-type activities.

Pilot phase and demonstration research. It was noted that a new program of this kind may be suited to a pilot test approach. Initial funding to state forestry agencies could accommodate experimentation and innovation through a pilot delivery phase with demonstration projects that allow each state to develop an appropriate, efficient, and effective system for delivery. At the landowner level, early-adopters may participate in demonstration projects or receive compensation to make their land available for data collection related to testing or refining how recommended silvicultural systems and practices work on the ground, in light of other management objectives and constraints.

Flexibility. Federal guidance on FCI should consider the unique needs and considerations of states, but should include minimum standards for silvicultural systems and carbon management practices. In turn, state committees (State Foresters and State Forest Coordinating Committees) can play a key role in delivery by way of regionalizing the basic federal guidance on forest carbon management practices and customize any benefits index used to objectively evaluate and rank individual landowner proposals. The committees may target focal areas for project implementation in accordance with their respective State Assessments and other state-level conservation plans. Representatives comprising state committees should include departments of environmental protection/quality.

3.1.3 Accountability

The contract period—a commitment to implement the prescribed management plan —will be based on landowner interest and the practice schedule but it was recommended that a period of 10-20 years be used with the option to reenroll. In addition, landowners may pursue a permanent easement option through programs like the Healthy Forest Reserve or Forest Legacy Program, which do not conflict with the management prescription agreed to for an FCI contract. However, incentives will not be used to pay for purchase of easements. Programs like the USFS Forest Legacy program already facilitates the purchase of easements. However, landowners who have existing easements are not precluded from participating and can receive cost share assistance as well as annual payments for implementing practices. Payments would vary depending on the length of the contract and penalties or rollback payment provisions will be established for cancellations or intentional reversals. How long FCI benefits endure and the frequency of decline or reversal will need to be monitored and tracked through sampling in order to account for the carbon at an aggregate level.[4]

The key concept that differentiates accounting associated with an incentives approach compared with an offset approach is that accomplishments could be measured in terms of "acres enrolled" in the program every year where carbon benefits are estimated as a function of area times the modeled average sequestration rate for approved silvicultural systems in each ecoregion. This approach provides a more cost-effective means of a program accounting for a program of this scale than measuring exactly how much carbon is sequestered year-over-year on enrolled acres.

Through modeling, the total carbon mitigation potential for silvicultural systems can be used to provide an aggregate estimate of mitigation (*see* next Section 3.2, below). While carbon benefits through these incentives would not be used to offset emissions in other sectors of the economy, this aggregate accounting would serve as a valuable addition to national and international goals of mitigating climate change through forestry activities.

To ensure credibility without encumbering individual landowners, in addition to the contract-level certification options described above, a multi-year, national review may be called for. This review would employ large-scale datasets and take advantage of independent land cover mapping (e.g. Mid-decadal or Theobold) and ground-based monitoring (e.g., FIA surveys).

Figure 2. Potential roles and responsibilities for administrative entities, landowners, and technical assistance, recommended for implementing FCI.

[4] Shorter term contracts will not secure permanent emissions reductions, and the loss of carbon benefits accrued and incentivized during the contract period will require program-tracking (e.g. analyses that sample program participants who did not re-enroll) in order to report aggregate emissions reductions. The group discussed, but did not develop a scale for weighting incentives based on the length of the contract.

3.2 SILVICULTURAL SYSTEMS AND PRACTICES

3.2.1. Developing Silvicultural Systems

"The term silviculture means the theory and practice of controlling the establishment, composition, character, and growth of forest stands to satisfy specific objectives (Broun 1912, Kostler 1956, Helms 1998, Daniel and others 1979, Smith 1986)." (quoted from http://fire.forestencyclopedia.net/p/p1693)

A silvicultural system is the explicit set of establishment, maintenance, and regeneration treatments used to achieve a specific set of objectives for a given forest stand or collection of stands. In this case, the silvicultural system would combine "carbon" objectives with other objectives a particular landowner may have. We recommend that the methods used to develop eligible silvicultural systems be consistent across regions even if they are developed by each state. The process should be based on a set of regional criteria for evaluating the CO2 implications of different systems. The criteria would address: (a) Initial forest type classification; (b) modeling techniques/methods; and (c) model parameters & assumptions.

(a) Initial forest type classification.
The definition of silvicultural systems needs to be specific to regions and forest types, such that landowners and their service providers could readily assign parcels to a silvicultural system recognized by the program. The responsibility of the manager will resemble present day management plan development, with the exception that carbon-beneficial silvicultural options will be pre-defined. In some instances, especially with large ownerships encompassing forestlands that include several major types of forests, multiple silvicultural systems would be selected. Other landowners, especially those with smaller holdings that include only one forest type, or types for which the same silvicultural system is appropriate, would select only one silvicultural system.

Silvicultural systems are specific to forest type. Efforts to classify the forest types of North America stretch back to the early part of the 20th century and include several approaches (Shantz and Zon 1924, Kuchler 1964, Daubenmire 1978, Bailey 1983). Presently, FIA plot data[5] is widely accepted as the most robust national dataset on forest age, type and structure. Therefore, FIA is the most suitable information for the purposes of modeling eligible systems.

(b) Modeling techniques/methods.
Studies are emerging in the peer-reviewed scientific literature that provide guidance on how to evaluate the effects of forest management on carbon stocks over time. Empirical studies that measure and track carbon stock changes as a result of silvicultural treatments are limited and do not provide sufficient

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[5] Most studies on US carbon stocks and efforts to estimate carbon potential of based on US Forest Service FIA data. The workshop group agreed that this would be the best data source for defining forest types and then silvicultural systems across the country. A recent protocol-driven effort to assign carbon storage potential essentially averages FIA data on forests in each region to provide a high and low value. However, data on existing stocks does not determine the appropriate silvicultural strategy, nor does understanding the average high and low using data for forests of that type in the region. Rather, FIA data enables robust nationwide data on carbon storage in different pools for different forest types and age-class.

breadth and replication to be useful nationally as a basis for silvicultural design (e.g., see Hines et al. 2010). However, studies that use growth models to simulate scenarios to evaluate alternate management regimes can be replicated widely and can provide tangible guidance for choosing carbon beneficial silvicultural systems.

In the US, a modeling package developed by the US Forest Service called the Forest Vegetation Simulator (FVS) has become the de facto method to calculate carbon credit eligibility under the Climate Action Reserve (CAR), American Carbon Registry (ACR), and Voluntary Carbon Standard (VCS) forest carbon protocols in the US. The Fire and Fuels Extension of FVS (http://www.fs.fed.us/fmsc/fvs/description/ffe-fvs.shtml) includes a carbon submodel that is a flexible tool to evaluate alternate forest management regimes on on-site carbon stocks and harvested wood products (see Teck et al., 1996; Crookston and Dixon, 2005). Its broad-acceptance and flexibility of use makes FVS an appropriate tool for modeling silvicultural systems eligible for inclusion in a carbon conservation program.

Recommended Modeling Tool - FVS Fire and Fuels Extension

The growth and yield models used within FVS are based on data collected by the USFS's Forest Inventory and Analysis (FIA) unit from the 1950s through the 1980s. Developed by the US Forest Service and widely used for more than 30 years, the FVS is an individual tree, distance-independent growth and yield model with linkable modules called extensions, which simulate various insect and pathogen impacts, fire effects, and fuel loading. Through region-specific "variants", FVS can simulate a wide variety of forest types, stand structures, pure or mixed species stands, and allows for the modeling of density dependent factors. To this end, it is the most broadly applicable modeling tool for U.S. forests.

The FVS model modifies individual tree growth and mortality rates based upon density-dependent factors. As observed in nature, the model uses maximum stand density index and stand basal area as important variables in determining density-related mortality. Most variants use a crown competition factor as a predictor variable in growth relationships. Potential annual basal area growth is computed using a species-specific coefficient applied to DBH (diameter at breast height) and a competition modifier value based on basal area in larger trees is computed.

There are generally two types of mortality. The first is background mortality which accounts for occasional tree deaths in stands when the stand density is below a specified level. The second is density related mortality which determines mortality rates for individual trees based on their relationship with the stand's maximum density.

Regeneration is an important factor in how carbon stocks respond to removals and disturbance and would vary across regions in the U.S. It is an especially important factor for silvicultural systems that require artificial regeneration to achieve adequate stocking over initial years following a harvest. Natural regeneration includes stump sprouting on harvested trees and seedling inputs that can be default rates or based on refined user inputs. The carbon sub-model of the FVS Fire and Fuels Extension tracks carbon biomass volume based upon recognized allometric equations compiled by Jenkins et al. (2003) and updated to include a component ratio method modifier (Heath et al. 2009). The carbon submodel allows the user to track carbon as it is allocated to different "pools".

Other growth and yield models have been used specifically to predict carbon storage of management alternatives, both *in situ* and *ex situ*, and may be preferred over the FVS Fire and Fuels extension in certain settings. There are far more models of many kinds that can be used to predict basic growth and yield, which range in how well they can predict growth in different regions and incorporate parameters that can significantly alter growth rates (Peng 1999). The forestry protocols promulgated by registries and the DOE/DOD 1605B program accept or recommend a variety of modeling tools.

The proposed framework for developing Forest Carbon Incentives does not recommend which organization or entity would perform modeling suitable to define eligible silvicultural systems. Options range from modeling performed nationally for all forest types and regions, to modeling performed at the state-level, since this is the recommended approach for proposed administrative functions. Who performs the modeling will undoubtedly influence which tool is selected. Reviewing studies that undertake analyses most similar to what this program would require reveals a number of different tools currently in use. The study in the U.S. northeast referenced above (Keeton and Nunery 2010) uses FVS. A study in the Pacific Southwest on fire-prone ponderosa pine systems use "3-PG" since it is a process-model that can incorporate physiological responses to stress conditions, and fire, major determinants of long-term growth and carbon storage and emissions (Zhang 2010). A recent study of coastal-plain slash pine systems uses a unique hybrid modeling approach to show the importance of planting, rotation, and types of removals for carbon sequestration (Gonzalez-Benecke 2010). In European countries, where similar modeling has been performed on long-term carbon outcomes of different silvicultural strategies, other models have been used (Ericksson 2007, Karjalainen 2003, Pussinen 2002).

Should the program be structured such that each state or region performs modeling to generate eligible silvicultural systems, and they do so in consultation/collaboration with expertise in that region, it is likely that a number of different approaches would emerge. A strong case can be made to standardize and centralize the modeling effort for the program, in much the same way that the Climate Action Reserve provided a nation-wide reference for mean carbon stocks by region and type. Regardless of which model is used, several key characteristics are critical for ensuring a common modeling basis. These include:

1) *Growth and yield models based on long-term field data*. Field data from permanent plots that have been re-measured over time provide the empirical basis for growth and yield models. FIA is one nationwide example; however other data sources from long-term ecological and forest management study sites are also acceptable.
2) *Growth and mortality based upon density dependence*. Forest management actions most typically involve the manipulation of density and competition among stems. Therefore a key characteristic of an appropriate modeling framework includes the ability to infer growth and mortality rates from changes in stem density.
3) *Regeneration inputs are flexible*. Regeneration is an important component of the response of a forest stand to management. The amount and type of regeneration will significantly influence the carbon accumulation over time. The ability to model the impacts of supplemental artificial regeneration as one likely mechanism for increasing carbon stocks will be important to consider.
4) *Harvest simulations allow repeated entries*. Modeling the potential benefits of repeated entries into a forest stand during a single rotation will assist in the identification of practices worthy of incentives. In some systems it may take multiple entries before the cumulative carbon benefits are realized.
5) *Biomass expansion factors based upon acceptable methodologies.* The choice of a biomass expansion factor can heavily influence carbon accumulation calculations. Most recently, Heath et al. (2009) have refined a components ratio method that has become accepted. (e.g., http://www.climateactionreserve.org/wp-content/uploads/2010/02/Appendix_J.pdf). The

components ratio method (CRM) involves calculating the dry weight of individual components before estimating the total aboveground or belowground biomass.

6) *All measurable carbon (biomass) pools are tracked*. Tracking the range of carbon pools will be important for understanding the broad impacts of management activity on total carbon stocks. For example, the deliberate retention of post-harvest coarse woody material will have a long term impact on the below ground soil organic layer and root systems.

7) *Removal volumes can be tracked by product pool*. Tracking removed carbon in the harvested product pool will be necessary to calculate the long-term benefits of management regimes. Product life-cycle (based on in-use decay rates) can be derived from Smith et al. (2006) or other updated product lifecycle models.

(c) Model Parameters and Assumptions (Recommended Modeling Process)

Baseline Definition

A ***baseline*** is generally defined as the minimum condition(s) that must be met in order for a landowner to be eligible for participation in a program, or a minimum level of compliance beyond which additional carbon benefits may be assigned. One method of defining the carbon benefits of management practices involves the establishment of a baseline relative to an "eligible" silvicultural system and set of practices. Baselines have been used by carbon registries for the purpose of calculating the additional carbon yielded, which then qualifies as an emission reduction that can be exchanged, or offered as an offset. Baselines can be defined in several ways, and different methodologies are being used by existing registries. This is a difficult and sometimes subjective task. This precise calculated baseline is fortunately not needed for FCI.

Selection and utilization of management regimes that enhance carbon benefits may be conceptually different than carbon markets, since the objective of creating incentives for carbon beneficial practices does not require absolute additionality. The objective is to encourage landowners to adopt silvicultural systems that maintain and provide "high" carbon benefits relative to other practices in a given region. For this reason, the baseline per se is not relevant, but rather some understanding of the relative benefits of different systems is most important. Defining the relative benefits of multiple scenarios avoids the need to develop consensus on specific baseline practices. Figure 3 shows how multiple practices can be compared without necessarily specifying a baseline Nunery and Keeton (2010). The authors present an unmanaged trajectory as context, but the absence of management would only be a legitimate baseline, or an eligible system, in certain circumstances. For an FCI, carbon management accumulation curves can be grouped by high/medium/low (or similar) categories. Incentives can then be tailored to prioritize silvicultural systems that provide high (and/or) medium benefits over the contract period or longer.

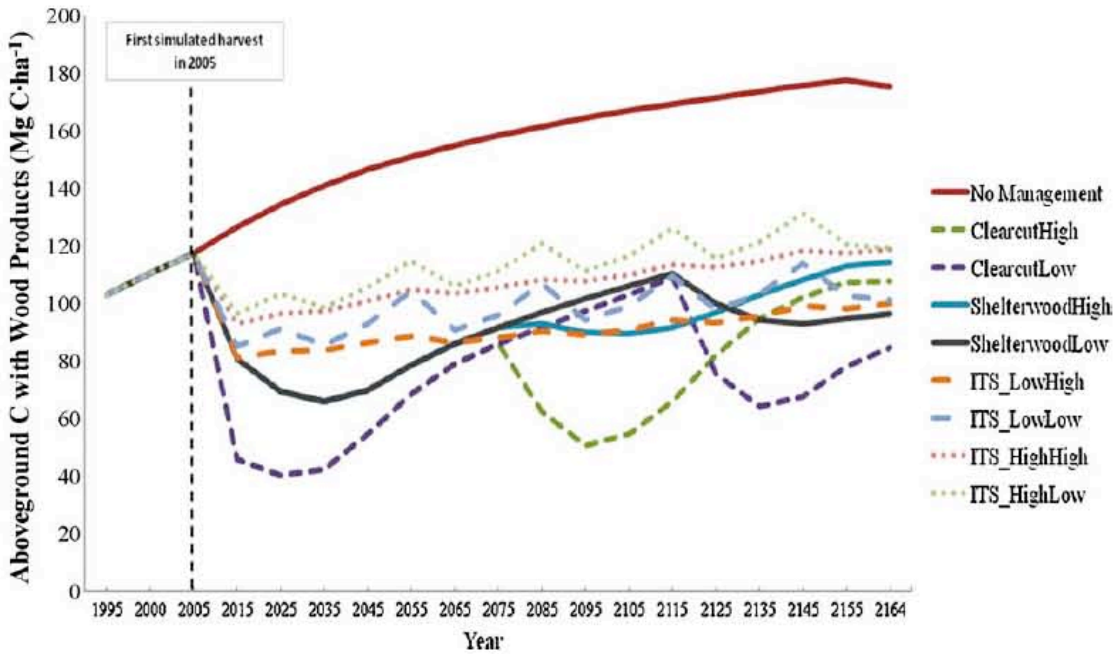

Figure 3. From Nunery and Keeton (2010*, Forest Ecology & Management* 259: 1361-1375). Simulation output time series for the 9 different management scenarios (values represent 10 year mean of 32 stands C storage in aboveground live/dead biomass and wood products). Ten year means of C sequestration were used to create chronosequences to illustrate the temporal dynamics for each management scenario, however these values were not used in the overall statistical analyses and are presented here for illustrative purposes. Average forest growth was estimated for 1995 using 20 year mean predicted growth rates of all stands. Chronosequences starts from the estimated mean averages in 1995, all harvest cycles began at 2005 (noted with vertical dotted line). For management scenario descriptions refer to Tables 2 and 3

Defining Stand Conditions

Defining stand conditions that reflect a range of real stand structures is important for developing carbon accumulation curves. US Forest Service Forest Inventory and Analysis (FIA: http://fia.fs.fed.us/) plot data as the basis for modeling forest carbon response to silvicultural systems. Other field based data that represents stand structure and development stages can also be used (e.g., state forest inventory data).

Time Horizon

Using a 100 year modeling horizon typically will be fully sufficient to capture the carbon benefits over time associated with multiple harvest entries throughout and entire rotation. Where the rotation length exceeds 100 years, the horizon should be extended to capture a full rotation. Caution should be exercised with model interpretation of specific results at the end of the modeling horizon. Shorter-term projections (ca. 30 to 50 years) have been verified to have a higher degree of confidence since the impacts of uncertainties are minimized by low probability of occurrence (Yaussy 2000).

Natural Disturbance Regimes

Modeling should incorporate natural disturbance regimes in landscape contexts where stand-replacing events occur at a frequency greater than the typical harvest rotation length. In landscapes prone to catastrophic fire events, carbon management practices could serve to reduce carbon stocks in the stands in the short term, but ultimately reduce carbon emissions when compared to disturbance scenarios over the long term (Hurteau 2008, Zhang et. al. 2010). A key to modeling the performance of silvicultural systems in different ecoregions is using the best available science on disturbance frequency and impact.

Carbon Pools

Model results should track above and belowground carbon stocks (live, dead down, dead standing, litter/duff). Aboveground biomass estimates should be made using the components ratio method (CRM) (Heath et al. 2009). Carbon in harvested wood products should be tracked to end of life, or 100 years, whichever comes first. Smith et al. (2006) provides decay curves for all regions of the US. These curves can be refined based on local expertise.

Silvicultural System Classification for Modeling Carbon Management Benefits

A program for the treatment of a particular forest stand over time is called a "silvicultural system" (Smith et al. 1997). For carbon management modeling, silvicultural systems can be defined by three elements:

1. Management objectives. In the case of an incentivized silvicultural system one of the management objectives will be carbon storage, whether onsite or in products. Modeling FCI carbon benefits will require considering other objectives.
2. Rotation length (the length of time a cohort is allowed to grow).
3. Cutting cycle for intermediate treatments): (a.) Frequency of entry schedule; and, (b.) Removal intensity at each entry

Modeling of this sort will then produce silvicultural systems to be prescribed for landowners wishing to participate in FCI. Landowners would be required to develop a plan that met stewardship planning requirements, including these schemes. The plan would also include existing carbon stock information from timber inventory data with extrapolation from existing reference tables (Birdsey 1993, Smith et. al. 2006), online tools such as COLE, or from carbon accumulation curves developed through novel modeling efforts by each state. Eligible participants would not necessarily be required to complete plot-based inventories, but would need to include a map with stands delineated and with associated values for carbon stocks.

3.2.2 Developing Carbon Practices

Silvicultural treatments or practices are tools of the silvicultural system being used. Therefore eligible practices will be defined by the modeled systems—i.e. what is the timing and intensity of treatment necessary to achieve desired carbon outcomes (in concert with other objectives incorporated in the modeling runs). Forest management practices today reflect existing market conditions and landowner interests, and do not necessarily reflect strategies to maximize net carbon storage. For example, opportunities for pre-commercial thinning, replanting, re-vegetating problem sites, and other practices are often left out of management schedules when they are costly or do not produce revenue. In some instances these management practices could significantly enhance the "carbon performance" of the silvicultural system over the long term. As a result, incentive payments for these practices may result in the implementation of a fuller suite of recommended practices in the silvicultural system.

There is a well-developed set of approaches in professional forestry for characterizing forested stands to reflect age, origin, site quality, stocking, etc. These factors are used in classifying forest stands and developing a schedule of silvicultural treatments. Stand classifications typically include three main descriptors: stage (e.g. seedling/sapling/pole-sized/mature), forest type (e.g. hardwood/ softwood/

mixed), and stocking (e.g. understocked/ overstocked). In similar forest types, stands in a variety of conditions—(i.e., stage and stocking) would be scheduled for different treatments, all of which involve practices fitted to a particular silvicultural system. Defining which forest practices are appropriate for FCI will require testing conventional knowledge against models that project forest carbon storage over the long term (including storage in harvested wood products).

Implementation of an approved silvicultural system might include a number of improvements in management—i.e. "Improved Forest Management" or "IFM"--falling under the broad practice categories of *Planting*, *Removals*, and *Retention* ("input, output, and stay-put"). These practices would be provided to states, along with guidelines on the analyses that could be used to determine appropriate strategies for implementation:

1. PLANTING PRACTICES

i. Artificial regeneration (if needed) following harvest or on under-stocked sites.

This practice would incentivize active reforestation efforts to improve stands to full stocking and productivity. Practice rates for artificial regeneration are readily available, but would still need to be adapted to site conditions. The necessity of artificial regeneration, and how it would be included as an eligible FCI, would be highly variable based on region and forest type. While always prescribed based on observed site conditions—whether there is adequate regeneration to lead to acceptable growing stock—the importance of artificial regeneration in different systems and conditions should be included in initial modeling.

The inclusion of artificial regeneration in the IFM -oriented framework proposed for FCI needs to be explained in that it departs some from the categories established by offset markets. Existing offset-market protocols on afforestation, reforestation, regeneration (ARR)[6] define eligible activities in the this category as *establishing, increasing or restoring vegetative cover through the planting, and sowing or human-assisted natural regeneration of woody vegetation to increase carbon (C) stocks in woody biomass and, in certain cases, soils.* Afforestation, or the establishment of forests on land that has not been forested for a long time, is a common offset project, but is not included in FCI. In the ARR lexicon, reforestation involves reestablishing forests on lands where forests were recently removed, destroyed or degraded. This includes land that has lost forest cover that is not recovering naturally.[7]

[6] The Voluntary Carbon Standard (VCS), Climate Action Reserve (CAR) and American Carbon Registry (ACR)

[7] For reference, many offset standards distinguish between afforestation and reforestation activities on the basis of how much time the land has been under a land use other than forestry. For CAR, only reforestation activities are eligible. CAR defines a reforestation project involving restoring tree cover on land that is not at optimal stocking levels by tree planting or removing of impediments to natural reforestation on land that: **a.** Has had less than 10 percent tree canopy cover for a minimum of 10 years; or **b.** Has been subject to a Significant Disturbance that has removed at least 20 percent of the Project Area's live biomass in trees. ACR requires that project proponents document that artificial regeneration (AR) project lands were not cleared of trees during the 10 years preceding the project start date in order to implement an AR project. This exclusion does not apply to natural disturbances or to removal of non-tree vegetation (e.g. heavy brush) in order to prepare the site for planting.

ii. Reforesting non-forest areas (road closures/decommissioning, logging roads/skid trails, large landings, skid trails).

This practice would incentivize reforestation and restoration of areas associated with a managed forest. Eligibility would be based on site-conditions typically associated with transportation infrastructure for forest operations—and even when implemented properly, in keeping with BMPs, would have reduced sequestration rates over many years. Fully restoring and re-vegetating these sites is often difficult to accomplish and is an opportunity to increase sequestration through incentives. This practice would be analogous in some ways to reduced impact forestry practices. There is little available information on the scope of this opportunity, and the aggregate sequestration potential on these sites.

iii. Adaptation of species mix to sites and soils.

The practice would incentivize the adoption of silvicultural approaches (including planting) that favor species that are better adapted to predicted future climate regimes. Soil surveys are an important part of forest management planning, and the adaptation of species to soil type and site characteristics can be an important carbon contributor. At times, micro-site conditions (e.g. north slope vs. south slope) may mean favoring two or more species mixes in the same forest management unit. A sound silvicultural program will include consideration of these species dynamics in reforestation and in selecting species preferences during thinning and other partial harvest operations. Planting or shaping a forest that can grow with best results involves adapting to the site conditions likely to be realized in the next quarter- to half-century rather than those of the past. Taking advantage of these opportunities will require forest managers and resource professionals to maintain close attention to forest and climate research and reporting.

2. CHANGES IN TIMING OR INTENSITY OF REMOVALS

i. Pre-commercial (and/or commercial thinning) to maintain free to grow conditions.

This practice would incentivize thinning strategies that improve net sequestration *in situ* and in removals. A number of studies in the U.S. and abroad have considered the carbon sequestration benefits of thinning treatments using different intensities and timing. Results are highly variable and specific to stand and forest conditions. Also, landscape-level sequestration rates—i.e. whether the same thinning practices are implemented on all similar forest types—is critical to the balance of in situ and product stocks. Most studies show that thinning from below increases total carbon storage. The benefit of thinning from above depends more heavily on product fates, intensity, and residual stocking. Recent studies provide better guidance on thinning for carbon sequestration, in many cases departing from conventional practice and strategies to optimize timber revenue. Practice guidance should supply service providers with silvicultural options tailored to forest types and regions, allowing comparison with other management objectives.

ii. Rotation length or cutting cycle designed to optimize carbon stocks.

This practice would define optimal rotation lengths to increase net sequestration for *in situ* carbon stocks and removals. As with thinning, silvicultural decisions on rotation lengths for optimizing timber revenue or other objectives, may or may not correspond with maximum net sequestration (i.e. extending or shortening rotations). Studies in different parts of the country, and outside the U.S., show widely varying outcomes depending on forest types, growth rates, forest product utilization, and continued sequestration in other carbon pools. In light of these studies, practice guidance should use best available science to set terms (years) based on forest types and ages for each ecoregion--such that silvicultural decisions actually reflect net sequestration benefits.

3. CHANGES IN RETENTION

i. Preferential post-harvest retention of long-lived species (decision made at time of harvest, also silvicultural system shift from short rotation intolerants).

This practice will incentivize management that retains a volume of standing trees not typically retained following a harvest. Tops and limbs may also be retained or returned to the stand in areas where biomass markets drive whole tree removal. Benefits include greater amounts of carbon stored in the residual stand that will continue to accrue volume between harvests. Forest floor carbon from tops and limbs also contributes to long-term soil carbon stocks. Retention of tops and limbs may also minimize soil carbon lost during harvest operations. Retention practices should not significantly compromise silvicultural objectives or create structural conditions outside the range of natural variability (and thus contribute to increase risk of catastrophic disturbance). (*see* practice sheet, attached).

ii. Set-aside of Carbon Reserves (with LSOG characteristics)

This practice will incentivize maintaining stands with forest structural components that are consistent with “mature forest” or “late-successional, old-growth” (LSOG) characteristics. For example, in the northeast, such characteristics typically develop in stands that have been free of stand-replacing disturbances for over 100 years. The temporal component will vary by region and forest type. Typical characteristics include: large trees (e.g., > 16” dbh in northeast); multiple age classes; dominance of shade tolerant species; high density of lichens present on trees; and large standing dead trees. Mature forests typically will have a higher volume of carbon stored per acre than the mean for a given forest type (see examples below, e.g., carbon volume can be 3 to 4.7 times higher than mean).

The practices described above will not be exclusive to a single silvicultural system. For example, thinning regimes will be employed in even-aged and uneven-aged systems. Likewise, adjustments to rotation lengths or cutting cycles would be appropriate to consider within many silvicultural systems. This list of practices is not exhaustive but is presented to provide concrete examples of how a set of practices might be described to implement within appropriate silvicultural systems. Examples of silvicultural systems and associated practices are provided in Appendix D.

4. ELIGIBILITY & REQUIREMENTS FOR A CARBON CONSERVATION PROGRAM

4.1. Eligibility: *Landowner Profile, Ownership and Tenure.*

4.1.1. Ownership Category.

4.1.1.1. Non-industrial private landowners, tribal lands, community forest lands, municipal, county lands

4.1.1.2. Land must be owned or leased for at least one year prior to enrollment to be eligible, and must be physically and legally capable of being planted in a normal manner.

4.1.1.3. Minimum parcel size of 10 acres.

4.1.1.4 Eligible landowners will be subject to a means test (e.g. Adjusted Gross Income).

Incentives will target non-industrial private forest landowners, tribal, and community forest lands[8] but will exclude state and federal lands in order to influence lands where continued carbon storage and sequestration is most uncertain and where land managers have fewer resources for implementation. However, some priority state and county lands could be eligible based on identified needs and potential impact on sequestration.

Ownership is not necessary for participation but the landowner must have legal control over the property for the tenure of the contract to enroll. Transfer of ownership is acceptable but there must be provisions in the contract for pay-back if cancelled or carbon gains through incentivized practices are reversed. The incentives will primarily target carbon benefits but cost sharing can encourage holistic management of the property in addition to individual stands. Similar to the Tree Farm and FSC, and in some states theForest Stewardship Program, here will be a floor on eligibility, perhaps set at 10 acres. It was recognized that landowners will self-select based on break-even costs[9].

There may also be a need to set a ceiling on the amount paid to each landowner to prevent "elite capture." While enrolling Timber Investment Management organizations (TIMOs) and REITs may be more cost effective because they are larger, one of the options is to prioritize enrolling landowners that do not have the scale and financial means to participate in an offset program to reach the greatest number of landowners. Administrators may consider ranking based on economic considerations to encourage enrollment of low income landowners, screening out some participants through an adjusted gross income measure as done in other assistance programs, and prioritizing new participants over those already enrolled. [10] Nonetheless incentives should reward early adopters for existing sustainable stewardship efforts while encouraging all participants to go to the next level of stewardship. Ultimately, prioritization of landscapes with the most potential for carbon sequestration will be weighted more heavily than social criteria for applicant selection.

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[8] Community forest lands are defined broadly but share attributes such as that residents have access to the land and its resources, they participate in democratic decision making processes concerning the forest, and they prioritize conservation and restoration of the forest (National Community Forestry Center, 2000).

[9] Administrators may model break even costs for how much expenditure and administrative costs landowners should foresee investing prior to receiving their return on investment.

[10] Leveraging existing resources could pay for other co-benefits.

4.1.2 Ranking

4.1.2.1 Applicants will be ranked according to a "Carbon Benefits Index"

4.1.2.1.1. Applications in areas with greatest carbon storage potential or "carbon carrying capacity", based on reference conditions for that region or site, will receive the highest priority

4.1.2.1.2. Applications that most enhance/protect carbon stocks (i.e. carbon benefits index) will receive highest priority: ***Measures for the carbon benefits index may include: carbon carrying capacity, priority conservation areas, adjacency to other priority landscapes, risk of conversion, restoration potential, risk of degradation, cost effectiveness, adjusted gross income of participant, and level of stewardship***

4.1.2.1.3 Applications that most enhance/protect environmental benefits will receive a higher ranking. A CBI will be composed of measures/sites identified in State Forest Resource Assessments, and other prioritization maps/datasets.

Administrators should not establish environmental criteria that determine or preclude eligibility but should instead require environmental and social safeguards (performance levels and commitments) as well as ranking applications for environmental benefits. The ranking and associated incentives for co-benefits will be formulated much like the NRCS Environmental Benefits Index (EBI) for objectively ranking applications. The prioritization will also utilize where possible existing work that has articulated priority areas such as state forest resource assessments and state wildlife conservation plans. The rationale behind this approach is to leverage existing assessments of opportunity and need based on localized knowledge. State forestry stewardship coordinating committees may play the role in setting these guidelines.

Carbon Benefits Index. Ultimately, spatial targeting of existing and potential carbon stocks regionally will be the first order priority with a social and environmental score as a second order priority. This "Carbon Benefits Index" (CBI) could examine the carbon stock in proportion to the site as well as its potential or "carbon carrying capacity", sequestration rate and the risk of loss to conversion and risk of degradation due to fire and other natural disasters. The CBI could also incorporate landscape-level benefits via landscape-position and/or adjacency/connectivity metrics by using the ranking score and adjusting payment levels or priority rank. Cost effectiveness, length of the contract or the commitment level, additionality concerns (such as participation in existing programs), graduated incentives for higher levels of stewardship, measuring, monitoring and reporting and permanence or reversal considerations could also be elements of the index.

The CBI will be a state-specific index that measures carbon intensity in terms of tons/acre/year depending on the ecoregion and FCI silvicultural systems within the state, and will help rank applications. When desirable CBI could help target high endemic carbon stocks and those under threat of conversion or degradation. It will evaluate the site richness (storage and sequestration capacity), site quality based on initial conditions, risk of carbon loss (either through conversion or fire), and ecological adaptation. The CBI can prioritize funds to strategic locations that demonstrate: a high benefit at a low cost, a high benefit at a high cost, a low benefit at a low cost and a low benefit at a high cost. The CBI will then assign an index value to certain eco-regions. The result would be national carbon intensity based on Forest Inventory Analysis (FIA) data average sequestration rates for carbon carrying capacity or stock versus flow (positive and negative) over time. This will enable landowner targeting and assessment of the costs as well as scarcity of carbon opportunities. Some landowners may be automatically eligible based on certain ecological criteria established in the CBI through a numerical rating such as the presence of old growth forests and late successional old growth forests (LSOG) which sequester 3 to 4.7 times the FIA mean amount of other forest types.

Every state forestry agency has the capacity to analyze FIA data and model growth and yield potential. Agencies, or whatever entity performs the modeling, should also associate the performance of silvicultural systems to set *carbon intensities* attributable to acres enrolled. At the project or landowner level, state forestry agencies would assign a carbon intensity number (CI) for the adopted silvicultural system and its suite practices. The carbon intensity number or potential is the result of assessing the carbon capacity or flow of the system based on modeled sequestration rates divided by the number of years of management under contract, this rating would be a component of the CBI.

4.2.0 Technical Requirements

4.2.1. Planning Basis

4.2.2 Measurement, Monitoring, Reporting and Verifying

A Forest Stewardship Plan will serve as the planning basis or the starting point. However, in order to participate a landowner will need to implement additional conservation, enhancement or improved management activities as well as document certain information about the property for FCI. The plan will need to meet all existing FSP requirements, and so should include resource assessments (e.g. timber, wildlife soil) as well as other requirements such as a description of the property including the location, boundaries, acreage under stewardship, a map of the forest stands, the forest type, soil types and age structure as well as an assessment of risks to the property. To receive incentives, Forest Stewardship Plans must include a carbon management component documenting estimated existing carbon stocks and maps, along with schedules for future management actions associated with the silvicultural systems called for in the plan. These silvicultural systems underpin the expected carbon benefits.

Measurement guidelines for forest carbon sequestration were first developed by the US Forest Service to support reporting and registering carbon reductions by public and private entities using the U.S. Department of Energy 1605(b) voluntary reporting registry. This same information provides a reference for designing a forest carbon inventory and monitoring system for FCI. Since payments are based on the modeled yield of silvicultural systems, documentation of existing stocks in the plan can be less accurate. A simplified and cost-effective approach for this "baseline" could be determined using US Forest Service standard tables of forest ecosystem and harvested wood carbon[11] and Carbon OnLine Estimator (COLE) type assessments.[12]

Finally, landowners may verify implementation of practices via an annual report attesting to implementation. Only through reporting would the contract holder remain eligible for incentives. Additional annual audits would be conducted based on a risk assessment and following a sampling protocol based on enrollment.

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[11] Tables are from a study that presents techniques for calculating average net annual additions to carbon in forests and in forest products. Forest ecosystem carbon yield tables, representing stand-level merchantable volume and carbon pools as a function of stand age, are available for 51 forest types within 10 regions of the United States. For each region and type, separate tables are presented for afforestation and reforestation. Because carbon continues to be sequestered in harvested wood, approaches to calculate carbon sequestered in harvested forest products are included in the accompanying publication. The estimates and methods in this report are consistent with guidelines being updated for the U.S. Voluntary Reporting of Greenhouse Gases Program and with guidelines developed by the Intergovernmental Panel on Climate Change. Available at: http://nrs.fs.fed.us/carbon/tools/#gtrne343

[12] COLE is an online tool used to generate carbon estimates based on forest inventory data for any area of the continental United States chosen by the user. COLE currently produces results for areas of a county or larger, with the uncertainty of the estimates decreasing for larger areas. Reports can be produced which calculate carbon "growth and yield" curves for 1605b reporting, based on averages across the selected area. Available at: http://nrs.fs.fed.us/carbon/tools/#cole

5. CONCLUSIONS

A Forest Carbon Incentives offers an avenue to engage private landowners in protecting and enhancing carbon sequestered by forests. Recommendations in this report focus on designs that are most suited to this category of landowner. On some topics the report includes singular options to be considered, and in other instances includes options with alternatives. This report is intended to provide background and guidance if such a program were to be developed in the US.

Achieving the goals of this program would have many additional benefits, to wildlife, water, and rural economies and communities. The options presented highly complement existing conservation incentive and technical-assistance programs, and in fact would rely on the organizations and individuals that are responsible for their delivery. However there are some key differences between what is proposed here and the opportunities available to most forest landowners. Among these distinctions include new options for eligibility, enrollment, payment, reporting, and accountability. What may seem in some cases minor differences in design may make big differences in rate of adoption and participation by landowners, and as a consequence the magnitude of carbon mitigation and other environmental benefits.

We propose the development of new ranking methodologies (a *carbon benefits index*, CBI, and an associated measure of *carbon intensity*, CI) that take into account the mitigation benefits of different forest management strategies and particular geographic settings. We also propose a program that would have several types of inducements for landowners, depending on escalating levels of commitment. The overall design links technical scientific assessment that is critical to understanding net-GHG benefits of forestry, with the practical concern of what is possible to implement on the ground, at-scale.

New information on managing forests for carbon benefits would require national, regional, or state level modeling of how multiple silvicultural systems perform in forest types in each ecoregion. The data and tools are available, and a number of studies have already been completed. However, modeling of this type is by no means complete or consistent. As conceived in this report, the outcomes of this work would provide the information needed by federal and state agencies to set the requirements for entry into the program, and determine what will be supported. This report also recommends technical and institutional approaches for completing the work.

Finally, the recommendations provided in this report represent the general agreement of the participants but in many cases there was not a consensus. Participants did not address the potential funding source(s) or specify how existing programs *should* be adjusted, i.e. “vehicles for delivery,” as this was outside the scope of this effort. However, many remarked that the carbon sequestration potential of forests cannot be met through existing resources or conservation programs and to be successful must be a part of overall GHG emissions reduction policy and financing strategies. A growing body of research has emphasized how land based mitigation, and the conservation of forest carbon stocks in particular, can be a very cost-effective, “off the shelf” mitigation option that provides significant emissions reduction while providing an array of other societal and economic benefits. Strengthening the role that forests play in climate change mitigation through an FCI approach as proposed could prove to be a highly-leveraged investment.

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7. APPENDICES

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Appendix A. Workshop Participants

We are grateful to all the participants listed below, who contributed time, energy, and good ideas resulting in the Forest Carbon Incentives concept. This effort was supported by the U.S. Forest Service. We are especially grateful to Al Todd and Amy Daniels of the Forest Service who also provided guidance and leadership, and information used throughout the process. We also sincerely appreciate the help of Dr. John Gunn and Dr. Neil Sampson who contributed ideas and writing all along the way.

Participants included:

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Appendix B. Legislative Context

The U.S. House of Representatives passed the American Clean Energy and Security Act of 2009 (ACES Act, otherwise known as the Waxman-Markey Bill, or HR 2454), on June 26, 2009 renewing the possibility of a market for land use offsets that store or remove greenhouse gas emissions. This attempt at producing comprehensive national climate and energy legislation established an economy-wide, greenhouse gas (GHG) cap-and-trade system. The Waxman-Markey bill also created an offset credit program for domestic agricultural and forestry projects and referenced a supplemental carbon incentives program for agriculture. Guidance on quantifying carbon benefits, establishing activity baselines, determining additionality, leakage and reversals, and third party verification set out a framework for a land based offset program in the US.

Following House action, several complementary and sometimes competing proposals to curb greenhouse gas emissions and promote clean energy production saw action in the Senate. In November 2009, Senator Debbie Stabenow (D-Michigan) introduced the Clean Energy Partnerships Act of 2009 (S.2729). The amendment created an offset credit but also a carbon incentive program for domestic emissions reductions from US farms and forests—language that was eventually carried forward in the American Power Act, proposed as a discussion draft by Senators Kerry and Lieberman in May 2010. This included a section titled the Carbon Conservation Program, providing the legislative basis for the proposed FCI. While Senator Bingaman in July 2010 released an energy bill that included provisions for 2.5 percent of emissions allowance revenues to fund agricultural soil carbon sequestration offsets, this proposal did not encompass forestry activities.

A Carbon Conservation Program for US Forest and Farm Landowners

A national level Forest Carbon Incentives was one of the most widely supported proposals for US landowners in the American Power Act. As described, legislative language set up a program adhering to these principles:

a) Landowners will not simultaneously receive both incentives and offset credits for the same activity;

b) Early adopters of conservation practices that sequester carbon will be rewarded to continue those practices;

c) Supports the development of new offset methodologies by landowners;

d) Improves management of privately owned agricultural land, grassland, and forest land that results in increased carbon sequestration;

e) Avoids conversion of land (including native grassland, native prairie, rangeland, cropland, or forest land) that would result in an increase of greenhouse gas emissions or a loss of carbon sequestration;

f) Encourages improvements and management practices that include sequestration benefits on federal and private land; and,

g) Addresses intentional or unintentional reversals in carbon sequestration contracts during the contract period.

The Carbon Conservation Program provided for conservation easements with a measurable carbon sequestration benefit and projects that sequester carbon and protect forests (including working forests) or native prairie and grassland within a working farm or ranch. The program described carbon sequestration contracts (10 years) for farmers, ranchers and forest owners who perform projects or practices that reduce or sequester GHG emissions. Compensation to landowners would depend on the emissions avoided or carbon sequestered, along with the duration of the reductions. USDA would prioritize early adopters of conservation practices (e.g., no till agriculture), improved forest management or other projects that reduce/sequester GHG emissions and contracts that sequester the most carbon per acre. A contract would specify eligible practices; acreage of eligible land where practices take place; agreed rate of compensation per acre per practice; and verification of fulfillment.

In terms of program measurement, monitoring and reporting, the Carbon Conservation Program would require reporting: (1) the total tons of CO_2sequestered or avoided through conservation easements and sequestration contracts on an annual and cumulative basis; (2) any reversals of carbon storage; and (3), total number of acres enrolled in the program by method and a state by state summary of the data . USDA would coordinate the program with other Farm Bill conservation programs. The Secretary of the Interior would coordinate activities under this program with the activities of the Land and Water Conservation Fund Act of 1965 and other applicable climate adaptation programs.

Table. A-1. Comparison of legislative proposals for climate change.

	Waxman-Markey House American Clean Energy and Security Act (ACES Act) - Passed June 29, 2009	**Kerry-Lieberman Discussion Draft American Power Act-Released May 2010 and a revised version in July 2010 but has not reached the floor**	**Bingaman Discussion Draft Climate and Energy bill – Released July 2010 but has not reached the floor**
Covered sectors	All sectors (utitlies, manufacturing, transportation, residential and commercial)	Utilities	Utilities with an opt in for manufacturing
General Overview of Provisions	The bill contains five distinct titles: I) clean energy, II) energy efficiency, III) reducing global warming pollution, IV) transitioning to a clean energy economy and V) agriculture and forestry related offsets.	The bill contains provisions for clean energy, greenhouse gas pollution reduction, an offset credit program for domestic and international emission reductions, REDD+, disposition of allowances, consumer protection, an energy refund program, international climate change activities and community protection from climate change impacts	The bill contains provisions related to greenhouse gas pollution reduction, allowances for agricultural soil carbon sequestration, an offset credit program, an international offset piloting program, a clean energy technology research fund, an energy efficiency consumer loan program and energy security dividends
% Cap on emissions	97% of 2005 levels by 2012 83% of 2005 levels by 2020 58% of 2005 levels by 2030 17% of 2005 levels by 2050	95.25% of 2005 levels by 2013 83% of 2005 levels by 2020 58% of 2005 levels by 2030 17% of 2005 levels by 2050	97% of 2005 levels by 2012 83% of 2005 levels by 2020 58% of 2005 levels by 2030 20% of 2005 levels by 2050
Offsets	Up to 2 billion tons of emissions system wide can be used for compliance. (1 billion domestic , 1 billion international) President may recommend to Congress to increase or decrease total number of offsets Starting in 2018, 5 international offset credits must be submitted for every 4 tons used for emissions compliance No mandated discount on domestic offsets Five-year term offset credits from agriculture and forestry projects may be used to temporarily	Up to 2 billion tons of emissions system wide can be used for compliance (25% of which can come from international sources) President may recommend to Congress to increase or decrease total number of offsets Starting in 2018, 5 international offset credits must be submitted for every 4 tons used for emissions compliance No mandated discount on domestic offsets	Offsets allowed as a percentage of annual compliance obligation

	demonstrate compliance. These credits must be replaced at the end of the period, and are subject to the domestic offset limits	Term offset credits are allowed.	
Eligible Practices	Afforestation or reforestation (A/R), management of peatland or wetland, conservation of grassland and forested land, improved forest management, including accounting for carbon stored in wood products, reduced deforestation or avoided forest conversion, urban tree-planting and maintenance, agroforestry	A/R, IFM, Agricultural, grassland and rangeland sequestration and management, avoided conversion, reduced deforestation, urban tree planting, management and restoration of peatland and wetland	Methane practices specified; forestry or soil carbon not specified but implied with USDA approval
Supplemental carbon incentives	Offset credit program from domestic agricultural and forestry sources	Carbon Conservation Program	An offset credit program and an international offset piloting program
% Set aside from allowance revenue for supplemental forest carbon landowner incentives	Not specified	Not specified	2.5% for agricultural soil carbon sequestration
Program administrator for supplemental offset or incentive program	USDA	USDA designates the Chief of the US Forest Service as the administrator	Not specified

APPENDIX C. PROGRAMMATIC & INSTITUTIONAL CONTEXT

A host of programs exists to influence landowner behavior toward defined environmental benefits. Farm bill legislation authorizes and appropriates most of these, and the specific details of implementation are ever-evolving. These existing programs follow two broad approaches. The "land retirement" approach works through contracts that range from temporary—via 10 or 15 years on agricultural cropland through the Conservation Reserve Program (CRP)—to easements made in perpetuity, as with the Forest Legacy Program or the Farm and Ranch Lands Protection Program (which includes forest, despite the title). In addition to retiring certain rights for the defined time period, these programs require management plans in accordance with respective program goals. The second "working lands" approach aims to enhance land management practices on production-oriented lands. The Environmental Quality Incentives Program (EQIP), for example, provides enrollees with cost-share incentives and technical assistance to facilitate compliance with environmental regulations, like the Clean Water Act. **Table B1** provides an overview of the core purpose of a dozen different land conservation programs, along with the implementing agency and budget/enrollment statistics. For many programs, demand exceeds congressionally-set enrollment caps or appropriated funds.

Any new incentive will not be implemented on a blank landscape, but must overlay and complement the suite of existing programs landowners are already familiar with, or possibly confused about. A key step in contemplating forest carbon conservation is to identify existing vehicles that incorporate forestry-related carbon sequestration practices. This ensures the design of any new program actually addresses unmet forest conservation objectives or synergistically complements existing programs with greatest possible efficiency. Forest carbon benefits as envisioned through FCI could possibly be achieved, for example, by adjusting existing programs that focus on promoting sustainable forest management or conservation easements on forest lands at risk for conversion. In the end, achieving intended benefits hinges on designing carbon-focused incentives with an appreciation for the factors that drive landowner decision-making; existing programs or incentives form an important part of that equation (Butler 2008, Daniels et al. 2010).

Many of the existing landowner assistance or incentive programs target agricultural lands. Yet the actual prescribed land management practices on retired/easement lands or via working lands programs include forestry/tree-planting to help reach soil conservation, water quality, wildlife habitat and other goals. For example, 3.5 million acres of trees, or around ten percent of the program area, are presently enrolled in CRP (Hyberg, *pers. comm*). The 2008 Farm Bill further expanded the application of forestry practices by authorizing their inclusion in programs like EQIP and the Conservation Stewardship Program (CSP). The Natural Resources Conservation Service (NRCS), as the ground-level technical assistance provider or coordinator for many of these landowner assistance programs, maintains and continuously updates National Conservation Practice Standards. These published standards provide detailed descriptions of the requirements, criteria and implementation details for all approved practices.

Table C1. Overview of federally-sponsored land conservation programs

Program (Agency)	Acronym	Description	Area Enrolled (millions of acres)	Funding	C eligibility criteria?
Conservation Reserve (FSA)	CRP, CCRP CREP	Financial incentives to retire marginal cropland and establish grass or tree cover for 10 or 15 years, respectively.	~31	$1.7 billion	Yes
Forest Legacy (USFS)	FLP	Market value compensation for protecting sensitive forest lands at risk of conversion via permanent easements.	~1.98	$76 million for '10	No
Forest Stewardship (USFS)	FSP	Technical assistance to promote sustainable forest stewardship.	~34 (>300,000 plans)	~$29 million for '10	Yes
Urban & Community Forestry (USFS)	UCF	Promotes community and urban forestry initiatives, including competitive grants	n/a	~30 million for '07	Yes
Farm & Ranch Lands Protection (NRCS)	FRPP	Up to 50% of market value compensation for permanent easement to preserve agricultural use of farms/ranches.	>0.53 (1996-2007)	$90.4 million financial assistance; $4.7 million tech. assist.	Yes
Healthy Forest Reserve (NRCS)	HRFP	Cost-share for restoration + up to 100% market value compensation for permanent easements to benefit TES,[13] biodiversity & c-sequestration.	http://www.nrcs.usda.gov/programs/hfrp/proginfo/2009applications/2009HFRPApplications.html	$9.75 per anum 2009-2012	Yes
Wildlife Habitat Incentives (NRCS)	WHIP	Financial incentives to restore habitat for wildlife benefits	0.65	$85 million	No
Environmental Quality Incentives (NRCS)	EQIP	Provides technical & financial assistance for implementing practices that convey environmental benefits (and that often bring landowners into compliance with regulations)	16.8 (unclear if cum. or '08 figure)	$937 million for '08	No
Wetlands Reserve (NRCS)	WRP	Market value compensation for easement term + cost share for restoring or enhancing grasslands	2	~$400/yr	No
Grassland Reserve (NRCS)	GRP	Market value compensation for easement term + cost share for restoring or enhancing grasslands	0.093	$54 million for '06	No
Conservation Stewardship (NRCS)	CSP	Provides incentives for added conservation practices on working lands (included managed woodlands)	0	$259 million	No
Small Wetlands	n/a	Market value compensation for permanent wetland easement.	3 (over life of program)	n/a	No
Prairie and Grassland Easement (FWS)	n/a	Provides market value compensation for permanent easement and cost-share for any needed restoration	~0.7 in 2008	> 100 over life of program	No
Biomass Crop Assistance (FSA)	BCAP	Cost-share assistance for biomass crop establishment, along with collection, harvesting, and transport subsidies.	0 (payments to landowners have not yet begun)	$30 million for producer payments; $47 million for biomass utilization, ARRA	No

[13] Threatened and endangered species

None of these programs focuses directly on carbon sequestration, nor have they historically accounted for carbon benefits in program tracking in any systematic or rigorous way. However, carbon-related benefits are either explicitly or implicitly included in the eligibility/enrollment criteria for several programs. For example, the Forest Stewardship Program identifies the "carbon cycle" as one of thirteen resource elements to be addressed in stewardship plans developed by landowners; the Healthy Forests Restoration Program includes "carbon sequestration" as part of its purpose; and CRP includes carbon as a minor consideration in the Environmental Benefits Index used for ranking contract proposals in its periodic General Signups. Carbon sequestration fetches three to ten points in the "Air Quality Benefits" factor of the index, out of 410 total in the six combined factors.

In terms of accounting for carbon sequestration resulting from prescribed practices, both the Farm Services Agency (FSA) and Natural Resource Conservation Service (NRCS) have estimated figures corresponding to different practices applied on the ground, as averaged across the broad expanse of the country where these practices are applied. FSA publishes estimated greenhouse gas reductions each year in its annual fiscal year program summary, which averages to nearly 15.6 Tg C (57 Tg CO2 equivalent in reductions each year from 2005 to 2009, FSA, *in press*). Annual FSA estimates are the sum of sequestration resulting from tree-related practices, wetland practices, and grasses, added to avoided emissions from reduced fuel use and fertilizer reductions. NRCS estimates are tallied per practice since many of the eligible land management practices apply across multiple programs (NRCS 2009). Some of these estimates are derived from published CCX modeling work whereas others use carbon calculators such as COMET-VR. Still other carbon flux factor estimates are based on expert judgment in combination with calculations from the Intergovernmental Panel on Climate Change. NRCS estimates that a riparian forest buffer, for example, sequesters around 7.5 mt/380ft each year.

Despite greater inclusion of forestry practices within existing programs as outlined in the 2008 Farm Bill, the history of existing cost-share and incentive payments is tightly linked to agricultural land by historical design. The institutional and administrative culture of landowner assistance for agricultural lands is distinct from that of woodland owners. And though a great variety of forestry practices are available as management tools for achieving environmental benefits and/or regulatory compliance, none of these existing programs include provisions for the improved management of standing forest. The Forest Stewardship Program, for example, provides technical assistance alone without cost-share provisions or other financial incentives. Yet the National Woodland Owner Survey reveals that the vast majority of private forest landowners stand to increase both carbon and other environmental benefits by participating in FSP and/or other programs that incentivize improved forest management.

The cultural distinctions between predominantly agricultural landowners and private forest landowners, along with the need for forest management plans and financial incentives for keeping forest as forest, suggest that a carbon incentives program for improved forest management may fill a critical void. To be circumspect in exploring this possibility, **Table B2** provides a detailed analysis of carbon considerations in existing conservation and landowner assistance programs, including current thinking about more explicit focus on carbon in relation to the respective programs' core purpose. This analysis reveals that while increased emphasis on carbon within existing programs may offer climate change mitigation benefits, this is unlikely to address land management concerns for landowners of standing forest. Thus, to complement current and future landowner assistance programs that may focus on—or shift greater emphasis to—land management toward climate change adaptation and mitigation, in the next sections we develop a protocol for improved forest management that offers carbon benefits.

Table C2. Analysis of existing landowner incentives and assistance programs in relation to forest carbon conservation.

Program (agency)	*Existing authority to include carbon? Consideration of Carbon Benefits in Eligibility Requirements? How?*	*Carbon Accounting in program reporting? If no, ability to estimate carbon benefits? Potentially useful carbon accounting tools*	*Exclusionary conditions to participating in carbon incentives? Double dipping allowed?*	*Program status / Direction of current internal discussion (discussion, proposal to include carbon, any changes in program structure/admin that could be in next farm bill)*	*Co-benefits (particularly in relation to climate change mitigation and adaptation)*	*How would a more explicit focus on carbon relate to core purpose of program?*
CRP, CCRP, CREP[14, 15], (FSA)	Yes. Yes. Only one of six factors of EBI explicitly includes carbon: three to ten points for C-sequestration are awarded within Factor 5 ("Air quality benefits from reduced wind erosion"). Factor 5 is a minor consideration in the EBI, comprising <9% of the total points. Though no points are awarded for carbon benefits elsewhere in the EBI, the wildlife habitat benefits factor may entail additional C-sequestration.	No. Yes and has been done Trees planted/protected in CRP land, averaged annual estimates from 1999 to 2009, sequestered 15.2 tons per year. Entire program estimated to provide ~ 14 Tg C (52 Tg CO2) per year in greenhouse gas benefits. *COMET-VR + Trees[16]*	Currently, CCRP enrollment does not foreclose participating in other incentives provided no spatial overlap for payments or cost-share.[17] If carbon were explicitly tied to the CRP payment, however, this could be unattractive to landowners by precluding them from engaging in potentially more-profitable carbon markets.	Declining budget and emphasis: CRP & WRP together comprise ~50% of mandatory conservation spending within USDA for 2008-12, down from 90% in the 1990s. Congress decreased the CRP enrollment cap from ~39 to ~32 million acres in 2008 Farm Bill. The first general signup since 2006 was just held in March 2010.[18] CRP faces competition for (a) congressional budget (b) land during periods of commodity price spikes as in 2007-08 and (c) multiple bioenergy subsidies that raise opp. cost for land retirement.	Paying for more trees in CRP often increases the permanence of crop land retirement.[19] Accumulation of organic matter on retired cropland demonstrates "additional" soil carbon sequestration. Ensures non-crop reserve land in highly agricultural landscapes which could prove increasingly key to landscape heterogeneity and connectivity. Enhances water quality, provides wildlife habitat and landscape heterogeneity.	CRP is a land retirement program. Eligibility requires that land was used for "agricultural production",[20] so any relation to strict forest-based carbon incentives would translate to paying for a land use <u>*and*</u> land cover change, rather than paying to conserve standing forest. Grasslands currently comprise 90% of CRP land; afforestation/reforestation may not be appropriate on much of it.

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[14] Payment is related to local land rental rates considering the following: base rental rate, cost of installation of conservation practices, annual maintenance costs and any special incentives. The base rental rate is the average dry land cash rental rate based on the three predominant soil types of the land.

[15] Iterations of the CRP concept include CCRP where payments are made for partial-field conservation practices like establishing riparian buffers, grass waterways, or contour grass strips. Whereas CRP retires whole fields, CCRP applies to partial-field practices on land in agricultural production. CRP is accessed only through the General Signup whereas CCRP operates via "continuous" signup up to some enrollment cap. CREP is like CCRP except that s

[16] NRCS CarbOn Management Evaluation Tool for Voluntary Reporting.

Program (agency)	*Existing authority to include carbon? Consideration of Carbon Benefits in Eligibility Requirements? How?*	*Carbon Accounting in program reporting? If no, ability to estimate carbon benefits? Potentially useful carbon accounting tools*	*Exclusionary conditions to participating in carbon incentives? Double dipping allowed?*	*Program status / Direction of current internal discussion (discussion, proposal to include carbon, any changes in program structure/admin that could be in next farm bill)*	*Co-benefits (particularly in relation to climate change mitigation and adaptation)*	*How would a more explicit focus on carbon relate to core purpose of program?*
FLP **(USFS)**	No, not carbon *per se*. No, not explicitly (only that project land is 75% forest and risks conversion to other non-forest use).	No. Yes; 1.6 million acres over life of program. A stewardship plan is a prerequisite for easement. Data on forest types could be gathered from state FLP programs to estimate carbon stocks/benefits via published growth models or sequestration rates.	States play a large role in preparing FLP applications and in project selection so there is a wide degree of variation across states to which guidance will have to apply. Note that FLP easement properties retain rights in timber resources.	Currently preparing guidance on the issue of easements in relation to rights in ecosystem services and market engagement. Draft guidance <u>disallows</u> FLP land engaging in markets for regulatory compliance and vice versa. <u>Does</u> allow participation in voluntary markets and allow application to FLP for land already engaged in voluntary market, provided no conflict w/ core purpose of FLP.	Protects forest land in perpetuity, along with all the goods and benefits provided by forest areas. FLP serves as a key climate change adaptation tool by facilitating landscape connectivity	FLP purpose is to protect environmentally important forest areas threatened by conversion. More focus on carbon is not incompatible since FLP project areas could already be considered "avoided deforestation." A carbon focus could shift project prioritization in some areas, however, and would have to be balanced w/ other program goals.
FSP **(USFS)**	Yes. Yes. FSP identifies the "carbon cycle" as one of 13 resource elements that a Stewardship Plan must consider.	No. Record keeping and follow-up to see if Stewardship Plan is implemented varies drastically by state. Plans are underway to spatially track parcels w/ a plan which would help in estimating carbon stocks and sequestration potential.	FSP is not a cost-share program, though it is a baseline practice/activity for accessing other Farm Bill programs. Since technical assistance is the focus and no payments are made to landowners, there is no double-	FSP is in some ways a "baseline" for accessing other programs. It provides diffuse and varied forms of technical assistance that may be "branded" in different ways by different states, making it hard to quantify.	Core purpose of FSP is to enhance sustainability and management of private forests. Carbon incentives would, like so many other incentive and cost-share programs, require a Stewardship Plan. The practices required for	Carbon module could be added to stewardship plan where elected. Because FSP itself provides no incentive or cost-share, carbon incentives would only stand to increase enrollment but not deter from underlying purpose of FSP.

[17] For any federally-funded cost-share or incentive, the general rule is "no double dipping" for a particular geographic space. CCRP practices typically occur along riparian zones or other margins, rather than on whole farms. These payments therefore may be combined with other assistance for practices on other parts of the farm. Also, some biomass production incentives apply without regard to payments from other assistance programs.

[18] The CRP "General Signups" use the EBI to rank bids in a competitive process whereas the continuous enrollment process allows any landowner meeting the criteria to enroll up to the cap. The latter does not explicitly include carbon, provides a lower payment.

[19] Since hardwood trees substantially improve the EBI, most bids in the CRP General Signups include some tree planting. An increased emphasis on carbon in the scoring system could further influence the planting of hardwoods.

[20] Land must have a cropping history of 4 of 6 years between 2002 and 2007 (this time window set in the recent interim rule). Alfalfa is now considered a crop. Marginal pastureland is eligible for payments through some CRP practices.

Program (agency)	*Existing authority to include carbon? Consideration of Carbon Benefits in Eligibility Requirements? How?*	*Carbon Accounting in program reporting? If no, ability to estimate carbon benefits? Potentially useful carbon accounting tools*	*Exclusionary conditions to participating in carbon incentives? Double dipping allowed?*	*Program status / Direction of current internal discussion (discussion, proposal to include carbon, any changes in program structure/admin that could be in next farm bill)*	*Co-benefits (particularly in relation to climate change mitigation and adaptation)*	*How would a more explicit focus on carbon relate to core purpose of program?*
			dipping issue here.		enhanced carbon benefits could be an addendum to the plan.	
BCAP **(FSA)**	No, not in terms of sequestration though bioenergy may lower emissions compared to other energy sources depending on context. No. No.	No, not in terms of sequestration, though comparative net emissions and accounting protocols are under consideration	BCAP allows multiple incentives to flow to a given biomass producer: cost-share of 75% for crop establishment, CHST incentive to the refinery (could be same owner). Land eligible for BCAP includes CRP, WRP and GRP enrolled land, along w/ public lands. Writers of revised BCAP rule see program as compatible with carbon incentives as described here.	Payments terminated in Feb 2010. A revised/finalized rule is underway that may prohibit certain wood materials and change acceptable moisture content.	Highly variable due to the broad interpretation of biomass and the diverse, feedstocks and production systems.	At its core, BCAP focuses on producing biomass to harvest for energy production whereas carbon incentives would focus on enhancing sequestration *in situ*. In certain contexts, however, the prescribed practices for carbon incentives (e.g., removal of competing vegetation) could be mutually compatible.
FRPP **(NRCS)**	Not explicit. No. Targets NIPF land , permanent easement for farm/ranch; easement area must be < 2/3 forestland; FStewPlan req'd if 10+ acres or 10% of area; NRCS provides 50% of fair mkt value of conservation easement	No. Land uses and vegetation cover is diverse and unique within each parcel making post-contract accounting challenging.	Cannot conflict with the purpose of easement or provisions outlined in management plan. Unclear whether other Farm Bill incentives and cost-share assistance may be coupled with FRPP.	Seems unlikely to add carbon emphasis given the nature of the program.	Prevents urbanization, loss of open space.	Currently a maximum of 2/3 easement area may be forested. Increased emphasis on carbon may change this and shift profile to landowner profile that relies more on off-farm income.

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HFRP **(NRCS)**	Yes. Carbon sequestration is one of three program foci, though TES appears to be a greater emphasis in most states that won HFRP funding. Consideration of carbon varies in each of the eight funded states. States target TES habitat and carbon is secondary benefit, not explicitly targeted as selection criteria.	No. Since program documents baseline habitat conditions and requires a Forest Stewardship Plan that outlines forest management, carbon benefits could be estimated.	Only to the extent that landowner cannot act contrary to purpose and restrictions in easement or the prescribed management plan. Otherwise, this could be combined with C-incentives.	Funded through 2012. No particular change to more-explicitly incorporate carbon benefits is imminent.	TES habitat conservation, forest restoration.	FWS is a key implementing partner and more emphasis on carbon would likely need to take care not to diminish the focus on TES habitat.
WHIP **(NRCS)**	Not explicit. No. WHIP priority areas are determined by states' habitat conservation plans.	No.	Unclear.	Baseline survey/assessment would have to be redesigned to include carbon. Unclear whether there may be justification or interest in program administration for doing this.	TES habitat restoration and conservation.	Emphasis is more on critical habitat so to the extent that carbon focus would not conflict with designated priority areas or with restoration plan in situ, carbon incentives could be compatible with core purpose.
EQIP **(NRCS)**	Not explicit. Sometimes.	Yes and has been done based on data in the NRCS Performance Results System:	EQIP contracts often occur along the margins and may complement cost-share or incentives program contracts on other parts of farm.	Increasing discussion about carbon within program focus.	Regulatory compliance, restoration of degraded riparian zones, reduced nutrient loading and thus emissions from water surface/aquatic respiration.	EQIP is typically intended to bring producers into compliance when there is a problem, providing a cost-share for practices that bring producers into compliance

Program (agency)	*Existing authority to include carbon? Consideration of Carbon Benefits in Eligibility Requirements? How?*	*Carbon Accounting in program reporting? If no, ability to estimate carbon benefits? Potentially useful carbon accounting tools*	*Exclusionary conditions to participating in carbon incentives? Double dipping allowed?*	*Program status / Direction of current internal discussion (discussion, proposal to include carbon, any changes in program structure/admin that could be in next farm bill)*	*Co-benefits (particularly in relation to climate change mitigation and adaptation)*	*How would a more explicit focus on carbon relate to core purpose of program?*
WRP **(NRCS)** **2 million acres (cum. by '08)** **~$400 million/yr**	Not explicit. No.	No. Yes and has been done based on data in the NRCS Performance Results System:	May not conflict with purpose and terms of easement but engagement in ecosystem services markets is possible.	Annual enrollment declining since 2002 despite high demand	Protects land in perpetuity; key cc adaptation tool by facilitating landscape connectivity	
GRP **(NRCS)**	Not explicit but can be/is sometimes considered where interest in carbon market exists.	Yes and has been done based on data in the NRCS Performance Results System:	May not conflict with purpose and terms of easement. Landowner retains rights to carbon and may sell credits.	NA.	Protects land in perpetuity; key cc adaptation tool by facilitating landscape connectivity	Could affect prescribed vegetation management practices to some degree, but would not really alter core purpose of program.
CSP **(NRCS)**	Yes, indirectly. Could target carbon under its "special project" designation; not sure this has been done. Indirectly, project dependent. Payments commensurate w/ "Conservation Measurement Tool" score. Tool does not account for C benefits,	No. Could be estimated from CMT.	Rights to credits or marketable benefits resulting from CSP practices are retained solely by CSP contract holder (p. 44 of comments doc). Lands already enrolled in CRP, WRP, GRP or former CSP are ineligible for CSP contracts but payments through	In the 2010 Final Rule (there were many comments related to carbon, and p. 25 mentions the possibility of directly accounting for environmental benefits like c-seq rather than practice-based approach alone: http://www.nrcs.usda.gov/programs/new_csp/special_pdfs/2010-12699.pdf	Approach is holistic farm management for "additional" environmental uplift.	"Forestland" here includes land suitable for tree planting. Payments for carbon could skew program toward re-/af-forestation activities with associated tradeoffs in benefits. CSP contracts are for 5 years. Increased emphasis on carbon would likely imply extending this term.

Program (agency)	*Existing authority to include carbon? Consideration of Carbon Benefits in Eligibility Requirements? How?*	*Carbon Accounting in program reporting? If no, ability to estimate carbon benefits? Potentially useful carbon accounting tools*	*Exclusionary conditions to participating in carbon incentives? Double dipping allowed?*	*Program status / Direction of current internal discussion (discussion, proposal to include carbon, any changes in program structure/admin that could be in next farm bill)*	*Co-benefits (particularly in relation to climate change mitigation and adaptation)*	*How would a more explicit focus on carbon relate to core purpose of program?*
	even though it evaluates practices that do convey such benefits (e.g. wildfire prevention, tree planting, etc.)		other programs is allowed.			
Prairie and Grassland Easement Program (FWS)	Not explicit. Not in most cases. Some intermediary organizations that facilitate easements (e.g., Ducks Unlimited) may facilitate the sale of carbon credits from conserved land in voluntary markets.	Only in cases of sales for voluntary markets, where the accounting follows the standard prescribed by that market (e.g., CCX).	Cannot overlap with other landowner assistance programs like CRP or WRP, but participation in other programs that do not conflict with the terms of the easement is allowed.	No consideration at national level for increasing program focus on climate change mitigation. However, at local implementation level, landowners are interested in greater participation in carbon markets after signing easements.	Landscape-level habitat conservation and maintenance of hydrologic connectivity.	Currently, vegetation management is allowed (burning, cutting, etc.) with certain timing and intensity restrictions. This aspect of the program could change if C-storage maximization were goal.

Appendix D. Sample Silvicultural Systems and Practices

1. Systems incorporating higher post-harvest retention practices.

Definition. Practices that retain a volume of standing trees not typically be retained following a harvest. Tops and limbs may also be retained or returned to the stand in areas where biomass markets drive whole tree removal. Benefits include greater amounts of carbon stored in residual stand that continues to accrue volume between harvests. Forest floor carbon from tops and limbs also accumulates and contributes to long-term soil carbon stocks. Retention of tops and limbs may also minimize soil carbon lost during harvest disturbance. Retention practices should not significantly compromise silvicultural objectives or create structural conditions outside the range of natural variability (and thus contribute to increase risk of catastrophic disturbance).

Practice Types. Set stand-level retention guidelines (e.g., Basal Area, Trees Per Acre) within accepted silvicultural practices and range of natural variability for a given cover type. Guidelines can be established within different silvicultural systems that can be adapted for all regions. For example:
Even-aged management (i) clearcut with minimal retention replaced with increased post-harvest retention of trees in clumps or dispersed, or (ii) two-entry shelterwood replaced with three entry shelterwood and additional retention during overstory removal.
Uneven-aged Management: selection silvicultural system maintaining residual basal area closer to A line in stocking table (compared to retention close to B line or below)

Data/tools that can be used to assess carbon sequestration benefits:

1. FVS Model of post-harvest retention scenarios
2. Basal Area Carbon Relationship (linear relationship)
3. Stocking Tables – trees per acre/basal area relationship maintain closer to A line, rather than between B and C lines.
4. State level forest practices act as floor setting mechanism establish a percent target increase over floor.

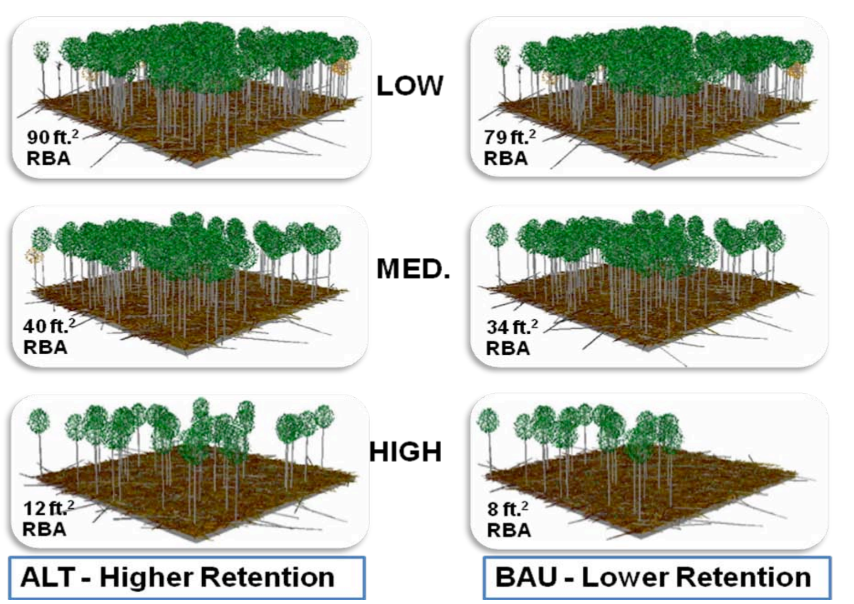


Figure D1. Visualization of examples of post-harvest retention (RBA = residual basal area) differences in a "business as usual" scenarios versus and "alternate" retention strategy with a carbon storage objective from north-central Minnesota aspen cover type. Alternate retention objectives can be set without compromising silvicultural objectives for a stand.

Table D1. Mean Metric Tons Carbon per acre (MtC/acre) post-harvest carbon differences derived from FVS modeled stands in north-central Minnesota (*from* Gunn et al. In Press). *Note: Standard Error of Mean post-harvest retention volumes average 0.18 MTC/ac*

Harvest Type	Retention Practice	Ash	Lowland Hardwood	Aspen	Birch	Northern Hardwood	Oak
	Pre-Harvest Volume	23.33	25.94	22.25	22.32	25.35	31.17
Clearcut	**BAU (8 ft^2/ac)**	1.98	2.06	2.07	2.27	2.41	2.73
Partial Harvest/ Shelterwood	**BAU (34 ft^2/ac)**	8.32	9.21	8.54	9.64	10.01	11.77
Selection/Crop Tree Release	**BAU (79 ft^2/ac)**	19.01	21.41	19.15	20.09	22.30	26.38
Clearcut	**Carbon Retention (12 ft^2/ac)**	2.96	3.10	3.09	3.41	3.60	4.12
Partial Harvest/ Shelterwood	**Carbon Retention (40 ft^2/ac)**	9.78	10.86	10.00	11.28	11.69	13.85
Selection/Crop Tree Release	**Carbon Retention (90 ft^2/ac)**	20.78	23.30	20.76	21.39	24.02	28.71
Carbon Benefit (Retention minus BAU)							
Clearcut		0.99	1.04	1.02	1.13	1.20	1.39
Partial Harvest/ Shelterwood		1.46	1.65	1.46	1.64	1.69	2.08
Selection/Crop Tree Release		1.77	1.89	1.61	1.29	1.71	2.33
Mean (MTC/ac, all types)		**1.52**					

Technical hurdles. Establishing the retention target has a hint of requiring a "baseline" definition. But "typical" retention levels can be readily defined from state forest practices codes, FIA data, and expert surveys and an alternate "carbon" retention level can be chosen that does not compromise silvicultural objectives. Additional guidance can be created to identify the types of trees to retain such as long-lived species and typical "cull" trees that would likely continue to live for decades and then ultimately would contribute to forest floor and soil carbon pools over time.

Co-benefits. Retaining higher post-harvest volumes of large diameter trees likely will have biodiversity benefits for a range of species including cavity nesters, raptors, lichens, mast-consuming species, etc. Retention of coarse woody debris will also benefit aspects of biodiversity dependent upon forest floor structure. Benefits could also be seen in the maintenance of soil nutrients and organic carbon.

Other resources:

1. Climate Change, Carbon, and the Forests of the Northeast by Robert T. Perschel, Alexander M. Evans and Marcia J. Summers (Forest Guild 2007)
2. Engaging Western Landowners in Climate Change Mitigation: A Guide to Carbon-Oriented Forest and Range Management (PNW-GTR 801)

2. Systems incorporating “Carbon Reserves” through mature forest recruitment.

Definition. Maintaining stands with forest structural components that are consistent with “mature forest” or “late-successional, old-growth” (LSOG) characteristics. In the northeast, such characteristics typically develop in stands that have been free of stand-replacing disturbances for over 100 years. The temporal component will vary by region and forest type. Typical characteristics include: large trees (e.g., > 16” dbh in northeast); multiple age classes; dominance of shade tolerant species; high density of lichens present on trees; and large standing dead trees. Mature forests typically will have a higher volume of carbon stored per acre than the mean for a given forest type (see examples below, e.g., carbon volume can be 3 to 4.7 times higher than mean).

Practice Types
(i) Retain existing mature or LSOG stands. Establish “carbon reserves” that are set aside as no harvest areas to retain stands with existing mature or LSOG structure. Stands should have low risk of catastrophic natural disturbance and a high likelihood of persisting for 50-100 years based upon lifespan of within stand species mix.
(ii). Recruit mature forest components through post-harvest retention of characteristics (refer to harvest retention practices). Uneven-aged management techniques can be employed to encourage the development of mature and LSOG characteristics. The “harvest retention practice” can be used to achieve this objective. Several resources exist to characterize mature and LSOG structural components. (see below)

Table D2. Data Example: Comparing LSOG Carbon volume with “typical” stand volume in northeast. *Climate Action Reserve Appendix F. Common Practices Mean for Northeast Ecoregions*

Ecoregional Supersection	Common Practice - Above Ground Carbon Mean in Metric Tonnes C/acre (BA)	Range (depends on site class, forest type)
Lower New England - Northern Appalachia	25 (111)	16-32
Maine - New Brunswick Foothills and Lowlands	14 (97)	7-22
Central Maine & Fundy Coast & Ebayment	16 (103)	11-23
Aroostook Hills and Lowlands	16 (107)	7-45
White Mountains	16 (100)	11-23

Figure D2. Ducey, Gove, Gunn, & Saah, In prep. Maine Family Forest Carbon Project Data (12 landowners, 82 stands) Western, Central, & Eastern Maine Carbon Stocks in "Typical" Stands

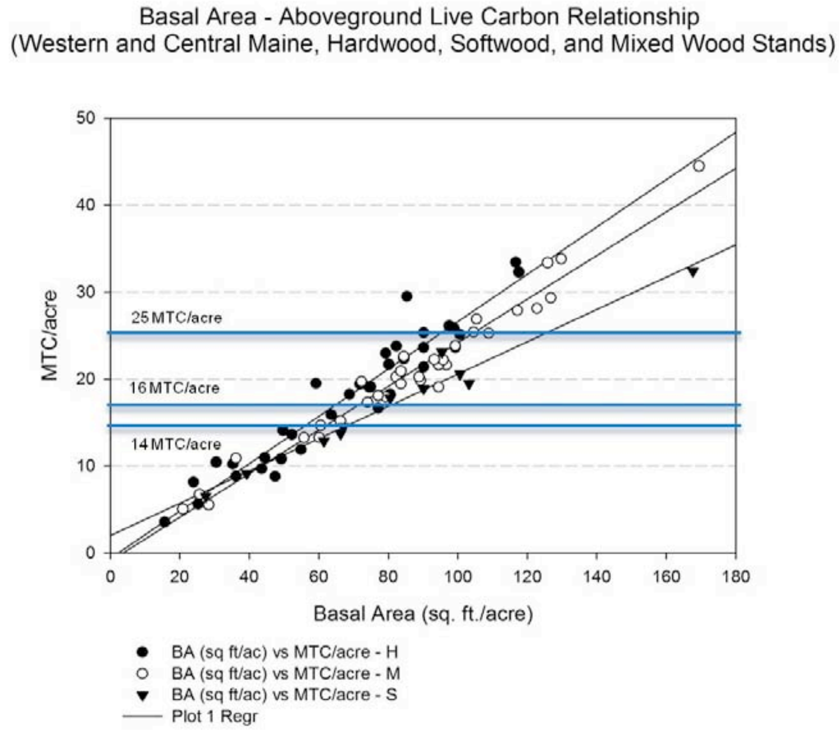
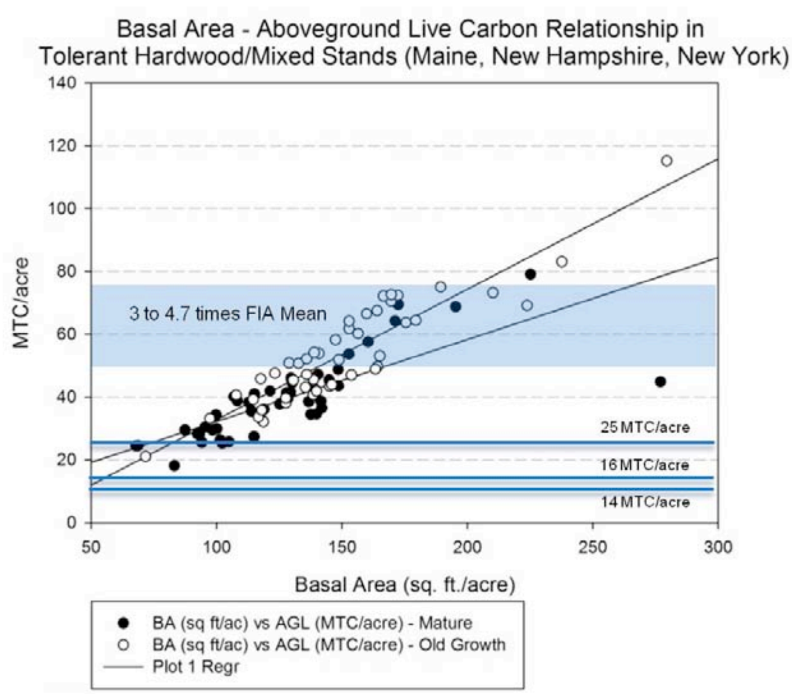


Figure D3. Keeton, W.S., A. A. Whitman, G.G. McGee, and C.L. Goodale. In Press. Late-successional biomass development in northern hardwood-conifer forests of the northeastern United States. Forest Science. Mature = 80-150 yrs; Old Growth= >150 yrs n=94



Data/tools that can be used to assess carbon sequestration benefits.

1. FVS Model of mature forest carbon accumulation trajectory
2. Basal Area Carbon Relationship (linear relationship)
3. Climate Action Reserve (CAR) Common Practices Baseline Appendix F
4. Trust to Conserve Northeast Forestlands Loggers' Guide to Mature Forest Structure
5. Hagan, J. M., & Whitman, A. A. (2004). Late-successional forest: a disappearing age class and implications for biodiversity. Brunswick, ME: Manomet Center for Conservation Sciences. www.manometmaine.org/documents/FMSN_LSPopularVer9_10pt.pdf
6. Keeton, W. S. (2005). Managing for old-growth structure in northern hardwood forests. Proceedings of the 6th Eastern Old Growth Forest Conference, pp. 6–11. www.masswoods.net/pdf/managing_og_structure_keeton.pdf
7. D'Amato, A., and Catanzaro, P. 2007.Restoring Old-Growth Characteristics. University of Massachusetts Cooperative Extension. http://harvardforest.fas.harvard.edu/publications/pdfs/Damato_umassextension_2007.pdf

Notes and technical hurdles.

- Leakage concerns should be minimal given dispersed landowners, variability of management rationale, and generally small stand size.
- Lack of forest-type specific LSOG indices for all regions may be a challenge.
- May require natural disturbance regime risk assessment mapping or other systematic evaluation.

Co-benefits. Retaining LSOG stands and structure likely will have biodiversity benefits for a range of species including cavity nesters, raptors, lichens, mast-consuming species, deer wintering areas, etc. The retention of coarse woody debris will also benefit aspects of biodiversity dependent upon forest floor structure. Benefits could also be seen in the maintenance of soil nutrients and organic carbon.

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