National Forest Carbon Inventory Scenarios for the Pacific Southwest Region (California)

Region 5 Climate Change Interdisciplinary Team

REPORT SUBMITTED TO:

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Pacific Southwest Region

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Conveyance Memo

TO: Randy Moore, Regional Forester, Pacific Southwest Region, and Deanna Stouder, PhD, Station Director-PSW Research Station

FROM: Bruce Goines, Team Leader, Pacific Southwest Region, and Mark Nechodom, PhD, Co-Lead, Pacific Southwest Research Station

We are pleased to convey the findings of the Climate Change Interdisciplinary Team (CCIDT) in fulfillment of the Forest Service's commitment to assess the carbon benefit capabilities of the national forests in the Pacific Southwest Region over the next 100 years and to join California in meeting greenhouse gas reduction goals established under California's "Global Warming Solutions Act of 2006." The Team was composed of resource specialists and technical experts from the Region, and worked under the shared leadership of Cooperative Forestry and Research and Development.

In 2007, the 20.2 million acres of national forests in Region 5 held nearly 620 million tons of carbon in live tree biomass. By 2107 – depending on Forest Service management choices – the Region's national forests could either lose *or* gain several hundred million tons of carbon. The pathways to those outcomes might vary from creating highly resilient forests with fewer, larger trees; to overstocked forests with smaller trees and severe fires resulting in long-term losses of carbon and other values; to intensive management resulting in shifting millions of tons of carbon from the forests to wood products and bioenergy.

In order to examine these options, the Team developed six management scenarios in which changes in carbon inventories were quantified over a 100-year timeframe. In addition, the study determined the monetary value of the carbon inventories, using hypothetical market assumptions, and evaluated the feasibility of measuring non-market benefits, or ecosystem services, associated with the national forest management in California.

The six scenarios – projected over the next century – included: "Business as Usual" management practices that reflect current practices and performance; "Business as Usual" with an additional aggressive post-fire reforestation program; the full implementation of the Land and Resource Management Plans for each national forest, as currently written and amended; and three scenarios with varying degrees of manipulation of stand structure to improve forest and stand resiliency to disturbance from fire, insects and disease and other factors. The modeling used readily-available growth and inventory data, combined with scientifically-based disturbance projections and staff expertise in forest resource management costs, practices and principles.

Ecosystem integrity, biodiversity, water quality, air quality, public health, property values, aesthetic values and a host of other resource values are tied to the resiliency of forests over time. The Team's rapid assessment raises significant questions regarding sustainability of national forest ecosystems under current management practices and program levels. It also poses important challenges to the Forest Service and its partners as all interests consider the long-term implications of federal management choices.

Key Findings:

The national forests in California will become net emitters of carbon by the end of the century. For the next 4-6 decades, under a Business as Usual (BAU) trajectory, the national forests will accumulate carbon at a higher rate than carbon will be lost through disturbances such as wildfire, pest mortality and inter-tree competition. However, at some point in the mid-21st century, losses from wildfire, disease and other disturbances will exceed growth. National forest carbon sinks will become unstable and unsustainable, under the BAU scenario.

Achieving high levels of carbon sequestration may be incompatible with other resource objectives. For example, the Maximum Forest Resiliency (MaxFR) scenario would reduce canopy cover below current Forest Plan requirement for some forest types, and may not be compatible with the maintenance of other multiple resource values.

Substantial levels of investment in management will be required for systemic, long-term carbon returns. This includes significant investments in post-fire reforestation and pre-fire thinning operations. Given the history of national forest management in the United States, nearly all future management strategies will be increasingly costly, whether driven by fire suppression, vegetation management or intensive protection of high-value resources on the landscape.

The sustainability of the Region's national forest carbon sinks over the next 100 years will depend on increasing the effectiveness of fire and forest health management strategies. Current management levels (modeled under the BAU scenario) will not achieve the level of improvement in forest health or the reduction of wildfire effects presumed by current policy direction.

Recommendations:

1. **A national-level team should extend this assessment to include wildfire emissions, bioenergy benefits, other carbon pools, ecosystem services values and a comprehensive economic assessment.** Further, that team should be charged to develop optimal strategies and investments to ensure stability and resiliency of the natural systems under our jurisdiction. This would require significant investment of staff and analytical capacity, and would likely require an extended commitment of a small number of professional and scientific experts.
2. **This analysis should be used as an opportunity to engage the public and the Forest Service's strategic partners in meaningful dialogues about the long-term implications of management activities on our national forests.** The Team's findings raise profound questions about trade-offs between near-term benefits and long-term consequences that must be addressed as public policy questions and choices.

We are proud of the work the Team was able to produce within the given constraints of time and resources. And we appreciate your willingness to invest time and resources in the overall understanding of carbon benefits from forests that is currently evolving in California. We hope this assessment will provide a cornerstone for building and extending the kinds of analyses that will meet the national scope of the challenges ahead.

R5/PSW Climate Change Interdisciplinary Team (CCIDT) Members

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This project and report are products of many hands. Beyond the Team members and authors already listed, there are several who contributed advice and analysis deserving of our sincere thanks.

The challenging task of justifying our assumptions about disturbance regimes, past and future, was unstintingly supported by our colleagues of the Stewardship and Fireshed Assessment program at McClellan: Jay Miller, JoAnn Fites-Kaufmann, Berni Bahro, Joe Sherlock, Laurie Perrot, Nathan Amboy and Tanya Kohler. The imagination and skill is theirs; the errors are ours.

A tough but friendly review was joined by several top experts, including: Rich Birdsey, Jeremy Fried, Matt Herteau, Chris Keithley, Max Moritz, Malcolm North, Tim Robards, Bill Stewart, Laurie Tippin, Tony Tooke and Doug Wickizer. While we may not have answered their tough questions adequately, we are doubtless improved because of them.

The Forest Service's Washington Office Policy Analysis team provided valuable help and feedback, probably increasing our intelligibility quotient immeasurably: Bill Lange, Duncan McKinley and Erin Uloth.

We are also much indebted to the indirect, but nonetheless influential, contributions of our colleagues serving on the California Climate Action Registry's Forest Protocol Technical Working Group, led with inimitable focus and aplomb by John Nickerson. If there is rubber on the tires, and should there be a road ahead, this is where they will meet.

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Executive Summary

California has become a national leader in meeting the challenges of climate change and in determining the roles of forests in reducing atmospheric greenhouse gases. California's Global Warming Solutions Act, known as Assembly Bill 32 (AB 32), requires statewide greenhouse gas (GHG) reductions to 1990 levels by 2020, with an additional reduction of 80% of 1990 levels by 2050 through an Executive Order (ES-03-05) of the Governor. The California Air Resources Board (ARB) is the lead regulatory and policy body charged with developing rules, protocols and policies to meet those targets.

California's forests and rangelands will play an important role in sequestering carbon and helping the state meet its greenhouse gas emissions reduction goals. Forests and rangelands in California, nearly half of which are on national forest lands, store a large quantity of terrestrial carbon in living biomass, standing and downed woody debris, duff, litter and soil organic carbon. Forest management can affect inventories of stored carbon by manipulating stand structure, composition, growth rates, and influencing the frequency, size and severity of natural disturbances that would reduce carbon inventories. Forest products also provide climate benefits by storing carbon in wood products, and by offsetting fossil-fuel energy as a source of carbon-neutral bioenergy for heat and electricity. Additional benefits may be measured because of substitution of wood for more energy intensive building products.

California state law requires AB 32's rules and regulations to be ready for implementation by January 1, 2010. Over the past two years, several state agencies, the Forest Service, University based researchers, a number of Non-government Organizations, and California's industrial and privately owned forestry leaders have been deeply involved in developing the policy framework and estimating potential contributions of forest lands to achieve targeted reductions.

In February 2008, the Pacific Southwest Regional Forester and the PSW Station Director assembled a Climate Change Interdisciplinary Team (CCIDT) to evaluate the potential for national forest lands in California to play a role in meeting AB 32 goals, in addition to supporting climate change mitigation and adaptation efforts. The Team –

comprised of specialists from State and Private Forestry, Research and Development and National Forest System – was chartered to utilize best available data, science and modeling techniques to complete a rapid assessment of carbon sequestration capabilities and associated costs on the national forests in California. This report represents the Team's findings. The following findings and recommendations conclude that additional analyses and scenarios may be appropriate in order to stimulate broad policy discussions and decisions.

The Team estimated carbon inventories and modeled growth and disturbance under six management scenarios over a 100 year period. Carbon inventories were benchmarked against the official AB 32 reference years of 1990, 2020 and 2050. The scenarios were designed to represent a range of management approaches, including intensities of forest stand manipulation and levels of investment. Modeled carbon inventories were expressed in millions of metric tons of carbon dioxide equivalent (MMTCO2e) in three major pools: 1) above ground live biomass, 2) harvested wood products, and 3) bioenergy (i.e., non-merchantable biomass that could be converted to renewable heat, power and biofuels, and are considered "carbon neutral").

These carbon pools were selected to serve as indicators of carbon values associated with the various management scenarios. Additional carbon pools such as below ground biomass, soil carbon, duff and litter, above ground dead biomass were not selected for modeling in this report, but should be included in a subsequent assessment. Although the carbon accounting procedures for UN Framework Convention on Climate Change and Kyoto protocol exclude carbon stored in wood products, California's ARB is currently considering whether and how to account for the carbon benefits of long-lived forest products and energy derived from renewable fuels. Because of these active deliberations, and the fact that this analysis can inform policymakers on real, measurable and verifiable carbon pools in the forestry sector, the Team decided to include carbon sequestration in solid wood products and immediate offsets of emissions from renewable energy resources. Other carbon accounting challenges, such as bioenergy and substitution of solid wood products are currently being debated in policy forums.

It is important to note that wildfire emissions – potentially a major source of carbon flux on national forest lands – were not measured or modeled in the initial assessment. While reviewers urged the Team to analyze emissions from all disturbances – such as wildfire and significant die-back from insects and disease – the Team determined that the modeling requirements would far exceed the limited resources available.

This study was designed as a rapid, macro-level assessment of forest carbon inventories, values, and implementation costs under six management alternatives modeled over 20 million acres of California's national forest lands using the best available data and modeling techniques. Regional growth and disturbance models were applied using Forest Inventory and Analysis (FIA) data, contemporary research and expert judgment of scientists and practitioners familiar with California's forests. The results reflect general projections rather than site-specific predictions of growth and disturbance, and display the key resource impacts of alternative management approaches. Precise modeling of unique vegetative types was beyond the scope of this analysis, and was constrained by a dearth of peer-reviewed research and scientific consensus on modeling disturbance in complex forest ecosystems.

Management Scenarios

Six scenarios were developed to depict a range of hypothetical approaches, designed to evaluate how different management regimes might affect forest growth and disturbance, expressed in terms of carbon storage and loss. The costs, revenues, acres treated and resulting carbon inventory volumes are reasonable estimations developed for this analysis only. They are not intended to be realistic or achievable within the current organizational, budgetary or regulatory environment. Each scenario is measured against a 1990 inventory reference point to assess the contributions of national forest lands to AB 32's goal of statewide greenhouse gas (GHG) reductions to 1990 levels by 2020, and 2050, and out to 2110.

Brief descriptions of the modeled scenarios follow, with more detailed descriptions found in the body of the report and in the appendices:

Business as Usual (BAU): The Business as Usual scenario is a projection of existing trends in management activities, budgets, workforce and anticipated social constraints. The scenario conforms to the Standards and Guidelines published in the Region's existing Land and Resource Management Plans (LMPs), but assumes a much reduced management accomplishment level compared to the number of acres identified in the official LMPs for each national forest in the Region. This reflects current reality in national forest management in California.

Land and Resource Management Plan (LMP): This scenario is a projection of management activities on the Region's national forests as described in existing LMPs, assuming that they are completed as written and amended and authorized with unconstrained budgets and workforce.

Intensive Even-Age Management (IEAM): This scenario is a simplified projection of an even-age, regulated forest management regime on a 70 year rotation, and maximizes carbon sequestration by replacing a stand of trees when it has reached culmination of mean annual increment (CMAI), or the maximum *annual rate* of carbon sequestration. It is a rough proxy for "Option C" for private industrial forest land management under the California Forest Practices Act. Option C is currently used to establish baseline under the California Climate Action Registry (CCAR) protocols as adopted by the California ARB in December 2007. In other words, this is the "business as usual" presumption applied to projects under the CCAR protocols as they were originally written in 2005.

Minimize Canopy Disturbance (MinCD): The Minimize Canopy Disturbance scenario (MinCD) is based on retaining standing carbon inventory in trees larger than 20" DBH (diameter at breast height) and maintaining high-density canopies as required under current Forest Plans for the Sierra Nevada. Under this scenario, management activities are designed to reduce surface and ladder fuels and retain carbon inventory in larger trees. Management activities are limited to hand or mechanical treatments that remove trees likely to be killed by a moderate fire (5-foot flame lengths) and to a follow-up prescribed underburn to reduce ground fuels. Purposeful reductions in existing canopy cover would be minimal.

Maximum Forest Resiliency (MaxFR): The MaxFR scenario removes suppressed intermediate and co-dominant trees up to 30" DBH, retains the most vigorous trees and reduces canopy cover to not less than 35%. Treatments are followed by underburning (or prescribed fire) to remove surface fuels. Acres burned to a deforested condition are assumed to be reforested within the decade following a wildfire event.

BAU Plus Reforestation (REFOR): This scenario was developed to model aggressive reforestation after wildfire. The REFOR scenario models reforestation on all acres deforested by wildfire, while maintaining the same management levels modeled under the BAU scenario.

Findings and Recommendations

1. Carbon sequestration under the "Business as Usual" (BAU) scenario will outpace losses to wildfire, pest, drought, and inter-tree competition for the next 4-6 decades. However, at some point in the mid-21st century, carbon losses (from wildfire, disease and other disturbance) overtake growth. The Region's national forests will become net emitters of carbon during the latter half of the 21st century under the BAU scenario.
2. The sustainability of the Region's forest carbon sink in the next 100 years is largely dependent upon the frequency and the extent of wildfire, and the effectiveness of forest health management strategies.
3. The precision of forest carbon measurements and predictions of future carbon inventories are extremely limited at large scales because of uncertainty in current inventories, and particularly in forest ecosystem components that have not been historically measured.
4. Long-term increases of carbon inventories in California's national forests will depend on the establishment of forest ecosystems that are resilient to increasing disturbance under anticipated changing climate regimes.
5. Maximum carbon sequestration is not always compatible with other resource objectives. Some trade-offs in other ecosystem values, including habitat and recreation qualities, may be required to maximize national forest carbon sequestration capabilities.
6. Assessments of the roles of forests in climate regulation and mitigation must include consideration of sequestration of carbon in forest products and the reduced carbon emissions associated with bioenergy produced from forest biomass.

The following two figures synthesize the modeled carbon inventories for the six scenarios. Figure 1 depicts inventories of the three major carbon pools modeled in this study: 1) above ground live biomass, 2) harvested wood products, and 3) biomass converted to renewable heat, power and bio-fuels. Figure 2 depicts above ground live biomass only.

Note that there are substantial differences in inventory, relative to the 1990 baseline, between Figures 1 and 2. Figure 1 shows a much higher level of total carbon inventory because both harvested wood products and bioenergy are included in the total amount of carbon tonnage counted.

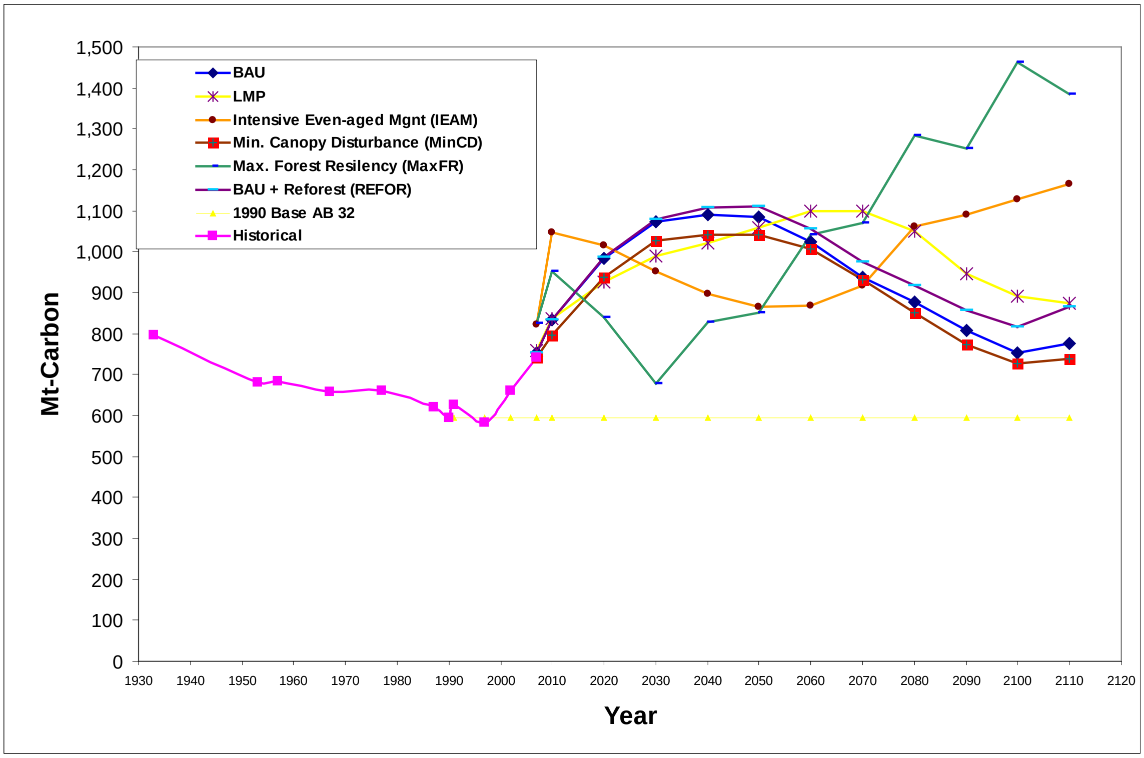

Figure 1 - Projected changes in Carbon inventories *including wood products and biofuel substitution*

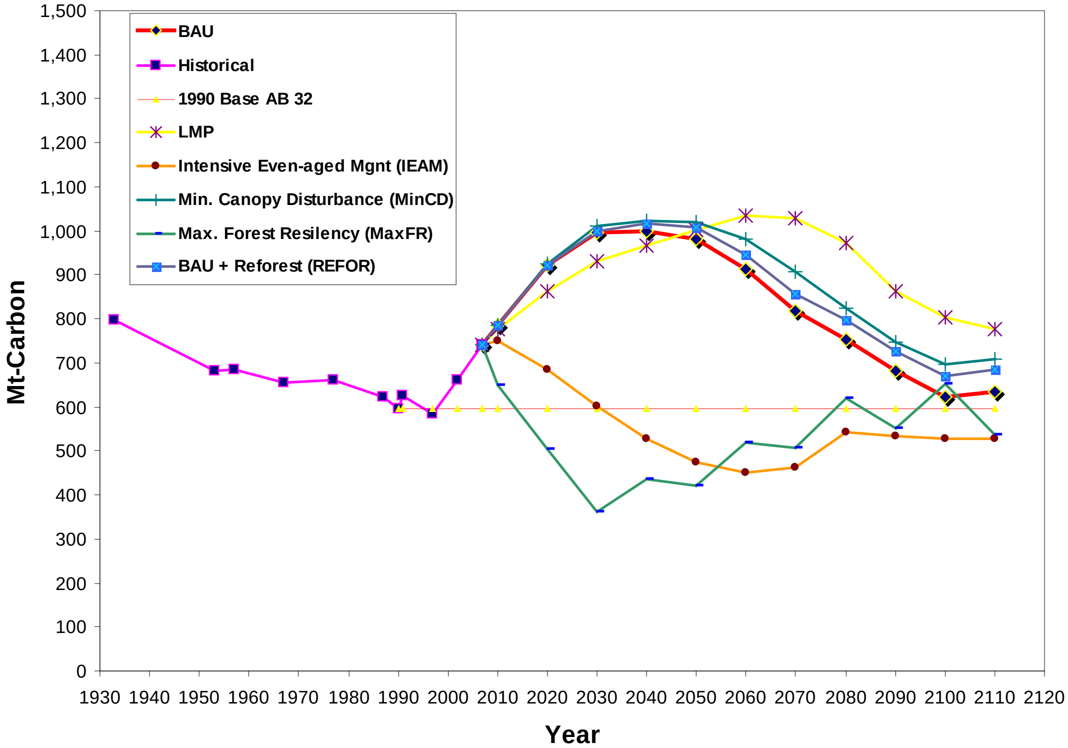

Figure 2 - Projected Changes in Carbon Inventories of *Above Ground Live Biomass Only*

Further interpretations of each scenario are included in the analysis and discussion below, with detailed descriptions of the modeling assumptions for each scenario in the appendices.

Introduction and Context

Forest systems are an integral component of global carbon cycles. Forest growth and disturbance also represent the sequestration and release of carbon. This report is an assessment of U.S. Forest Service Pacific Southwest Region 5 lands capability to sequester carbon under a range of forest management and disturbance scenarios. It was designed as a quick assessment using best available information, and does not represent a final analysis for management consideration. This report serves to better understand carbon cycle implications of different approaches and intensities of forest management and to identify areas of opportunity for further analysis.

Relationship to California Global Warming Solutions Act-Assembly Bill 32

This analysis was developed in parallel with the state of California's efforts to significantly reduce the greenhouse gas emissions for all sectors in the state. California's Global Warming Solutions Act, known as Assembly Bill 32 (AB 32), requires statewide greenhouse gas (GHG) reductions to 1990 levels by 2020. In addition, by Executive Order ES-03-05, Governor Schwarzenegger ordered additional reductions to 80% of 1990 levels by 2050. The California Air Resources Board (ARB) is the lead regulatory and policy body charged with convening interests, scoping sources and potential sinks, formulating the strategy to achieve the mandated reductions and developing rules, protocols and policies to meet those targets. State law requires those rules and regulations to be ready for implementation by January 1, 2010.

In analyzing greenhouse gas sources and sinks, California's forests and rangelands were identified as an important sector capable of sequestering additional carbon and helping the state meet their greenhouse gas emissions reduction goals. These forests and rangelands, nearly half of which are on national forest lands, store a large quantity of terrestrial carbon in living biomass, standing and downed woody debris, duff, litter and soil organic carbon. Forest carbon inventories are directly affected by management activities and by levels of disturbance from fire, insects and diseases and other factors that affect forest inventories. Forest growth and disturbance levels are affected by manipulating stand density, age, species composition, amount and location of ground and ladder fuels, and, by influencing the frequency, size and severity of natural disturbances that would reduce carbon inventories. Harvested forest products provide climate benefits by storing carbon in wood products, and providing a source of carbon-neutral energy in the form of heat and electricity. Wood products also provide climate benefits by serving as a substitute for more energy-intensive building products.

A great deal of analysis is being performed to determine the capability of California's forests to contribute to AB 32 goals. Several California state agencies, the forest products industry, university researchers, a number of land conservation non-governmental organizations (NGOs) and the Forest Service have been deeply involved in developing the policy framework and estimating forest lands' potential contributions for targeted reductions.

AB 32 Scoping Plan

In October 2008, the state of California produced a Proposed Scoping Plan target for California's forest sector. This plan proposed that the forest sector maintain the current 5 Million Metric Tons of CO2 equivalent (MtCO2e) per year of sequestration through 2020. This would be achieved by continuation and enhancement of sustainable forest management practices, including reducing the risk of catastrophic wildfire, and the avoidance or mitigation of land-use changes that reduce carbon storage. The scoping plan also recognizes the importance of promoting sustainable forest management, conserving biodiversity, providing recreation, and other benefits associated with sustainable forest management. California's Board of Forestry and Fire Protection has the authority to provide for sustainable management practices on private forest lands, and has committed to the maintenance of current carbon sequestration levels on private forest lands where feasible.

The 5 MMTCO2E emission reduction target through 2020 is equal to the magnitude of the current estimate of net emissions from California's forest sector. It is recognized that data and inventories are less than optimal, and that as technical data improve the target can be recalibrated to reflect new information. The scoping plan recognized California's forests could play an even greater role in reducing carbon emissions for the 2050 greenhouse gas emissions reduction goal, and that forests are unique in that planting trees today will maximize their sequestration capacity in 20 to 50 years. Near-term investments in activities such as planting trees will help California reach the 2020 target, but they will also play a greater role in reaching the 2050 goals.

The scoping plan recognizes the formidable presence of public forest lands in California. Although public lands are managed primarily under federal statute, the scoping plan states that "the federal government must also use its regulatory authority to, at a minimum, maintain current carbon sequestration levels for land under its jurisdiction in California." Recognizing that the state has an advisory role in federal land management, this statement nonetheless underscores the potential importance of all forest lands in addressing greenhouse gas goals.

The Pacific Southwest Region's Regional Forester and Research Station Director recognized the important role of the Forest Service in this analysis, and the important contributions California's public forest lands can make to long-term greenhouse gas management goals. Recognizing the need to articulate Forest Service lands contributions in January of 2008, the Pacific Southwest Region and Research Station assembled a Climate Change Interdisciplinary Team (CCIDT) to help analyze the agency's potential contributions to California's greenhouse gas mitigation goals. This Team, comprised of specialists from State and Private Forestry, Research and Development and National Forest System was chartered to utilize best available data, science and modeling techniques to complete a comprehensive assessment of carbon sequestration capabilities, cost, timeframes, and non-market benefits on the national forests in California. Further, in direct support of AB 32 the Team developed a set of carbon accounting principles that could be applied to public land forestry. This report presents information to the Regional Forester and Station Director on forest management opportunities for increasing forest carbon pools and assesses potential national forest participation in California Global Warming Solutions Act and the California Climate Action Registry.

Scenario Design

The CCIDT evaluated a variety of management scenarios to understand the carbon sequestration benefits public forest lands could provide under the California Global Warming Solutions Act (AB 32). The scenarios were designed to evaluate how different management approaches would affect forest growth and disturbance, expressed in terms of carbon storage and loss. The range of scenarios evaluated represents a spectrum of approaches. Other than the Business as Usual (BAU) scenario, the BAU with additional emphasis on reforestation of deforested areas, and possibly the Land Management Plan scenario, the scenarios are simply benchmarks designed to stimulate thinking on how different approaches would affect disturbance and inventory. The costs, revenues, acres treated and volumes are reasonable estimations developed for this analysis only, but are not realistic nor necessarily achievable within the current organizational, budgetary or regulatory environment. Each scenario is measured against a 1990 inventory reference point to assess forest service lands contributions to AB 32 goals of statewide greenhouse gas (GHG) reductions to 1990 levels by 2020 and 2050.

Detailed descriptions of scenarios are as follows:

Business as Usual (BAU): The Business as Usual Scenario is a projection of existing trends in management activities, budgets, workforce and anticipated social constraints. The BAU scenario conforms to the Standards and Guidelines within the existing Land and Resource Management Plans (LMPs), but does not treat the number of acres in the fashion identified under LMP's.

Forest Land and Resource Management Plan (LMP): A projection of management activities in all national forests implied in existing LMP's completed with unconstrained budgets and workforce. It approximately doubles treatment areas in BAU and conducts more intensive stand management and more follow up fuel hazard reduction treatments.

Intensive Even-Age Management (IEAM): Projects an even-age, regulated forest on a 70 year rotation. This scenario maximizes carbon sequestration by replacing a stand of trees when it has reached culmination of mean annual increment (CMAI) in carbon production and is a rough proxy for California Forest Practices Act Option C forest management approach that serves as a baseline for accounting for carbon values under AB 32 Forest Conservation Management projects

Minimize Canopy Disturbance (MinCD): The Minimize Canopy Disturbance Scenario (MinCD) is based on retaining carbon inventory in trees larger than 20" DBH and retaining high canopy densities. Under this scenario, management activities reduce surface and ladder fuels and retain the carbon inventory in larger trees. Management activities would be limited to hand or mechanical treatments that remove trees that would be killed by a moderate fire (5' flame length) and to a follow-up prescribed fire, to reduce ground fuels. Reductions in existing canopy cover would be minimal.

Maximum Forest Resiliency (MaxFR): The MaxFR scenario vigorously thins and removes suppressed intermediate and co-dominant trees up to 30" DBH, retains the most vigorous trees and opens canopies up to 35% canopy cover. These management activities reduce canopy closure to the point that crowns are for the most part not touching. Treated acres are followed by prescribed burning to remove surface fuels. Lands that are burned into a deforested condition are reforested.

BAU Plus Reforestation (REFOR): This REFOR scenario reforests areas that are burned in wildfire to a deforested condition, exceeding the reforestation acres analyzed in the BAU scenario. This scenario reforests nearly all areas burned into a deforested condition by wildfires, and achieves reforestation of 50,000 acres of the 136,162 acres of current reforestation need.

Commonalities among scenarios

Each scenario shares key commonalities in the land area modeled and the data sources for vegetation and disturbance. Assumptions specific to each scenario are detailed further in the report. The following parameters are common among all scenarios:

1. Total carbon inventories are calculated on 20.2 million acres, which comprises all national forest lands in California (i.e., Region 5 excluding the Pacific Islands).
2. Scenarios assume management activities are implemented on 10.7 million of the total 20.2 million acres in the analysis area. The managed land base is defined as those productive national forest lands within the Region that are *not* withdrawn from management by Congress or the Secretary of Agriculture (such as wilderness areas or other administratively withdrawn lands).
3. The inventory source data are derived from US Forest Service Forest Inventory and Analysis (FIA) databases, and are supplemented by additional databases managed by the Region 5 Remote Sensing Lab.
4. Modeled carbon inventories are expressed in millions of metric tons of carbon dioxide equivalent (MtCO2e) in three carbon pools: above ground live biomass,

harvested wood products, and non-merchantable biomass that could be removed and converted to heat or electric power.

5. Below ground live biomass, duff and litter, standing dead and down material, and soil organic carbon pools are not modeled for this analysis, given limitations and inconsistencies of data across the analysis area.
6. The range of practices modeled in this analysis include:

Site preparation	Regeneration harvesting without reserved trees.
Tree planting	Prescribed burning
Natural Regeneration	Wildland Fire Use
Conifer release	Fuelbreak construction and maintenance
Pre-commercial thinning	Pruning
Commercial Thinning	Hardwood management
Salvage harvesting	Group selection
Regeneration harvesting with reserved trees.	

Carbon Capacity Capabilities Assessment by Scenario

The following section provides detailed descriptions of the management activities, modeling assumptions, modeling results, management regimes and disturbance conditions for each of the scenarios modeled for the study. Each section provides:

1. Description of the management activities and costs;
2. Description and justification of modeling assumptions;
3. Estimated carbon sequestered and stored in the Baseline year (2007), and subsequently in 2020, 2050, and 2110;
4. Economic analysis displaying scenarios costs, net present value estimates and the potential market value of the carbon stored under each scenario.

Business as Usual Scenario (BAU)

Management Activities and Costs

Business as Usual Scenario is a projection of existing trends in management activities, budgets, workforce and anticipated social constraints. BAU scenario conforms to the Standards and Guidelines within the existing Land and Resource Management Plans (LMPs), but does not treat the number of acres in the fashion identified under LMP's.

The BAU projected curve represents the continuation of integrated vegetation management (IVM) activities on an average of 93,600 acres per year which includes reforestation of an average of 8,600 acres/year. The integrated vegetation management footprint represents management of slightly less than .5% of the 20.2 million acre Forest Service land base per year. Harvested volumes represents removal of ~.2% of annual growth. Essentially stands are adding inventory and continuing to age.

Reforestation figures were determined by surveying past program accomplishments. Most reforestation activity has been performed on lands burned to a deforested condition by wildfires, however some regeneration has occurred on areas harvested under the Northwest Forest Plan (NWFP 1994). The 7-year average annual number of acres burned into a deforested condition is 23,943 and the 5-year average of all acres planted is 8,600. Wildfire deforested acres are surveyed by Forest Service staff and are deemed to be capable of “recovering naturally” through natural seeding, and not in need of planting, or are identified a “reforestation need” and in need of planting. These determinations are consistent with Forest Service policy and direction. Reforestation need acres are currently accumulating each year because of wildfire-driven deforestation. Currently, 136,162 acres are in need of reforestation, not including areas burned in 2008.

Integrated vegetation management treatments are designed to produce a desired change in vegetative composition, stand densities, improve forest health, resistance to drought, insects and diseases, aging stands, and to compliment and enhance other resource values. These IVM treatments can span more than one fiscal year: such as thin from below and under burn. Each treatment can accomplish one or more established Forest Service targets: such as wildlife habitat improvement and fuel hazard reduction. One or more budget line items (BLI) can be used to fund the accomplishment of the vegetation treatments. An average of 93,600 acres per year has been treated in the last 5 years, representing less than .5% of the land base.

Table 1 provides estimates of harvest volumes and associated costs to implement vegetation management under BAU. Costs were derived from an analysis of Forest Service Region 5 funds spent on IVM treatments during fiscal years 2003-2007.

Table 1 - BAU Harvest Volumes and Costs by Decade

Decade	Volume Harvested MMBF Average Annual	Acres of Reforestation In IVM Average Annual	Acres Integrated Vegetation Management* Average Annual (x 1,000)	Cost of IVM $MM Average Annual
2007-2009	371	8,600	93.6	119
2010- 2019	389	8,600	93.6	119
2020-2029	442	8,600	93.6	119
2030-2039	479	8,600	93.6	119
2040-2049	505	8,600	93.6	119
2050-2059	505	8,600	93.6	119
2060-2069	480	8,600	93.6	119
2070-2079	443	8,600	93.6	119
2080-2089	386	8,600	93.6	119
2090-2099	352	8,600	93.6	119
2100-2109	331	8,600	93.6	119
2110-2119	328	8,600	93.6	119

*Includes reforestation acres

Modeling Assumptions

BAU models were developed by first looking at past forest inventories and updating all plots to 2008 in order to normalize to a common inventory. Using Forest Vegetation Simulator (FVS) (Ritchie, 1999), the Team modeled forest inventory growth for the next 100 years using the FIA and R5 inventory plots,. The projected inventory growth from FVS was very close to being linear and growth rates declining slightly. During the last 50 years of the analysis most forest vegetative types will reach culmination of mean annual increment and growth rates will begin slowing. As the FVS does not model the effects of catastrophic mortality, such as wildfire, insect and disease outbreaks and drought, all of which are predicted to increase, this continuing accumulation of volume was determined to be unachievable and most likely inaccurate. Natural disturbances from wildfire, insects and diseases currently impact approximately 3% of lands not withdrawn from management each year, and are predicted to increase in the modeling of this alternative. Data supporting the growth and disturbance modeling performed for this scenario includes: predicted increasing trend in wildfire acres and severity, as current USFS data show (Miller et al., 2008, Westerling et al., 2006), expected increase in pest mortality based on past precipitation and mortality trends (CA Forest Pest Council, 2007), increase in pest risk (25% or greater loss of basal area in next 15 years) based on stand densities, precipitation and other forest parameters (USDA Forest Service, 2007), minimal reforestation of areas burned into deforested condition (USDA Forest Service Pacific Southwest Region Reforestation Trends 2008), a direct relation between the amount of biomass/fuels being accumulated and the number of acres and severity of wildfire. (Sugihara et al., 2006)

The Team used SPECTRUM and FELDSPAR (FOR PLAN) models to incorporate these natural disturbance regimes and trends described above into the modeling process. FIA plots, R5 densified inventory plots, USFS fire history and mortality data were used as inputs to the model.

A more detailed description of the methods used to develop the BAU Scenario is contained in Appendix A.

Estimated Carbon Sequestered

Carbon stocks in above ground live biomass are projected to increase in the next 30 to 40 years with growth exceeding loss due to wildfire, insect and disease, and drought. At this point the disturbance agents will exceed growth, causing above ground live biomass inventories to decline, carbon storage will crest and then decline.

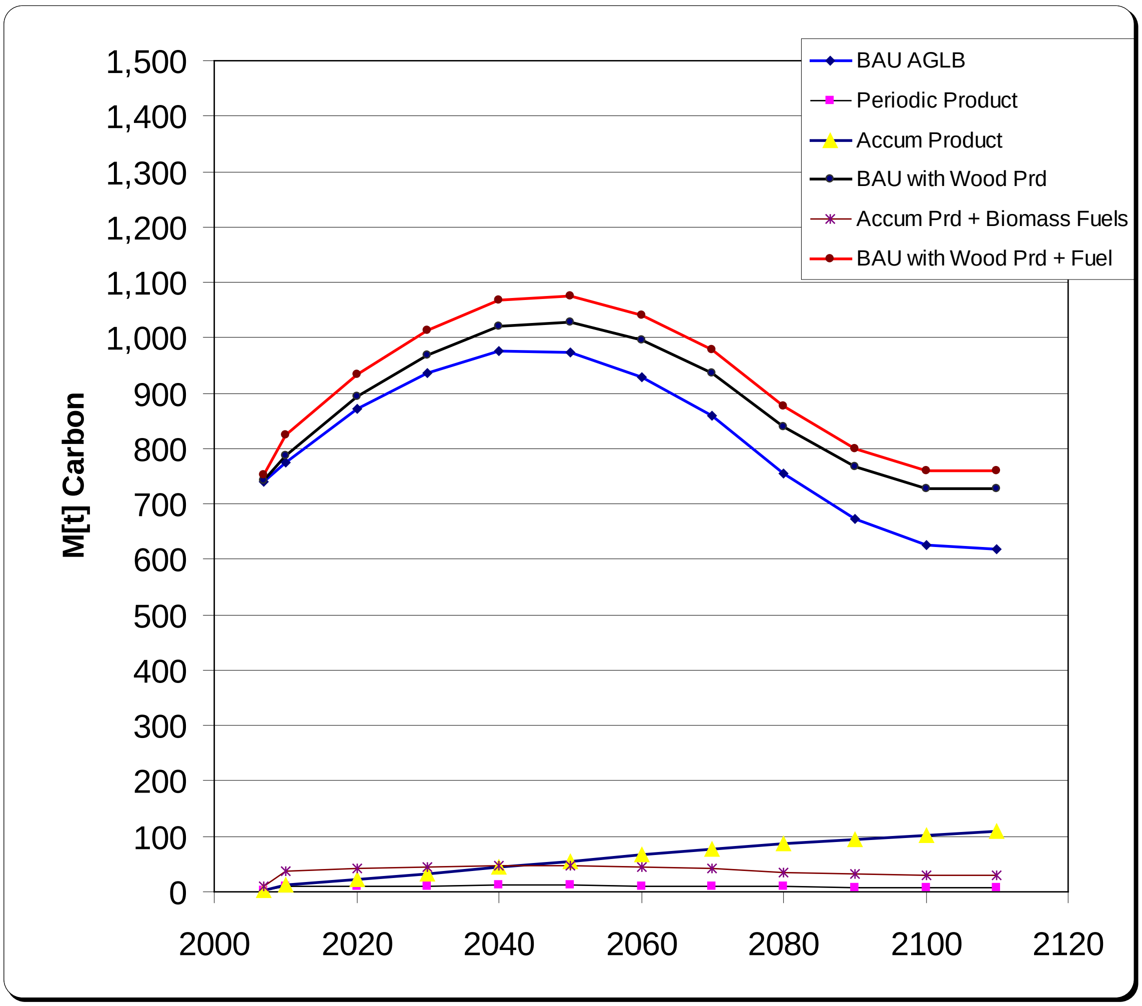

Figure 3 - Carbon Inventory for "Business As Usual" Scenario (BAU)

Table 2 - BAU Modeled carbon inventories in 1990, 2020, 2050 and 2110 expressed in Million metric tons of C02 equivalent

Carbon Pool	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	872	973	619
Above Ground Live Biomass + Wood Products	595	893	1028	728
Above Ground Live Biomass + Wood Products + Non Merchantable Biomass	595	935	1076	759

Discussion

The BAU scenario indicates a general increase, peak and then declining pattern for live biomass carbon inventory. Between 1990 and 2020, the above ground live biomass carbon inventory rises from ~595 MtC to ~872 MtC on the 20.1 million acres of NF lands, sequestering slightly over 9 MtC per year. Between 2020 and 2050 the above ground live carbon inventory rises to 973 MtC averaging slightly over 3 MtC per year. Between 2050 and 2110 forests are modeled to become a net carbon emitter, emitting nearly an average of 6 MtC per year.

Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, changes the projections of carbon storage; however, sequestered carabon still follows the same general decreasing trend. Wood products add approximately 140 MtC over the century.

Overall, the BAU scenario modeling indicates that as national forests continue to grow over the next 30-40 years they will serve as a significant sink for atmospheric carbon. Eventually, as stands age, growth rates slow, and disturbance continues, forests will begin to emit stored carbon back into the atmosphere.

Land and Resource Management Plan Scenario (LMP)

Management Activities and Costs

The Land and Resource Management Scenario (LMP) is based on following the activities implied in each national forest's land management plan given unconstrained budget, workforce and social restrictions.

The LMP curve represents integrated vegetation management treatments averaging 220,750 acres per year as determined in each Forest's LMP. Similar to the BAU scenario, integrated vegetation management treatments are designed to produce a desired change in vegetative composition, stand densities, improve forest health, resistance to large catastrophic fire, drought, insects and diseases, and to compliment and enhance other resource values. Under the LMP scenario, lands that are burned into a deforested condition are reforested.

Management activities under this scenario remove approximately 0.22% of annual growth per year for the first three decades (~2.2% per decade), declining to approximately 0.08% per year by year 2110 on productive forest lands. The projected changes in inventory are based on each Forest Plan's Final EIS, except for the Southern California Province Forests, where there is no implied schedule of treatments in the Plans.

See Appendix C for a listing and description of the activities.

Table 5 - LMP Harvest Volumes and Costs by Decade

Decade	Volume Harvested MMBF Average Annual	Acres Integrated Vegetation Management* Average Annual (x 1,000)	Cost of IVM $MM Average Annual
2007-2009	496	191	243
2010- 2019	478	194	247
2020-2029	425	227	289
2030-2039	294	206	262
2040-2049	188	214	272
2050-2059	201	226	288
2060-2069	219	211	269
2070-2079	200	229	292
2080-2089	244	243	309
2090-2099	237	239	304
2100-2109	245	234	298
2110-2119	274	235	299

*Includes reforestation acres

Modeling Assumptions

The LMP carbon inventory curve is based on SPECTRUM and FELDSPAR analysis used in the Sierra Nevada Forest Plan Amendment Final Supplemental Environmental Impact Statement (SNFPS) and the Northwest Forest Plan (NWFP). The volume estimates in the current LMP's, except the Southern California Province Forests, were projected using the current inventory from FIA and RSL plot data under management goals and objectives outlined in the SNFPS and NWFP. The increasing effects of wildfire intensity and size included in the BAU scenario were not included in this projection as implementation of treatments that meet Forest Plans were assumed to reduce acres burned by 20-40 percent and severity by 70-80 percent (USDA Forest Service, 2004).

Estimated Carbon Sequestered

The LMP curve shows a trending increase in carbon resulting from land management treatments that reduce the threat of catastrophic wildfire, modify fire behavior over the landscape and reforest burned areas. The trending accumulation of carbon peaks where the current management practices of the LMP's no longer sustain such a large accumulation of growing stock. Carbon storage reaches a peak that may or may not be sustainable. The LMP scenario indicates a general increasing, peaking and slight declining pattern for live biomass carbon inventory.

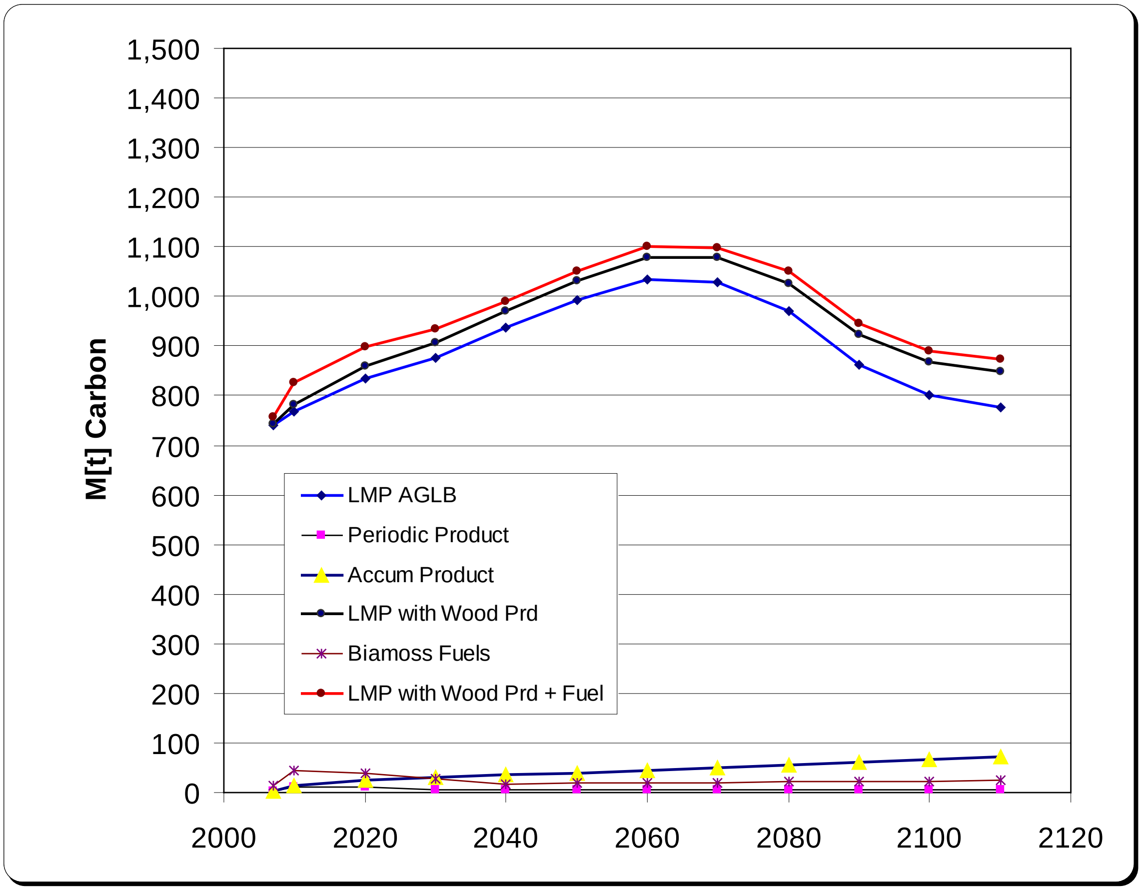

Figure 4 - Carbon Inventory for "Land and Resource Management Plan" Scenario (LMP)

Table 4 -Land Management Plan modeled carbon inventories in 1990 2020, 2050, and 2110 expressed in MtCo2E

Carbon Pool	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	835	992	775
Above Ground Live Biomass + Harvested Wood Products	n/a	859	1032	848
Above Ground Live Biomass + Harvested Wood Products + Non Merchantable Biomass	n/a	898	1050	873

Discussion

This scenario indicates a general increase, peak and then slight declining pattern for live biomass carbon inventory. Between 1990 and 2020, the above ground live biomass carbon inventory rises from ~595 MtC to ~835 MtC on the 20.1 million acres of

NF lands, sequestering slightly over 8 MtC per year. Between 2020 and 2050 the above ground live carbon inventory rises to 992 MtC averaging slightly over 3 MtC per year. Between 2050 and 2110 forests are modeled to become a net carbon emitter, emitting nearly 4 MtC per year.

Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, changes the projections of carbon storage; however, carabon sequestered still follows the same general decreasing trend. Wood products add approximately 100 MtC over the century.

Overall, the LMP scenario modeling indicates that as national forests continue to grow over the next 50-60 years they will be less subject to disturbance than BAU. This is the product of increased integrated vegetation management activities designed and located to reduce losses to disturbance. Modeling indicates that as stands age, growth rates slow, and disturbance continues, forests will begin to emit stored carbon back into the atmosphere.

Intensive Even-Age Management Scenario (IEAM)

Management Activities and Costs

The Intensive Even-Age Management Scenario (IEM) is based on implementing an even-aged management scheme on the productive land base within the national forests. Under this scenario all management activities are done to produce wood products and sequester carbon. This alternative is a proxy for intensive forest management under the California Forest Practices Act, and would result in establishment of a regulated forest. Lands that are burned into a deforested condition are reforested. Even-age silvicultural prescriptions are employed when a stand has reached culmination of mean annual increment and is then replanted to a fully stocked condition. All lands that make up the productive forest land base are managed on a 70 year rotation. Acres treated are 1/7 of the productive land base each decade, an average 153,000 acres/year. The management activities implemented under this scenario remove approximately 1.1% of annual growth per year or approximately 11% per decade. See Appendix C for a listing and description of activities that are accomplished under this scenario.

This is a modeling exercise only and does not represent current standards and guidelines, practices, prescriptions and schedules for each forest LMP nor National Forest Management Act or Forest Service Manual direction regarding the use of clear cutting.

Table 5 - IEM Scenario Harvest Volumes and Costs by Decade

Decade	Volume harvested MMBF Average Annual	Acres Integrated Vegetation Management* Average Annual (x 1,000)	Cost of IVM $MM Average Annual
2007-2009	2364	153	195
2010- 2019	2373	153	195
2020-2029	2214	153	195
2030-2039	1963	153	195
2040-2049	1742	153	195
2050-2059	1570	153	195
2060-2069	1488	153	195
2070-2079	1518	153	195
2080-2089	1773	153	195
2090-2099	1773	153	195
2100-2109	1773	153	195
2110-2119	1773	153	195

*Includes reforestation acres

Modeling Assumptions

Modeling assumptions are based on replacing the existing inventory with plantations using maximum biomass rotation and sequestering approximately 37% of the total volume removed into wood products. Modal Site 60 index mixed conifer yield tables were utilized. Data Source: Dunning and Reineke Yield Table for 2nd growth.

Estimated Carbon Sequestered

The IEM scenario would reduce above ground live biomass in the process of establishing a regulated forest. Inventories would eventually level off and remain stable through the end of the century. Without accounting for wood products, live biomass carbon would drop below the 1990 base of 600 MtC at around 2030 and remain below this level through the 100 year projection. Accounting for the carbon stored in products shows a significant increase in carbon storage to approximately 1170 MtC at the end of the century.

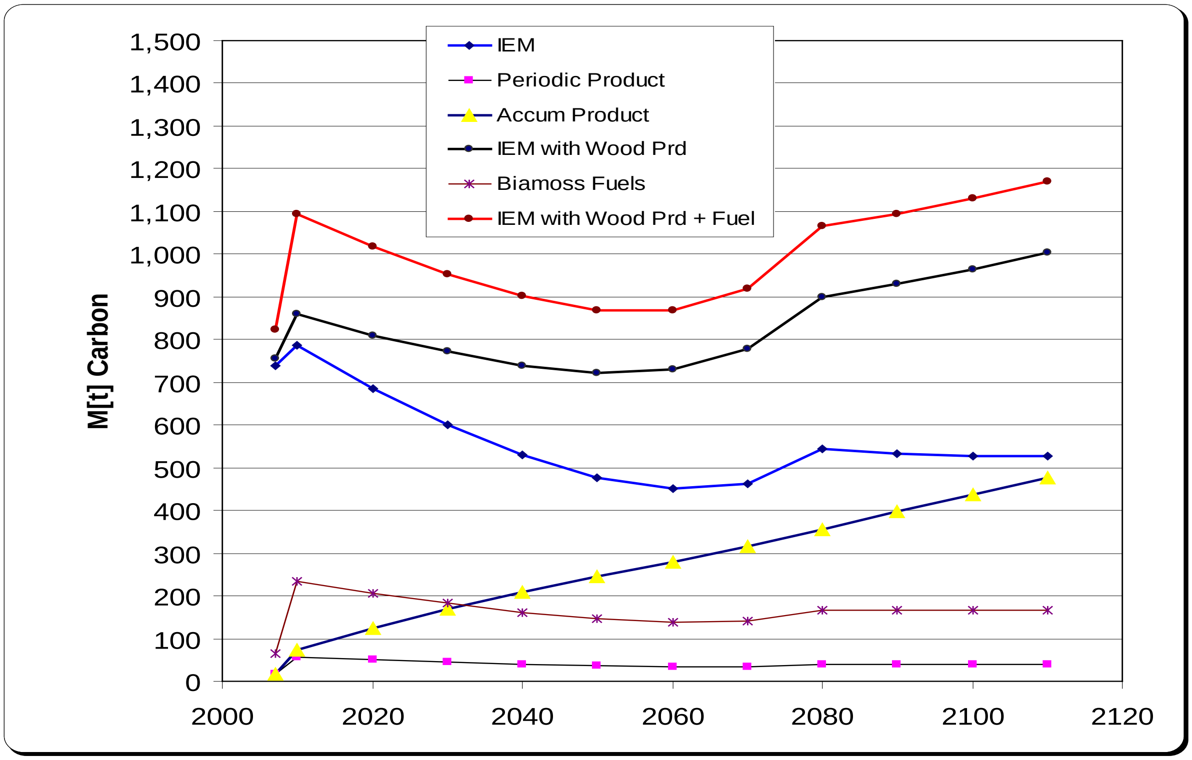

Figure 5 - Carbon Inventory for "Intensive Even-Aged Management" Scenario (IEAM)

Table 6 - Intensive Even Aged Management modeled carbon inventories in 1990 2020, 2050, and 2110 expressed in Million metric tons C02e

Carbon Pools	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	686	475	526
Above Ground Live Biomass + Harvested Wood Products	n/a	810	721	1004
Above Ground Live Biomass + Harvested Wood Products + Non Merchantable Biomass	n/a	1016	867	1170

Discussion

Between 1990 and 2020, the above ground live biomass carbon inventory rises from ~595 MtC to ~686 MtC on the 20.1 million acres of NF lands, sequestering slightly over 3 MtC per year. Between 2020 and 2050, in the process of establishing a regulated forest inventories decrease ~7 MtC per year. Between 2050 and 2110 as harvested areas recover and grow, inventories recover at slightly less than 1MtC per year and remain stable. The process of establishing a regulated forest results in significant decreases in standing inventory until harvested areas recover and grow. In the long term, regulated forests constitute a stable inventory across the landscape.

Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, significantly changes the projections of carbon storage. The carbon inventory, including all three carbon pools, shows an overall increase of 96% above the 1990 baseline at the end of 2110.

Minimize Canopy Disturbance Scenario (MinCD)

Management Activities and Costs

The Minimize Canopy Disturbance Scenario (MinCD) is based on retaining carbon inventory in trees larger than 20” DBH and retaining high canopy densities. Under this scenario, management activities are performed to reduce surface and ladder fuels and retain the carbon inventory in larger trees. Management activities would be limited to hand or mechanical treatments that remove trees that would be killed by a moderate fire (5' flame length) and to a follow-up prescribed under burn, to reduce ground fuels. Purposeful reductions in existing canopy cover would be minimal. Similar to the IEM Scenario, approximately 1/70 of the productive forest land base (153,000 acres) is treated per year. Lands that are burned into a deforested condition are allowed to recover naturally. Standards and guidelines, practices, prescriptions and schedules for each forest LMP's are not followed.

Management activities under this scenario remove approximately 0.04% of annual growth per year or approximately 0.4% per decade.

See Appendix C for a description of activities.

Table 7 - MinCD Harvest Volumes and Costs by Decade

Decade	Volume Harvested MMBF Average Annual	Acres Integrated Vegetation Management* Average Annual (x 1,000)	Cost of IVM $MM** Average Annual
2007-2009	74	153	195
2010- 2019	79	153	195
2020-2029	90	153	195
2030-2039	101	153	195
2040-2049	108	153	195
2050-2059	110	153	195
2060-2069	107	153	195
2070-2079	100	153	195
2080-2089	90	153	195
2090-2099	84	153	195
2100-2109	80	153	195
2110-2119	79	153	195

*Includes reforestation acres

Modeling Assumptions

The MinCD carbon inventory curve was developed by using the FVS model to apply a light thin from below, allowing no tree over 20-inch dbh to be removed, followed by an under burn to remove surface fuels on our inventory data. Essentially, surface and small ladder fuels are removed. This practice was repeated every 70 years to make this scenario comparable to the IEM scenario, which used an even-aged rotation of 70 years. Over time, tree volume accumulates into larger diameter classes.

Assuming treatment of 1/7 of the landscape every 10 years, fuels treatment activities can have a life expectancy up to about 20 years. Therefore, once the first cycle is completed, approximately 2/7 of the landscape, or 27% is in various stages of a treated condition.

To reflect the gain from reduced mortality by moving a larger proportion of the biomass into larger trees, the modeling Team assumes that the inventory would increase approximately 20% over BAU by 2080 due to reduced fire mortality and increased resilience of the larger trees. This percentage is based upon the Pacific Southwest Region's Stewardship and Fireshed Assessment (SFA) cadre fire gaming exercises on Forests through the Region.

Figure 6 - Carbon Inventory for "Minimize Canopy Disturbance" Scenario (MinCD)

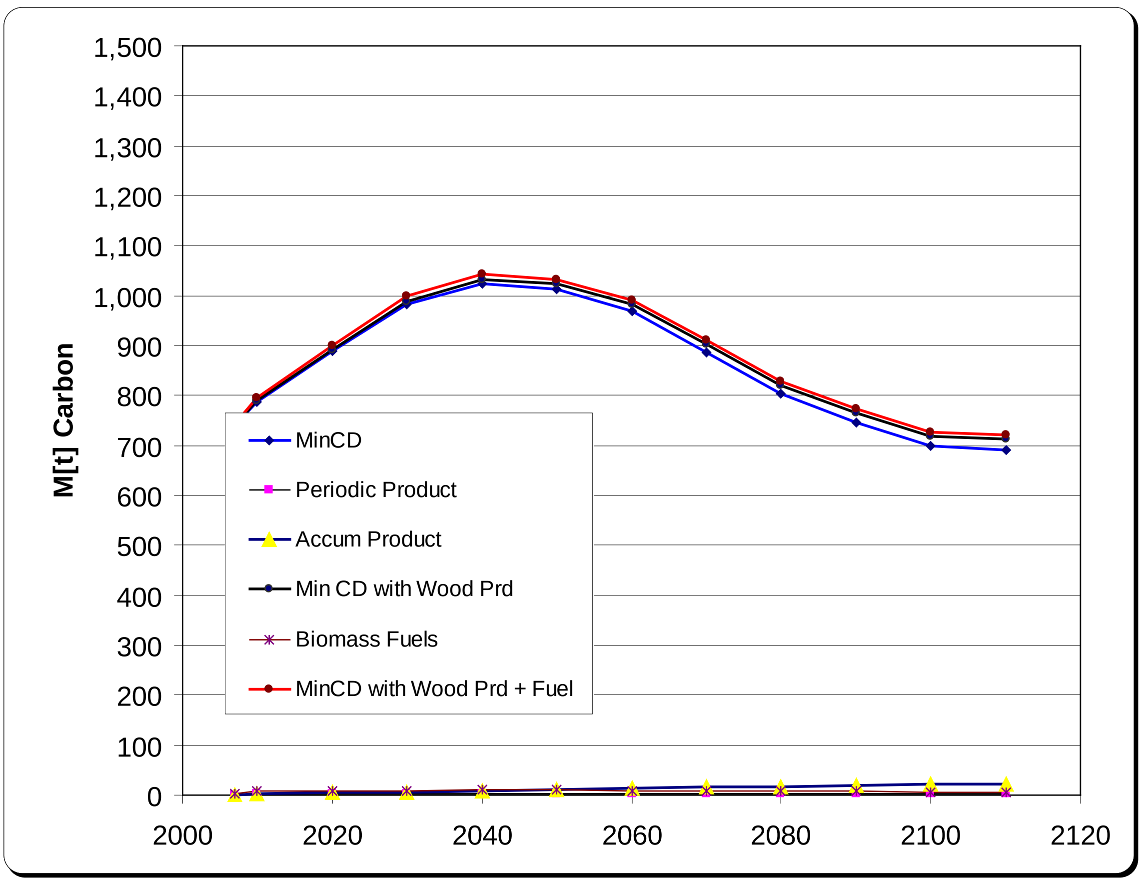

Table 8 - Minimum Canopy Disturbance modeled carbon inventories in 1990 2020, 2050, and 2110 expressed in Million metric tons C02e

Carbon Pools	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	867	1012	693
Above Ground Live Biomass + Harvested Wood Products	n/a	892	1023	714
Above Ground Live Biomass + Harvested Wood Products + Non Merchantable Biomass	n/a	900	1033	720

Estimated Carbon Sequestered

The MinCD curve shows a gradual increase in carbon for the first four decades as management activities focus on the removal of smaller diameter trees and carbon accumulates in larger trees, stands grow at relatively high rates of growth. As treated stands age, growth rates slow down, fires continue to affect the landscape according to Stewardship and Fireshed Assessment Team modeling guidelines, and carbon inventories begin to level off and then begins to decrease.

The MinCD scenario indicates a general increasing, peaking and declining pattern for live biomass carbon inventory. Between 2007 and 2040, the carbon inventory rises from ~740 MtC to ~1020 MtC. From 2040, the carbon inventory steadily declines to 693 MtC in 2110.

Discussion

The MinCD scenario indicates a general increase, peak and then slight declining pattern for live biomass carbon inventory. Between 1990 and 2020, the above ground live biomass carbon inventory rises from ~595 MtC to ~867 MtC on the 20.1 million acres of NF lands, sequestering slightly over 9 MtC per year. Between 2020 and 2050 the above ground live carbon inventory rises to 1,012 MtC averaging slightly over 5 MtC per year. Between 2050 and 2110 forests are modeled to become a net carbon emitter, emitting nearly an average of 5 MtC per year.

Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, only slightly changes the projections of carbon storage; however, carbon sequestered still follows the same general decreasing trend. Wood products add approximately 30 MtC over the century.

Maximize Forest Resiliency Scenario (MaxFR)

Management Activities and Costs

The MaxFR scenario vigorously thins and removes suppressed, intermediate and co-dominant trees up to 30” DBH, retains the most vigorous trees and opens canopies up to 35% cover. These management activities reduce canopy closure to the point that crowns are for he most part not touching. Treated acres are followed by an under burn to remove surface fuels on our inventory data. Lands that are burned into a deforested condition are reforested. Standards and guidelines, practices, prescriptions and schedules for each Forest LMP are not followed. Approximately 5% of the productive forestland base (536,000 acres), is treated per year, which represents about 2.6% of the 20.2 million acre land base. Management activities under this scenario remove approximately 1.3% of annual growth per year or approximately 13.5% per decade.

See Appendix C for a listing and description of activities and the vigor prescription

Table 9 - MCD Harvest Volumes and Costs by Decade

Decade	Volume harvested MMBF (x 1,000)	Acres Integrated Vegetation Management* (x 1,000 per yr)	Cost of IVM $MM**
2007-2009	2432	536	682
2010- 2019	2456	536	682
2020-2029	2259	536	273
2030-2039	1652	536	273
2040-2049	1973	536	273
2050-2059	1908	536	273
2060-2069	2318	536	273
2070-2079	2240	536	273
2080-2089	2652	536	273
2090-2099	2423	536	273
2100-2109	2891	536	273
2110-2119	2657	536	273

*Includes reforestation acres

** In 2008 $$ of $1,273/acre for first decade. In subsequent decades treatments will be ¼ mechanical @ $1,273/acre and ¾ acres burning @ $254/acre.

Modeling Assumptions

The MaxFR carbon inventory curve was developed by using the FVS model to apply a thin from below treatment favoring retention of co-dominant and dominant trees, allowing no tree over 30 inch dbh to be removed. Trees are sorted into crown classes, then by crown ratio, then by dbh and starting with suppressed crown classes, the FVS model removes the poorest trees until the 35% canopy cover limit is reached. This practice was repeated every 70 years to make this scenario comparable to the IEM scenario, which uses an even-aged rotation of 70 years. Over time, tree volume accumulates into larger diameter classes.

To reflect the gain from reduced mortality by moving a larger proportion of the biomass into larger trees, the modeling assumes that lands that would be burned into a deforested condition would be reduced significantly and the inventory would increase approximately 20% over BAU by 2080 due to reduced fire mortality and increased resilience of the larger trees. This percentage is consistent with Stewardship and Fireshed Assessment cadre fire gaming exercise on Forests through the Region.

Half of the productive land base is assumed to be treated each decade, an average of 536,000 acres a year. Assuming that fuels treatment activities on forested lands have an effective life of up to about 20 years, retreatment is required. Therefore, once the first cycle is completed, approximately 100% of the “productive” forested landscape is assumed to be in a treated condition. Beginning year 21, treated acres would receive a combination of manual, mechanical and prescribed fire to maintain the areas in a fire resilient condition.

Estimated Carbon Sequestered

The MaxFR scenario indicates a decreasing then gradual increasing and leveling off pattern for live biomass carbon inventory. Between 2007 and 2030, the live biomass carbon inventory decreases from ~740 MtC to ~360 MtC. The carbon live biomass inventory then gradually builds to an average level equaling the 1990 base of ~600MtC.

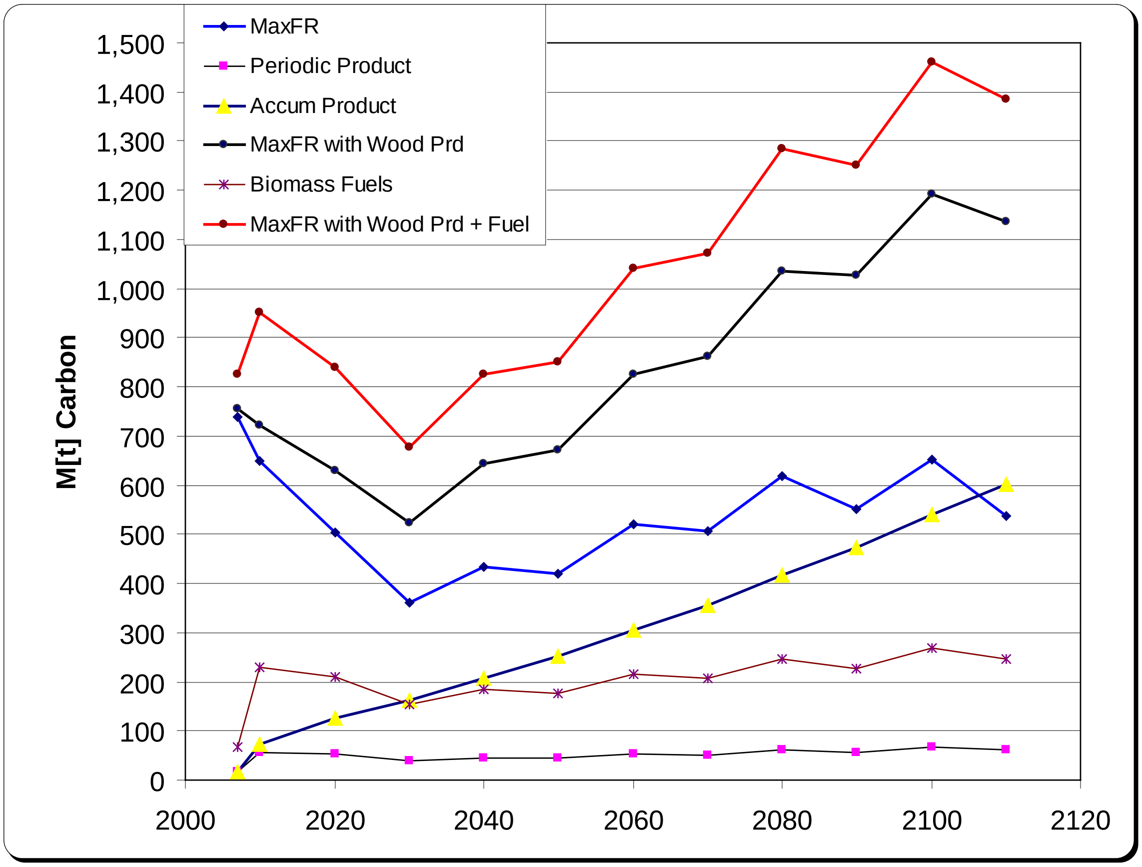

Figure 7 - Carbon Inventory for "Maximize Forest Resiliency" Scenario (MaxFR)

Table 10 - Maximum forest Resilience modeled carbon inventories in 1990 2020, 2050, and 2110 expressed in Million metric tons C02e

Carbon Pools	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	504	420	538
Above Ground Live Biomass + Harvested Wood Products	n/a	629	672	1136
Above Ground Live Biomass + Harvested Wood Products + Non Merchantable Biomass	n/a	840	849	1383

Discussion

The MaxFR scenario reduces above ground live biomass below 1990 levels throughout the entire modeling period. Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, significantly changes the projections of carbon storage.

Carbon inventories would increase nearly 3 MtC per year by 2020, continue to drop because of harvest and then increase slightly by 2050 and increase significantly nearly 9 MtC per year by the end of 2110.

Reforestation Above BAU Scenario (REFOR)

Management Activities and Costs

This REFOR scenario conducts the reforestation of more acres than those analyzed in the BAU Scenario. In addition to the reforestation of an average of 8,600 acres/year, and integrated vegetation management activities on 94,000 acres per year, this scenario conducts reforestation of nearly all areas burned into a deforested condition by wildfires, and reforestation of 50,000 acres of the 136,162 acres of current reforestation need. Similar to BAU, Management activities remove approximately 0.2% of annual growth per year or 2% per decade on productive forest lands until 2090, when additional volume is harvested from reforested plantations.

The reforestation curve shows a trending increase in carbon similar to the BAU curve.

Additional Assumptions

- All practices are accomplished according to plans and prescriptions approved in Forest LMPs. Activities would be bound by standards and guidelines approved in Forest LMPs.
- This reforestation scenario assumes 23% of the total acreage of national forest land burned resulting in a deforested condition on productive forest lands. This assumption was derived from an analysis done by the R5 Regional Silviculturist, analyzing fires in Region 5 greater than 1,000 acres, over a six year period from 2001 to 2007. “Deforested condition” is defined as areas that burn in the highest 3 of 7 mortality classes. Data for this analysis were derived from remote sensing.

- Clearcut salvage harvesting will be implemented on 7.5% of the acres burned (based on an analysis of average clearcut salvage areas on national forest lands between 2003 and 2007).

Modeling Assumptions

Growth and disturbance models used in this scenario are similar to those described for BAU. All management activities that are accomplished under BAU would be accomplished in this scenario. To determine the number of additional reforestation acres, it is assumed that 50,000 of the current reforestation need acres would be reforested in the first decade, and 85% of the acres modeled to be burned into a deforested condition by wildfire would be reforested throughout the analysis period. Acres reforested above BAU would average 31,600 acres/year over a 100 year period. See Appendix A for a detailed description of how these figures were derived.

Table 11 - BAU Harvest Volumes and Costs by Decade

Decade	Volume harvested MMBF Average Annual BAU+	Volume Harvested MMBF Average Annual BAU	Acres Integrated Vegetation Management* BAU Average Annual (x 1,000)	Acres of reforestation above BAU Average Annual (x 1,000)	Cost of IVM & Reforestation $MM** Average Annual
2007-2009	371	371	93.6	7.1	129
2010- 2019	389	389	93.6	28.5	155
2020-2029	442	442	93.6	35.7	165
2030-2039	479	479	93.6	47.4	179
2040-2049	505	505	93.6	59.1	194
2050-2059	505	505	93.6	59.1	194
2060-2069	480	480	93.6	47.4	179
2070-2079	443	443	93.6	35.7	165
2080-2089	386	386	93.6	24.0	150
2090-2099	380	352	93.6	11.8	134
2100-2109	446	331	93.6	11.8	134
2110-2119	645	328	93.6	11.8	134

*Includes BAU reforestation acres

Estimated Carbon Sequestered

The Reforestation scenario indicates a general and increasing trend, peaking and then declining pattern for live biomass carbon inventory. Between 2007 and 2050, the carbon inventory rises from ~740 MtC to ~1000 MtC on the 20.1 million acres of national forest lands. From 2050, the carbon inventory steadily declines to ~684 0MtC in 2110. The carbon inventory, while steadily increasing 34% to 2050, shows an overall decrease of 10% at the end of 2110.

Figure 8 - Carbon Inventory for the "Business as Usual plus Reforestation" Scenario (REFOR)

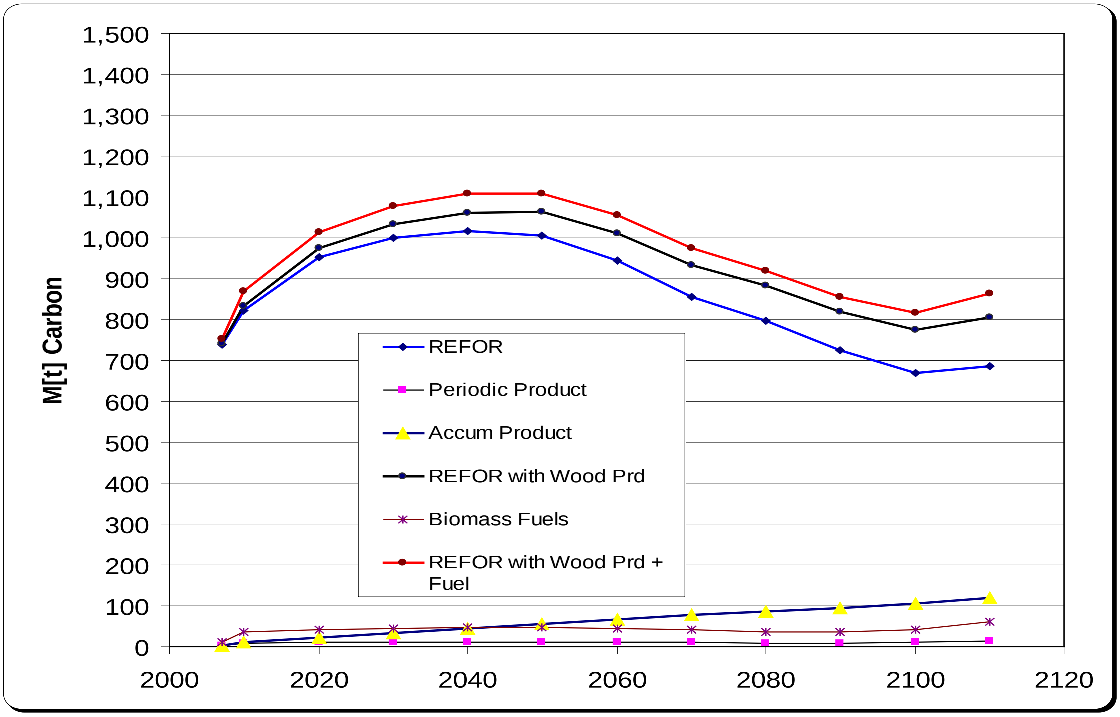

Table 12 - Reforestation modeled carbon inventories in 1990 2020, 2050, and 2110 expressed in Million metric tons C02e

Carbon Pool	1990 Baseline	2020	2050	2110
Above Ground Live Biomass	595	951	1006	684
Above Ground Live Biomass + Harvested Wood Products	n/a	973	1062	804
Above Ground Live Biomass + Harvested Wood Products + Non Merchantable Biomass	n/a	1014	1109	864

Discussion

The REFOR scenario indicates a general increase, peak and then slight declining pattern for live biomass carbon inventory. Between 1990 and 2020, the above ground live biomass carbon inventory rises from ~595 MtC to ~951 MtC on the 20.1 million acres of NF lands, sequestering slightly under 12 MtC per year. Between 2020 and 2050 the above ground live carbon inventory rises to 1006 MtC averaging slightly under 3 MtC per year. Between 2050 and 2110 forests are modeled to become a net carbon emitter, emitting slightly over 5 MtC per year.

Including carbon sequestered in forest products and carbon value of non merchantable biomass that could be converted to renewable heat, power and bio-fuels, changes the projections of carbon storage; however, carabon sequestered still follows the same general decreasing trend. Wood products add approximately 180 MtC over the century.

Overall the REFOR scenario modeling indicates some carbon benefits from actively reforesting areas that have been damaged by natural disturbances. The FVS modeling indicates these areas recover above ground live biomass more quickly and provide other benefits in the form of merchantable wood products from subsequent stand management activities.

Economic Analysis of All Scenarios

This economic analysis is based on the value of carbon that is projected to be sequestered over a 100 year period for seven different scenarios. The amount of carbon that is available above a given baseline is assumed to be potentially available. The modeling assumes all carbon storage above baseline levels is designated as Federal Carbon Reserves and all sequestered tons above baseline are fully allocated (rented out) as credits. Carbon payments are assumed to be made in dollars per metric ton of CO2.

Two market rule sets were analyzed, each with two different baseline scenarios. See Table 13 for an explanation of the market rules used for this analysis.

Table 13 - Carbon Market Rule Sets

Factor	Market Rule Set 1	Market Rule Set 2
Duration of Carbon Credit	100 years	10 years
Valuation relative to the Baseline Reference	Amount above or below baseline is analyzed. Can have positive or negative value.	Only carbon above the baseline is available for market each decade. If the carbon available in a scenario is less than the baseline, then zero carbon is available, and the value is zero.
Value per metric ton of carbon	$6	$0.60 (credit is only available for one-tenth the time, 10 years vs. 100 years).
Carbon Pool	Live bole volume of the timber inventory. Timber products sold leave the carbon market system and are no longer available as carbon credits.	Live bole volume of the timber inventory. Timber products sold leave the carbon market system and are no longer available as carbon credits.

Factor	Market Rule Set 1	Market Rule Set 2
Carbon available for market	Assumes the entire inventory above baseline is rented each decade, so only the increment (increase or decrease) above baseline from the previous decade is new carbon (or carbon debt if negative) available for market. Only new carbon from tree growth is available in each decade. Or if the amount of carbon is going down then a carbon debt is produced for that time period.	Only the amount that is greater than the baseline is available for market and given a positive value. If the amount available for a scenario is less than the baseline in any time period, a value of zero is assigned. No negative values or carbon debt is accumulated. The ten year time period allows easier entry and exit from the market, so the market goes to zero if no carbon above baseline is available
Increment valued	Assumes that the change from the previous decade for each scenario, as compared to the change from the baseline, is what is valued. So even if the overall amount of carbon inventory for a scenario is less than the baseline, as long as the incremental change is greater than the incremental change of the baseline, the amount over baseline is given a positive value. So if the scenario is adding carbon faster than the baseline, it is given a value.	Since the carbon credits expire every ten years, there is no accumulated obligation of carbon credits that were purchased in previous time periods. So the amount above baseline for a given scenario in each time period (decade) is available on the carbon market.
Baselines	Two baselines were studied: 1. Business as Usual (BAU) 2. 1990 Reference Point	Two baselines were studied: 1. Business as Usual (BAU) 2. 1990 Reference Point

- This model does not attempt to do the accounting for individual purchases of carbon credit offsets and to track them through time. It just uses all net carbon available each decade and assumes all carbon is purchased as a credit and payments are made.
- All forms of carbon storage have the same value per metric ton. The price per metric ton remains the same regardless of volume purchased. This analysis does not attempt to determine potential differences in market prices from changes in supply and demand for carbon credits over time.
- The economic model assumes that carbon is sequestered in increments of 10 years.
- Discount rates are applied at the midpoint of each decade.
- A constant discount rate of 4% is applied across all scenarios for all ten decades.
- Simple discounting is used. The discount formula of Net Value / (1.04)^n is used. The years to discount, n, is the midpoint of each decade.
- Net Value is the ($/metric ton * Metric Tons Sequestered above baseline) + (Timber Harvest Value as stumpage) – Integrated Vegetative Management Costs.
- This model assumes that all carbon credits do not include any rights to the eventual harvest of the timber. Timber harvest is a separate activity and set of values.
- Value of carbon per metric ton is assumed to be $6 per ton. Values on the Chicago Carbon Exchange have ranged from about $2 to over $6 in the past three years. The current trend is toward the higher level and so was used for this analysis.
- Integrated Vegetation Management (IVM) costs were developed for each scenario. This is an overall average cost to treat acres on national forest lands in Region 5. It includes normal reforestation acres, timber harvest costs, fuel treatments, and costs for planning and NEPA analysis.
- Timber values are an average of the R5 Transaction Evidence Timber Sale database for the past two years for stumpage values.
- Carbon values were added to timber values in each decade for each Scenario to arrive at a total undiscounted value.

- The IVM costs were subtracted from the total value for each decade for each scenario.
- Net Present Value (NPV) was calculated by discounting this net value from the midpoint of each time period using a 4% discount rate. All values are in 2008 base year dollars.
- Analysis was done for each Scenario using Market Rules 1 and 2, with two baselines each, BAU and 1990 Baseline.

Economic analysis results

Each of the market outcomes are summarized here. Details of the analysis may be found in the spreadsheet model developed for this study, on file at the Regional Office.

Market Rule Set 1 With BAU as the Baseline

(See tab “1-NPV w BAU Base” in the economic modeling spreadsheet.)

- All total NPVs for each scenario were negative. These ranged from -$815 million for the Intensive Even-Age Management scenario down to -$13,023 million for the Maximize Forest Resiliency scenario.
- The Intensive Even-Age Management scenario is the only scenario to have positive NPV’s, in decade 2, then there is enough growth and harvest to go back above zero in the later decades (decades 7-10).
- Maximize Forest Resiliency has the lowest NPV’s, especially in decades 1-5. This scenario has the highest costs, with over three times the costs of the next lower scenario cost.
- The BAU scenario is negative, but has the next highest NPV. This is the baseline in this set, so the carbon values are zero, but timber harvest values are present.

Market Rule Set 1 with 1990 Base as the Baseline

(see tab “1-NPV w 1990 Base” on economic modeling spreadsheet)

- The 1990 Base provides more carbon available for market as it is a lower baseline to compare to than the BAU scenario. So NPV’s are generally greater than those using the BAU baseline.

- Intensive Even-Age Management is the only scenario with an overall positive NPV using this set of rules.
- Maximize Forest Resiliency remains the lowest NPV.

Market Rule Set 2 With BAU as the Baseline

(see tab "2-NPV w BAU Base" on the economics spreadsheet)

- Intensive Even-Age Management is the only scenario with an overall positive NPV using this set of rules.

Market Rule Set 2 With 1990 Base as the Baseline

(see tab "1-NPV w 1990 Base" on economics spreadsheet)

- NPV's are generally higher with these rules. The 1990 Base allows more carbon on the market, and Rule Set 2 does not allow accumulation of negative NPV.
- Scenarios 2, 3, 5 have an overall positive NPV using these rules.
- Three of the scenarios, 2, 3, and 5 have positive NPV's (with an exception in decade 2 for Scenario 3). These rules and scenarios allow an opportunity to conduct a more realistic carbon market as there are some economic incentives for trading.

Table 14 - Total Net Present Value ($Millions)

	Scenario					
Market Rule Set & Baseline	**BAU**	**Land and Resource Management Plan (LMP)**	**Even-Age (IEM)**	**Minimize Canopy Disturbance (MCD)**	**Max Forest Resiliency (MFR)**	**Reforest**
Market Rule Set 1, BAU Baseline	**-1,891**	**-5,736**	**-815**	**-5,209**	**-13,023**	**-3,338**
Market Rule Set 1, 1990 Base	**-553**	**-4,397**	**523**	**-3,870**	**-11,685**	**-2,000**
Market Rule Set 2, BAU Baseline	**-1,891**	**-5,814**	**200**	**-5,298**	**-11,500**	**-3,370**
Market Rule Set 2, 1990 Base	**2,593**	**-1,059**	**1,971**	**-473**	**-10,435**	**1,230**

Summary of Economic Findings

- Maximize Forest Resiliency, has the lowest NPV of all scenarios across all the rule sets and assumptions. It provides negative NPV in all decades and is significantly lower than the other scenarios
- Intensive Even-Age Management has the highest NPV in all of the Rule Sets except for the Market Rule Set 2-1990 Base set, in which BAU is the highest overall. Examining the NPV chart shows that BAU provides a steadier, higher stream of NPV across decades 1-7, whereas the Even-Age scenarios peaks in decade 2 and then less is available after that as these stands are young and growing back.
- Carbon revenues under Business as Usual (BAU) do not appear to be economically reasonable within a decade and worsens thereafter.
- Market Rule Set 1 with BAU as the baseline most closely resembles the California proposed registry in AB 32. In this set of rules, all of the scenarios provide an

overall negative NPV. The Intensive Even-Age Management scenario shows positive NPV during decade 2 and decades 7-10.

- Sensitivity testing of Market Rule Set 1 (with BAU as the baseline) shows that carbon values must increase to over $30 per metric ton in order to stimulate an increase in overall NPV. Most scenarios produce even lower NPV, since this rule set allows negative NPV or carbon “debt”. As a consequence, raising the price only amplifies the negative NPV’s for those scenarios and decades when the net carbon sequestration is negative.

Discussion

Although the carbon accounting guidelines used by United Nations and the Kyoto protocols exclude carbon stored in wood products, this analysis suggests that any assessment of the role of forests must consider sequestration of carbon in forest products and a scientifically-based accounting of emissions.

The sustainability of the Region’s forest carbon sink in the next 100-years is largely dependent upon the frequency and the extent of disturbance from fire activity, drought, and effectiveness of the fire and forest health management strategies employed.

The BAU trajectory, accumulates carbon in the short-term at a rate greater than it is lost to wildfire, pest, drought, inter-tree competition, etc. This growth is a function of past harvesting and growth.

The analysis indicates that we cannot sustain these present inventory levels with our present practices, budgets and light touch management constraints. Maintenance of inventories and reliable increases will be dependent on our ability to establish healthy, resilient forest ecosystems systems that would be less susceptible to disturbance agents, and would require the Forest Service to modify landscape scale fire behavior which would reduce the size and severity of wildfires. If we are going to develop a number of fast growing plantations which would remove carbon from the air at rates 150% higher than non-intensive management, then they will have to be protected. If we are counting on keeping a large proportion of our carbon in large trees, then these trees need to be protected from severe fire and from pest and drought. We can make these stands more resilient by selecting the most vigorous trees and maintain lower stand density; however, then we run into problems of habitat for many of our key species that desire or need dense and high canopy cover.

While the national forests are seen by many as sinks, it is still unclear how the Region is going to manage forests with frequent fire regimes while increasing carbon storage and reducing carbon emissions from treatments which use fire and wildfires.

Appendix A: Assumptions for BAU, Reforestation Scenarios and Analytical Integrated Vegetation Management Modeling Procedures

Methods used to develop BAU scenario

The BAU scenario was developed by examining past forest inventories derived from RPA and RSL data and then normalizing them to reflect various utilization standards, different land bases, and tree species. These normalized points reflect general trends of increasing inventory that were the product of growth, changing management trends, harvest and disturbance levels. Inventories reflected that beginning in the early 1990's as a result of significant decreases in harvest levels resulting from Northern Spotted Owl/California Owl management considerations, a sharp increase in volume was occurring. Theoretical modeling of these trends into the future projected an exponential increase in volume. While this could occur for a short period of time, standing inventories were assumed to be reduced by mortality due to increasing size and severity of wildfire, and mortality from insects and disease disturbance.

Using Forest Vegetation Simulator (FVS) (Ritchie, 1999), the Team modeled forest inventory growth over 100 years using the FIA and R5 inventory plots, updating all plots to 2008 in order to normalize all scenarios to a common inventory. The projected inventory growth from FVS was very close to being linear with slight declining growth rates during the last 50 years of the analysis. This projection was very similar to the results of the RPA analysis, using the 1990 inventory reference point. As FVS does not model the effects of catastrophic mortality, such as wildfire, insect and disease outbreaks and drought on growth, this continuing accumulation of volume is most likely inaccurate. Although this type of growth shown with FVS might be able to be sustained over the next 10-20 years, it is not reasonable to postulate that much of California national forest land, under current vegetation management programs and trends, would be able to withstand the intra-forest competitive pressures of high growth rates combined with disturbances such as wildfire, insect and disease. The utility of the FVS model is constrained because it cannot model the effects of stand-replacing wildfire, insect outbreaks, disease epidemics and drought. Therefore, FVS can facilitate reasonable projections of future trends, but is limited in its ability to project out to 100 years.

The Team used SPECTRUM and FELDSPAR (FORPLAN) models as they can incorporate natural disturbance regimes into the modeling process. FIA plots, R5 densified inventory plots, USFS fire history and mortality data were used as inputs to the model.

Projected forest inventory growth from this analysis indicates that most forest vegetative types will reach culmination of growth (growth rate will begin slowing, but the forest will continue to increased inventory until mortality exceeds growth) the next 5-15 years based on the average condition of the Region. This indicates increasing inventory followed by decreasing inventory in light of current management trends and natural disturbance events. This modeling approach appears closer to what may occur on national forest lands, since major natural disturbance events are now the major disturbance agents, as opposed to vegetative treatment activities. The Team also assumed that there is a direct relation between the amount of biomass/fuels being accumulated and the extent and severity of wildfire.

The Team then determined the height of the curve. Other estimates of inventory growth over the next 50 years were analyzed, including the following summarized in Table 1.

Table 1 - Sources consulted to determine likely growth curves for first five decades of model

Sources	% increase over base year	Factors and assumptions included in source data
Conservation Biology Institute database and analysis (CBI)	67%	with Historical data
FVS w/FIA plots	69%	without catastrophic Fire, Pest, Drought
SPECTRUM	48%	with increasing fire
Forest Plans	38%	with disturbance – accelerated
RPA	76%	w/o disturbance

While some of these estimates consider the effects of natural disturbance, none consider the increasing effect of wildfire, insect and disease threat and potential climate change effects. Forest Service forest inventory, fire, and forest growth and yield experts (Warbington, Bahro, and Sherlock 2008 (pers. Comm.)) were consulted in order to establish reasonable assumptions about the effects of increasing natural disturbance. Expert consensus concluded that a 30 to 40% increase in natural disturbance can be expected over the 2007 level in the next 40-50 years.

In summary, the BAU carbon inventory curve is a product of growth models predicting a declining rate of growth due to stands aging, adjusted for expert estimations of increasing incidence and scale of disturbances from wildfire and insect and disease mortality. Other scenarios' impacts on inventory can be modeled and compared to BAU, and additional carbon sequestration or emissions can be evaluated. Given the errors associated with measuring and sampling the biomass/carbon inventory, attempting to develop models or algorithms with greater precision did not seem productive. The Team used conservative estimates below those defined by RPA and Forest Plans.

Activities used to project the existing trends are summarized from the FACTs database and uses the last 5-year budget and FACTS footprint for making future projections. The FACTS database includes acres of Wildland Fire Use (now called "Appropriate Management Response"), many of which are in designated wilderness areas.

Each LMP identified vegetation management practices necessary to implement the goals within land allocations. All practices are assumed be accomplished according to approved plans and prescriptions. All forest management activities are assumed to be bound by national forest standards and guidelines, budget, etc.

Assumptions Intensive Even-Age Management scenario

a. The land base for the Intensive Even-Age Management scenario is the RPA productive forest lands.
b. Assumes that 1/7 of the productive forest land is clearcut and reforested every 10 years (70-year rotation).
c. Standards and guidelines, practices, prescriptions and schedules for each LRMP would not be followed. NFMA and FSM direction on the use of clear cutting would not be followed.

Assumptions in the Maximize Forest Resiliency scenario:

a. The land base for the carbon flux benchmark is the RPA productive forest lands.
b. The activities to optimize the carbon inventory are modeled with the "vigor" set of prescriptions. This prescription reduces canopy cover to 35%, removes trees based on crown position (suppressed first), crown ratio (smallest crown within each crown position) and then dbh (smallest dbh and works its way up). Removes roughly 50% of the trees.
c. Carbon storage with this scenario is focused on the larger trees.
d. Standards and guidelines, practices, prescriptions and schedules for each LMP would not be followed

Assumptions used for the REFOR Scenario

a. The land base used to apply activities for the Reforestation Scenario is the BAU Scenario land base, non-withdrawn productive forest lands.
b. All practices will be accomplished according to plans and prescriptions approved in Forest LMPs. Activities would be bound by standards and guidelines approved in Forest LMPs.
c. Under this reforestation scenario all activities accomplished under the BAU scenario would be accomplished. Additional reforestation, above the acres reforested under BAU, would be accomplished by reforestation of areas burned into a deforested condition by wildfire and by reforestation of acres currently part of Region 5's reforestation need. Reforestation would be done by planting trees or by natural methods.
d. Region 5 currently has a reforestation need of 136,162 acres. Under this scenario approximately 50,000 acres of the reforestation need would be reforested. Many acres of the reforestation need are

covered with dead wood and competing vegetation. Reforestation work on these acres would be expensive and contentious because the use of herbicides would be required to ensure success. The 50,000 acres treated under this scenario would focus work on recent fires; approximately 43,700 acres would come from fires that burned in 2007.

e. The number of acres burned into a deforested condition in the future will be based on a projection of total acres burned each year from 2008 through 2050 (projection by Scott Conway, Mark Nechodom et al). This reforestation scenario assumes 23% of the total acreage of national forest land burned results in a deforested condition on productive forest lands. The assumption that 23% of total national forest acres burned will result in a deforested condition was derived from an analysis done by Mike Landram using fires greater than 1,000 acres in Region 5 from 2001 to 2007. Landram's analysis defined "deforested condition" as areas mapped in the 3 highest mortality classes in a 7 class mortality map derived using remote sensing technology. Deforested condition implies a reforestation need. See the website for an explanation of methods used.

f. Clearcut salvage harvesting will occur on 7.5% of the acres burned. (Business As Usual). The 7.5% was developed by querying the FACTS data base and getting the number of acres harvested using Activity Code 4114 (Stand Clearcutting - Salvage Mortality) from years 2003 to 2007. The number of acres harvested using code 4114 was divided by the acres of national forest lands burned to a deforested condition from years 2001-2005. An assumption was made that there is a 2 year lag between the fire and salvage harvesting. An assumption was made that the activity code Stand Clearcutting - Salvage Mortality would only have been used to report harvesting on stands having less than 20% crown cover. The need for reforestation in the salvaged areas is a result of the wildfire and not the result of the harvesting. Other salvage harvesting would occur in burned areas but that salvage harvesting would not result in a reforestation need.

Reforestation (REFOR) assumes use of the following methods;

1. Traditional tree planting - This method is the one most commonly used in the last 30 years. Reforestation would occur by site preparation of the planting site, planting trees approximately 200 to 300 trees/acre, two release for survival treatments within 5 years of planting and one precommercial thinning at age 15. Areas will be surveyed to verify the success of tree planting. This prescription would occur on areas where salvage harvesting has been accomplished and in areas where small trees or young plantations burned and removal of large overstory trees would not be needed.
2. Natural Regeneration - Natural Regeneration would be accomplished in areas having an adequate seed source or root stock of trees capable of sprouting such as hardwood trees. It would occur in areas where salvage harvesting does not occur. Site preparation and release may or may not occur depending on site conditions. Precommercial thinning may or may not occur at age 15. Areas will be surveyed to verify the success of natural reforestation.
3. Wide spaced cluster planting - Wide spaced cluster planting would be accomplished in areas where an adequate seed source does not exist or where natural regeneration is not reliable. It would occur in both salvaged and not salvaged areas. 145 (30 foot cluster spacing, 3 trees/cluster) to 544 (20 foot cluster spacing, 5 trees/cluster) trees/acre would be planted in clusters of 3 to 5 trees per cluster, clusters would be 20 to 30 feet apart. Site preparation and release would occur. Precommercial thinning may or may not be needed. Areas will be surveyed to verify the success of planting.
4. Planting Founder Stands - Founder Stands would be created where seed sources are gone, in areas that are inaccessible or too steep for other methods, where technology is not available to accomplish site preparation or areas where costs of reforestation work is prohibitive. It would occur

in areas where salvage harvesting does not occur. Strategically placed small stands (< 10 acres), would be planted to provide a future seed source for a large area that has no seed source. The actual acres planted within the area with no seed source would be minimal. Site preparation and release may or may not occur depending on site conditions. Precommercial thinning may or may not be needed. Areas will be surveyed to verify the success of planting.

5. Natural Recovery - Under this prescription, areas would be allowed to develop without assistance, no deliberate reforestation would be attempted utilizing either natural regeneration or planting. This method would be used in areas that are inaccessible or too steep for other methods, where technology is not available to accomplish site preparation, areas where costs of reforestation work is prohibitive, or where vegetation conditions such as brush prohibit reforestation. No surveys or monitoring would be done to determine if and when the areas become forested.

Reforestation after fires

In 2005, the Silviculture group at the R5 Regional Office began encouraging utilization of all the methods described above. These practices have not been in place long enough to draw any trends on the number of acres used for each method. Professional judgment is being used to assign percentages of the treatments used for purposes of this scenario.

1. Traditional tree planting -This method could be used on the 7.5% of the acres burned into a deforested condition and in burned areas of small trees and young plantations. Some of the acres salvaged would also be planted using wide spaced cluster planting. Traditional tree planting would occur on 5% of the acres burned into a deforested condition.
2. Natural Regeneration – The FACTS data base was queried to get the number of acres of natural regeneration accomplished in Region 5 from 2001 – 2007. The query resulted in very few acres of natural regeneration accomplished in Region 5. No estimate from historic use of the code can be made. This prescription would occur on 25% of the acres burned into a deforested condition.

3. Wide Spaced Cluster planting – There are no records in the FACTS data base to show how many acres of cluster planting had been accomplished. This prescription would occur on 50% of the acres burned into a deforested condition.
4. Founder Stands - There are no records in the FACTS data base to show how many acres of founder stand planting has been accomplished. This prescription would not be widely used. As described above the actual acres planted under this scenario would be minimal, this prescription would occur on less than 1% of the acres burned into a deforested condition. No acres are planned for this method.
5. Natural Recovery - Activity Code 4453 is a new code, the code has only been available since 2006. There is not sufficient data to develop an estimate using the FACTS data base. This prescription would occur on 15% of the future acres burned to a deforested condition.

Reforestation of Reforestation Needs – The 50,000 acres of reforestation need planned to be treated under the reforestation scenario would be treated by traditional tree planting and wide spaced cluster planting. Some establishment of founder stand would occur but the acreage would be minimal. No acres for natural recovery or natural regeneration are planned.

Table 2 - Distribution of Reforestation of "Reforestation Needs" areas

Prescription	% of acreage treated by the prescription	Acres of Reforestation Need treated by the prescription
Tree Planting to meet standards	10	5,000
Wide Spaced Cluster Planting	90	45,000

Appendix B: Definitions

Land and Resource Management Plan (LMP) - A plan that provides the framework to guide the ongoing land and resource management operations of a national forest. The goal of the LMP is to provide a management program reflecting a mix of activities for the use and protection of the Forest. To accomplish this, a LMP:

- Establishes the management direction and associated long-range goals and objectives for the Forest;
- Specifies the standards, approximate timing, and vicinity of the practices necessary to implement that direction; and
- Establishes the monitoring and evaluation requirements needed to ensure that the direction is being carried out, and to determine if outputs and effects have been reasonably estimated.

Forest land — Land at least 10 percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between heavily forested and nonforested lands that are at least 10 percent stocked with forest trees and forest areas adjacent to urban and built-up lands. Also included are pinyon-juniper and chaparral areas in the West and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of trees must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet wide.

Reforestation Needs - National Forest Management Act of 1976 established policy that all forested lands in the National Forest System shall be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans. It directed the Forest Service to report annually all lands in the National Forest System where objectives of land management plans indicate the need to reforest areas that have been cut-over or otherwise denuded or deforested, and best potential rate of growth. The acres reported by each forest each year are commonly referred as the “Reforestation Need.”

Appendix C: Management Activities and Practices

Forest practices modeled in the scenarios include:

- Site preparation
    - Clearing land to prepare the ground for tree planting or to prepare the ground for natural regeneration. This activity can be accomplished mechanically by piling debris with a tractor, by hand piling the debris, or by using prescribed fire.
- Tree planting
    - Planting tree seedlings in the ground.
        1. Traditional tree planting – Planting trees on a grid spacing such as 10' X 10'.
        2. Cluster Planting – Planting trees in widely spaced clusters of 3-5 trees.
- Natural Regeneration
    - Reforestation that occurs without planting trees. It occurs where root stock of sprouting trees is present and sprouts. It also occurs where seed from standing trees falls on the ground, germinates and survives. Site preparation may be done to create an environment that favors the germination of seed and survival of seedlings.
- o Natural Recovery
    - Acres burned into a deforested condition would be allowed to develop without assistance; no deliberate reforestation would be attempted utilizing either natural regeneration or planting.
- Conifer release
    - Removing unwanted competing vegetation from around favorable tree seedlings. Release for survival is done within 1-3 years after planting or seed germination to help the survival of seedlings. Release for growth is done after the seedling has become established. Release can be accomplished mechanically, by hand or with herbicides.
- Pre-commercial thinning
    - Cutting small (1" DBH – 10") trees around desirable leave trees. Trees are thinned to a target spacing or trees/acre.
- Commercial Thinning
    - Cutting medium to large (10" DBH +) trees around desirable leave trees, the trees are removed and used for wood products. Trees are thinned to a target spacing or trees/acre.
- Salvage harvesting
    - Cutting and removing dead and dying trees for wood products.
- Regeneration harvesting with reserved trees.
    - A harvest done to remove an existing stand of trees and replace with a new stand. Most of the trees are removed; some reserve

trees are left as part of the new stand. Under the North West Forest Plan (NWFP) 15% of the old stand must be retained, this practice is called Green Tree Retention (GTR).

- Regeneration harvesting without reserved trees.
    - A harvest done to remove an existing stand of trees and replace with a new stand. All of the trees are removed, also called a clearcut.
- Group selection
    - A harvest done to create small openings in a larger stand. Openings ½ acre to 5 acres in size are created by removing all the trees in the group.
- Prescribed burning
    - Burning under a specific set of conditions to achieve objectives identified in a burn plan.
        1. Broadcast burning - burning that cover a majority of the burn unit.
        2. Jackpot burning - burning of fuels in scattered concentrations, not a majority of unit.
        3. Underburn - burns of low intensity covering a majority of the burn unit.
        4. Fuels Benefit - acres burned in an unplanned ignition where the outcome meets the planned objectives for fuel treatment.
        5. Pile Burning - burning of piled material, includes hand and machine piles and decks.
- Wildland Fire Use
    - Letting natural ignition fires burn under specific conditions to achieve resource objectives.
- Fuelbreak construction and maintenance

Vegetative treatment to create a treated strip of lower surface, ladder and /or crown fuels in which expected fire behavior would be reduced.

- Fuels Treatments
    - Rearrangement or removal of vegetative material accomplished by one of the following methods
        1. Lop And Scatter - rearranging fuel, limbs & tops, brush, to reduce fuel bed depth or speed up decomposition.
        2. Mulching – any crushing, mowing, or other treatment that grinds or chews up fuel.
        3. Piling - hand piling or machine piling of fuels.
        4. Chipping – feeding fuels into a chipper to change the size/shape, includes leaving on site or removal.
- Pruning
    - Cutting the limbs off a tree up to a specified height on the bole.

Table 1 - Management Activities by Scenario

Management Activity	#1 BAU	# 2 LMP	# 3 Even-Aged Mang	#4 Min Canopy Disturb	#5 Resiliency	# 6 BAU + Reforestation
Site preparation	X	X	X		X	X
Tree Planting	X	X	X		X	X
Natural Regeneration	X	X			X	X
Natural Recovery	X			X		X
Conifer Release	X	X	X		X	X
Precommercial Thinning	X	X	X		X	X
Commercial Thinning	X	X			X	X
Salvage Harvesting	X	X	X			X
Regeneration Harvesting With Reserve Trees	X	X	X			X
Regeneration Harvesting Without Reserve Trees			X			
Group Selection	X	X	X			
Prescribed Fire	X	X		X	X	X
Wildland Fire Use	X	X		X	X	X
Fuelbreak	X	X				X
Fuels Treatment	X	X	X	X	X	X
Pruning	X	X			X	X

Appendix D: Economic Analysis Methods and Assumptions

Assumptions in the Economic Analysis

- Carbon payments are made each year in dollars per metric ton.
- Assume all carbon tons above baseline levels as allocated as Federal Carbon Reserves and all carbon tons are fully allocated (rented out) as a credit.
- This model does not attempt to do the accounting for individual purchases of carbon credit offsets and to track them through time. It just uses all net carbon available each decade and assumes all carbon is purchased as a credit and payments are made for a ten year period at the midpoint of each decade.
- All forms of carbon storage have the same value per metric ton.
    - The price per ton remains the same regardless of volume purchased.
    - This analysis does not attempt to determine potential differences in market prices from changes in supply and demand for carbon credits over time.
- Time horizon is 100 years.
- Carbon sequestration is modeled in increments of 10 years. Total system carbon sequestration is reported net carbon sequestered over ten decades (100 years).
- Discount rates are applied at the midpoint of each decade.
- A constant discount rate of 4% is applied across all scenarios for all ten decades.
- The discount formula of Net Value / (1.04)^n is used. This assumes a 4% discount rate. The years to discount, *n*, is the midpoint of each decade.
- Net Value is the ($/ton * Tons Sequestered above baseline)
- This model assumes that carbon credits do not include any rights to the eventual harvest of the timber. Timber harvest is a separate activity and valued separately (not done in this model).
- Value of carbon per metric ton is assumed to be $6 per ton. This value seemed reasonable in that the price for carbon on the voluntary market during 2007-2008 ranged from $4-7/ton depending on the market (e.g., Chicago Climate Exchange, reported trades under the Regional Greenhouse Gas Initiative (RGGI) and other international trade indices).

Appendix E: Management, Monitoring and Verification Requirements for Project Accountability

This appendix documents how Forest Service managers manage, monitor and verify forest growth and condition. If public lands become an integral component of carbon accounting, management, monitoring and verification will be essential to overall accountability. This appendix is intended to help the interested reader to understand the context for public lands management systems for planning, managing and verifying carbon inventories.

There are two levels of reporting forest carbon stocks and biological emissions: carbon inventory reporting and project reporting. Forest Service managers could plan to achieve inventory levels, project inventory changes, implement programs, monitor, and verify and report carbon inventory over time. Projects are reported in the FACTS and TIMIS databases.

Discussion

The authority to report forest carbon inventory is comparable to the basic authority to report silvicultural practices (project reporting) on National Forest System lands is contained in:

1. Organic Administration Act of 1897.
2. Knutson-Vandenberg Act of 1930
3. Forest and Rangeland Renewable Resources Planning Act of 1974 (88 Stat. 476, as amended; 16 U.S.C. 1601-1610), that states "it is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans."
4. National Forest Management Act of 1976 (90 Stat. 2949; 16 U.S.C. 1600 (note)), that states "it is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans."

5. Title 36 Code of Federal Regulations, Part 219-Planning. These regulations guide silvicultural practices by the requirements found in * 219.15, * 219.27(b), and * 219.27(c).
6. Forest Service Manuals and Handbooks.

R5 Forest Plans and Interactions with Carbon Sequestration

All of the 17 national forests and the Lake Tahoe Basin Management Unit in the Pacific Southwest Region (R5) have approved land management plans (LMPs). These LMPs were developed as required by the Forest and Rangelands Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976 (NFMA). All of the LMPs in R5 were developed under the guidance of the 1982 Planning Rule. The LMPs in R5 were first established in the late 1980's up through 1995. The four Southern California national forests were revised in 2005 using the 1982 Planning Rule.

A new Planning Rule was released in April, 2008. The Region is currently developing work plans for plan revisions over the next few years. However, no plan revisions have been completed under the 2008 Planning Rule as of the publication of this report.

Carbon Sequestration

The amount of net carbon that is sequestered on the national forests in R5 is affected by many things. There is variability in both natural and human caused factors that will vary the amount of carbon sequestered in vegetation and the soil. Natural factors include changes in weather patterns, soil types, elevation, slope aspect, insects, disease, wildfires, etc. Human activities include timber harvest, prescribed burning, fire prevention activities, tree planting, silvicultural activities, range management, etc.

Land management plans can affect carbon sequestration through the goals established, the objectives identified for treatments, allocation of lands to various allowable uses and limitations/controls on activities through standards controlling how activities are planned and carried out.

Controls on Vegetation Management:

- Land allocations – wilderness, nonmotorized recreation, backcountry, motorized recreation, timber harvest, riparian zones, wildlife protection emphases, etc.
- Timber suitable lands criterion
- Controls over diameters available for harvest
- Controls on stand density
- Controls on allowable canopy cover
- Fire prevention/control strategies – SPLATS, HFQLG, suppression, etc.
- Controls for wildlife protection – big trees, spacing, distance from nests, etc.
- Controls for water quality – equivalent acres harvested, riparian strategies, MMR's, BMP's
- Range management – rest/rotation, stubble height,

Procedures for reporting carbon inventory

The three steps to report carbon inventory are:

1. Carbon inventory is derived from forest inventory plots. The National FIA Program collects, analyzes, and reports information on the status and trends of America's forests: how much forest exists, where it exists, who owns it, and how it is changing, as well as how the trees and other forest vegetation are growing and how much has died or has been removed in recent years. The FIA Program combines this information with related data on insects, diseases, and other types of forest damages and stressors to assess the health condition and potential future risks to forests. The program also projects what the forests are likely to be in 10 to 50 years under various scenarios. This information is essential for evaluating whether current forest management practices are sustainable in the long run and whether current policies will allow future generations to enjoy America's forests.
2. The R5 vegetation inventory program fits within a National FIA program. R5 has augmented the National program by installing plots on all vegetation types, not just forests, and by targeting rare types that require additional samples. The design is intended to provide a baseline vegetation inventory from which long-term monitoring of change (growth, mortality, species composition, etc.) can be assessed. These data are used for a wide variety of purposes, including timber

resource status, wildlife habitat assessment, wildfire hazard rating, and monitoring of biological diversity and climate change.

a. Periodic inventories are updated with the latest vegetation map and inventory mortality data. The tree mortality and removal information is collected in the field on FIA plots. Vegetation maps are overlaid with the plot locations to determine the map label associated with the subplots. The Forest Vegetation Simulator (FVS) is used to grow individual tree data forward to a common year. Previous growth measurements are used to calibrate diameter growth multipliers.
b. Annual inventories are compiled using the latest vegetation map and available inventory data. For annual inventories, 10 percent of the forested FIA plots are measured each year, each plot represents a 6000 acre hexagon area. Intensification plots and non-forest plots are measured in one field season.
c. Inventory data is put into RSL "Core Tables." Core Tables are used to assist in making projections and adjust the land base to the 1990 reference level. The Western Core Tables are developed to report basic information on land, water, vegetation, forests and timberland on the national forest lands of the Pacific Southwest Region. Land class, and forest type, as well as wood volume information, are organized by reserved, administratively withdrawn, special units, and available lands. Timberland availability and suitability under each national forest Plan is also reported. These reports are similar to those used in the Resource Planning Act Assessment, but with more details on forest land allocations. All FIA and RSL plots are grown and adjusted to the year 2007.

3. Once the Carbon inventory is derived from forest inventory plots and GIS-based resource inventories, vegetation simulation models (GAMMA/FVS and SPECTRUM) are then used to look at land management through time (changes in vegetation over time) and outputs (C) are generated. Vegetation prescriptions, management activities, and disturbance events are assigned to specific land types and the resulting effects on forest outputs (C inventory) are derived. All

inventory data are projected in to the future (up to 100 years) using these models.

To summarize, forest inventories provide the vegetation data including species, dbh and height. This data is the input in the GAMA/FVS model that grows the trees and the inventory, growth, mortality and removals are tracked over time. The linear programming model SPECTRUM is used to model vegetation change over time while analyzing different alternatives. SPECTRUM is intended to look out into the future and choose options that best satisfy the selected objectives of each scenario. Refer to the Sierra Nevada Forest Plan Amendment FEIS Appendix B-5 for more details on the modeling effort.

Project Reporting

The six steps to report projects are:

1. Projects that are reported include a set of activities or practices to remove, reduce or prevent CO_2 emissions in the atmosphere by conserving and/or increasing on-site forest carbon stocks such as planting and thinning.
2. Annually, the Regional Forester reports integrated vegetation management activities including reforestation accomplishment and program trends, plantation survival, timber stand improvement (TSI) activities, fuels reduction activities and timber harvest including thinning and salvage program accomplishment in the Forest Service Activity Tracking System (FACTS).
3. The FACTS database is the activity tracking system used for all levels of the Forest Service to report projects.
4. All integrated vegetation management activities are recorded in FACTS annually. Activities from surveys, prescriptions preparation, site preparation, harvest, planting, certification including planting certification, certification of natural regeneration, natural recovery, TSI, etc.
5. A parallel reporting process is the Timber Management Information System (TMIS). TMIS is designed to store and retrieve timber-related information. It provides an efficient way to interface with a variety of other planning and operation systems to avoid duplicating information reporting and beginning anew

with each new information requirement. Use of the system is mandatory at the service-wide level. It performs the following functions:

- Provides information to manage the timber program.
- Stores and manipulates site specific information in numerous ways.
- Meets data requirements for support analysis systems, such as forest planning models (FORPLAN) or special studies (for example, endangered species habitat, or defaulted timber sales).
- Meets data requirements for analysis systems, such as multi-year program budgeting and program accounting and management attainment reporting systems.
- Sorts and retrieves treatment accomplishment data.
- Aggregates accomplishment data for regional and national summaries.

6. An additional certification is required for plantations. Certification for adequate restocking is performed on a systematic survey and can take place after the third growing season from planting or anytime thereafter that established seedlings meet Regional certification requirements. Adequate restocking consists of:
   - Meeting a minimum number of established commercial conifer trees per acre (TPA) by forest type and site class.
   - At least 50 percent stocked plots.
   - Stocking well distributed over the area.
   - Silviculturists shall certify plantations as stocked, when in their professional judgment there is reasonable assurance that the plantation will persist in the expected future under prescribed management practices. Persistence means that no additional funds will be needed to replant release for survival, or protect to meet stocking objectives as stated in this section, or as otherwise stated in the prescription for the stand. Accomplishments are reported in the FACTS database.

APPENDIX F: Conceptual Framework for US Forest Service Public Lands Forest Protocols and Principles

Purpose of protocol

These concepts are brought forward to facilitate discussion among California Climate Action Registry protocol technical team and entities advancing forest carbon accounting protocols on possible approaches to the Forest Service demonstration of carbon benefits accrued through specific projects on national forest lands.

Background and Context in California

The exact role of public forest lands was not explicitly identified in the protocols or the scoping plans estimating California forests capabilities to sequester carbon. The role of public forest lands in AB 32 was a matter of public comment and interest in the ARB Managed process to develop forestry carbon accounting protocols in California.

After receiving public comments, in December 2007, the California Air Resources Board (ARB) formally requested that the California Climate Action Registry (CCAR) convene a forestry technical working group to develop a revised and expanded set of forestry protocols that would broaden participation of the forest sector including some assessment of public lands. The working group is composed of several State agencies, a number of non-government organization (NGOs) representing land trusts and land conservation interests, environmental interests, representatives of California's industrial and non-industrial private landowners, State Parks and the Forest Service. This group's work was submitted through CCAR to ARB in November 2008 for public review, comment and possible adoption. At the close of this analysis, five forest strategies were identified by the California Climate Action Registry (CCAR) to sequester carbon in California's Forests.

- Reforestation-Increase forest stocking by restoration of native tree cover on lands that were previously forested, but have been out of tree cover for a minimum of ten years-Adopted October 2007
- Conservation Forest Management-Maintain higher forest stocking than required under the California Forest Practices Act regulatory requirements- Adopted October 2007

- Conservation- Prevent the conversion of native forests to non forest uses such as commercial development or agricultural use- Adopted October 2007
- Urban Forestry- Plant trees in urban landscapes for carbon sequestration and energy conservation benefits- Adopted September 2008
- Fuel Hazard Reduction- Manipulate forest stands to increase stand health, reduce susceptibility to drought, insects and disease, and to reduce size and intensity of potential wildfire-Slated for Adoption late 2009.

Under AB 32, any reductions or offsets of carbon emissions are required to meet five principle standards- offsets must be:

- Real ------ reflect actual emission reductions/removals
- Additional ------ beyond what otherwise has happened
- Quantifiable ---- reliably measured or estimated
- Verifiable ---- easily monitored and verifiable
- Permanent ---- irreversible or backed up by a guarantee
- Enforceable --- backed up by contracts, legal requirements and official registration requirements

These standards required entities interested in providing carbon offsets to establish a carbon baseline against which additional carbon could be credited under an accounting framework. California's law governing forest protocol development, SB 812 passed in 2002, also required carbon to be secured under a permanent conservation easement and verified by a third party certifier.

Significant public comment was received by ARB in public review of these strategies. The permanent conservation easement requirement proved viable for a very small segment of forest landowners in California, primarily non profit land trusts who already had forest lands under conservation easements. The permanent conservation easement requirement proved particularly problematic for most forest landowners.

Intended scope of protocol

These concepts were developed as starting points for determining how Forest Service lands might begin to address the principle standards outlined in the California Climate Action Registry's protocol revision process in California. They are designed as a starting point for further discussion. Examples are drawn from Region 5, however, the protocol is intended to be applicable to all Regions and under most current (2008) protocol and reporting regimes.

Entity

Proposal

The entity shall be the designated Region of the U.S. Forest Service, as a division of the US Department of Agriculture.

Discussion

The USFS Region is the logical entity definition. The proposal will need discussion of what level of reporting will be required of the entity vs. the administrative reporting unit for the purposes of project reporting.

Administrative Reporting Unit

Proposal

The reporting unit shall be the Region, as defined above under Entity.

Discussion

The justification for this administrative boundary is primarily based on the authorities of the Regional Forester, and the level of the agency at which budgetary and land use allocation decisions are made. Land designations are made by Congress and implemented by the agency. However, administrative allocations, such as special management areas (e.g., Protected Activity Centers, Riparian Management Zones, etc.), which limit, designate or encumber management activities are determined by the Regional Forester.

The Region is also appropriate because of baseline definition parameters, described below.

Permanence

Proposal:

The Regional Forester must amend the LMP to designate project lands under a land allocation – a Federal Forest Carbon Reserve (FFCR) – that assures continued accrual of carbon benefits.

Discussion:

The key purpose of permanence provisions within any protocol or reporting regime is to ensure that carbon benefits claimed on a particular parcel or by a particular project are protected in perpetuity. The Forest Service considers the requirement for permanence to be minimal to nil on national forest lands. While it is widely recognized that forests are subject to dynamic changes over time, permanence provisions are generally concerned with conversion of land uses from forestry to other uses, such as urban development or agricultural production. Therefore, the CCAR protocols, as currently written, require a Conservation Easement to be established on the property within which the project takes place. Since Conservation Easements are not a legally plausible solution on public lands, an administrative means of ensuring the basic principles of carbon asset protection over an extended period of time must be found.

The Forest Service must demonstrate that FFCRs on national forest lands will be managed in a manner compatible with accrual of carbon benefits. Any given project on national forest lands, if reported as a project intended to sequester carbon, must show that the land designation or allocation of the specified project site will not be converted to uses incompatible with the reported carbon benefits.

Analysis shows that acreage held in public trust by the Forest Service has increased by 0.025% per annum over the last five years. A brief assessment of Region 5's land acquisition program has shown that, while nearly 5000 acres have been brought into the National Forest System over the past five years, only 500 acres have been conveyed out of the System during the same period. Therefore, it is logically arguable that lands designated for the purposes of carbon benefits accrual will be managed for those benefits for the foreseeable future, and are at little risk of conversion to other uses. Should the Regional Forester determine that project lands should be converted to uses other than carbon benefits accrual, the forestry protocol reporting would reflect that conversion as an emission, just as with any other project. If alternative lands with equivalent carbon benefit values can be designated to replace project lands, those substituted lands would be subject to the same evaluation of baseline and additionally that would be applied to any new project (i.e., they would have to grow carbon to replace the losses to conversion).

The administrative justification for this definition of permanence under this protocol can be strengthened by understanding the authorities under which the Regional Forester may change a land use designation permanently:

1. Under the "Educational Land Grant Act," (cite) the Regional Forester may convey up to 80 acres out of National Forest System lands for the purposes of establishing a public school.

2. The Regional Forester may remove lands from the National Forest System in very small increments under the Small Tracts Act, in order to correct minor property line infringements, such as an inaccurate historical survey, or a private building or development with an insignificant infringement of property boundary.

3. The Townsite Act provides that the Regional Forester may dedicate up to 640 acres for "community purposes" such as a landfill, a recycling center or water treatment plant.

In each of these cases, the total acres that may be removed by the Regional Forester are relatively minor when compared to the minimal size of parcel that must be dedicated under a reported project (CCAR requires a minimum of 100 acres).

Baseline

Proposal

Regional baseline will be established by documentation of management trends beginning at least ten years prior to project registration, and projected within the context of existing LMPs for each national forest within the Region.

Discussion

Baseline is the "business as usual" trend in land use and management, which would be in effect were there no deliberate actions or investments to create carbon benefits. The USFS baseline should use a ten-year retrospective analysis of the Regional management direction, including an aggregated analysis of the Land and Resource Management Plans (LMPs) from each national forest within the reporting Region.

Since CCAR requires any participating entity to meet the General Reporting Protocol (GRP), the Regional emissions level should be already established prior to any project reporting. At this time, only non-biological emissions reporting is required. However, in order to establish the carbon stocking levels, the Region would need to report total inventory and removals for the last ten years prior to project establishment. This forms the baseline inventory of biological resources (i.e., trees for the most part!).

It is important to recognize that the LMPs do not provide an adequate analysis of baseline. LMPs are written on a periodic basis by each national forest to document the goals and preferred ecological and management outcomes for that forest over the next ten to fifteen years. While many LMPs are out of date (i.e., their official revision is well beyond the customary 10-15 year cycle), they are largely guidance documents and do not reflect actual management practices, including levels of funding available to accomplish preferred goals.

Additionality

Proposal:

1. The USFS defines additionally as "financial additionally" consistent with international standards.
2. Carbon Benefit Projects will be limited to reforestation, made possible through exogenous funding.
3. Bioenergy feedstocks may provide an additional carbon benefit, claimable by a non-Forest Service contractor or operator, as long as the management project meets the criteria established under Integrated Vegetation Management program definitions.

Discussion

In order to make the case that a given project has actually accrued carbon benefits, the agency must prove that intentional investments were made and actions were taken in order to create carbon benefits that would otherwise not have been created under the business as usual scenario.

Since most preferred management activities are limited by availability of funds, despite completed NEPA analyses and records of decision, it would seem logical that a given project should demonstrate that accomplishment of the project's objectives were due solely to additional funding. The agency may wish to contemplate whether it would limit project designation to sites where extra-curricular funding has been invested.

Leakage

Proposal

The requirement to quantify leakage is moot. There is no nexus with reforestation and other emission-stimulating activities.

Discussion

The burden of proof on the agency is to show that no additional emissions, beyond *de minimus* levels of emissions, have been created as a result of reforestation or IVM project implementation. Concerns about leakage focus on whether the reporting entity has increased emissions outside of the project's boundaries or activities as a direct result of completing the project. The risk of leakage, or manipulation of any crediting system to show benefits while obscuring impacts, is decreased where the ambit of administrative decision making coincides with project establishment and management. For example, if an entity's land base is no larger than its project, the risk of leakage is nearly null.

Verification

Proposal

Project certification and verification will be conducted in accordance with standard practices for all forestry protocols under any reporting regime. A minimum requirement for certification is a "Certification of Establishment," produced by a USFS certified silviculturist.

Discussion

All reforestation projects on national forest lands require that planted stands be certified within three to five years by a Forest Service certified silviculturist, and documented in FACTS. This long-standing process under USFS rules is to ensure that the stand has been properly stocked and established commensurate with the site's capabilities.

Integrated Vegetation Management

Stand density management and modification of fuel profiles in order to decrease the size and intensity of wildfire and to increase resistance to stressors, such as drought, insects and fire is done through integrated vegetation management.

Table 2 - Relationship of FS Programs of work to the AB 32 Forestry Protocols

CCAR Protocol and Status	USFS Program and Management Approach
Reforestation/Afforestation	Reforestation after disturbance
Conservation (avoided conversion of forests to other uses; use of conservation easements)	State and Private Forestry programs, such as Legacy and some urban forestry programs
Fuel hazard reduction (CCAR protocol work has not begun in this area)	Hazardous Fuels Reduction to accomplish complementary objectives, such as stand improvement or wildlife habitat improvements
Conservation forest management (CCAR protocol under revision as of September 2008, expected presentation and adoption by Air Resources Board in November 2008)	Several categories of work to accomplish objectives
Urban Forestry (CCAR protocol coordinated by USFS PSW Center for Urban Forestry Research [McPherson]	Urban and Community Forestry cooperative program to protect, maintain and enhance trees within communities. (Cooperative Forestry Assistance Act of 1978, as amended)

Status of CCAR Working Group Public Lands Discussion

Baseline

"For lands owned or controlled by public agencies, the baseline qualitative characterization shall reflect common forest management practice for the agency and agency project area (harvest retention standards, rotations, and other practices that significantly affect carbon stocks) determined by applicable statutes, regulations, policies, plans and budget over the past ten years. The subsequent quantification of the baseline projection shall use a current inventory estimate and project it into the future for the life of the project based on the qualitative characterization. In the event that such statutes, regulations, policies, budgets, and plans have changed to materially affect the project carbon over the past ten years, the policies leading to the most conservative baseline carbon estimates should be used." (*August 2008, CCAR Public Lands Working Group Draft Protocols*)

The subgroup has adopted the following approach to establish a baseline on public lands. The following analysis is used with the goal of addressing current and past management constraints in order to provide a picture of why carbon stocks exist at the current level:

Apply a qualitative test to the public land project to determine conditions substantiating the baseline which have existed over the past ten years, including the following:

1. Regulatory structure under which land is managed;
2. Public agency mission;
3. Land management plans officially in place for the project area;
4. Other policy documents that control management activities on the land;
5. Physical management practices applied to the land, including silvicultural practices implemented.

Quantify current carbon stocks on the land using the protocol accounting method for each carbon pool to be measured.

Apply a dynamic baseline (as opposed to base point) by the use of acceptable models used to project the existing carbon stocks into the future for the life of the project.

The goal of this approach is to apply the baseline determined by using these criteria to two new CCAR project types: "Public Land Reforestation" and "Public Land

Conservation Forest Management". It is the consensus of the subgroup that the CCAR "Avoided Deforestation" baseline for private lands is equally applicable to public lands.

Discussion

The starting point for this discussion is the existing CCAR Forest Protocol policy on baselines[1], which requires that the proponent of a project determine the amount of forest carbon stocks at the start of the project, and which would have existed and continued to exist in the absence of the project designed to enhance forest carbon storage. Baselines are most often used at the project level, and establish a control point for determining what the Registry considers additional carbon storage that is verifiable and recordable. CCAR has adopted language governing the meaning of "additional" in this context that will be the topic of further discussion by the public lands subgroup and the committee as a whole[2].

The premise of the above recommendation is that the entirety of the social, fiscal and policy constraints placed on the public forest land managers have resulted in the existing forest stand conditions and carbon stocks. Thus without the implementation of a project, carbon stocks would continue to accrue at the existing rate.

At this point the group found that the answers to several questions stood in the way of defining how the base-point would be carried forward to complete a baseline. Some of those questions are:

- What project types (Conservation, Reforestation, Conservation Forest Management, Restoration or others) will be carried out on public lands?
- What baseline is appropriate for each project type (static or dynamic)?
- How would the qualitative assessment of the past 10 years be used to set a future projection of carbon stocks if a dynamic baseline is used?

The group has concurrence that the starting point of a baseline should be the existing carbon stocks with a qualitative description of a previous ten years of operation

[1] The protocol wording is as follows: "Setting GHG accounting baselines for projects is a subjective process, as these baselines are counterfactual scenarios (i.e. what would have happened in the absence of the project). As a result, it should be noted that other programs may have approaches to forest project baselines that differ from those described in this section…"

[2] The existing CCAR forest protocols define additionality as "Forest project practices that exceed the baseline characterization, including any applicable mandatory land use laws and regulations".

and constraints. The subgroup needs further guidance on the questions raised here, in order to reach a recommendation on how a baseline would move forward from the base-point and how this would apply to a variety of project types

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