Exploring the Potential of Obtaining Carbon Credits for Restoration Activities on Navajo Tribal Forest Lands

NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of dry, frequent-fire forests in the Intermountain West. These forests have been significantly altered during the last century, with decreased ecological and recreational values, near-elimination of natural low-intensity fire regimes, and greatly increased risk of large-scale fires. The ERI is working with public agencies and other partners to restore these forests to a more ecologically healthy condition and trajectory—in the process helping to significantly reduce the threat of catastrophic wildfire and its effects on human, animal, and plant communities.

Cover photo: After a snowy day on the Navajo Tribal Forest, this clump of large ponderosa pine not only looks beautiful, it continues to sequester carbon as it has for a hundred years or more. This ERI Issues in Forest Restoration paper examines the potential economic value of carbon sequestration for the Navajo Tribe. *Photo by Jean Palumbo*

NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute

PO Box 15017
Flagstaff, AZ 86011-5017
928-523-7182
www.eri.nau.edu

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Authors: Dr. Ching-Hsun Huang and Christopher Sorensen
Editor: Dave Egan
Reviewers: Charlie Denton, David D. Diaz, Dr. Alex Finkral, and Diane Vosick
Series Editor: Dave Egan

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Table of Contents

Executive Summary

Economic development in forested rural areas is a key component of ecological restoration activities in the frequent-fire forests of the Intermountain West, and nowhere is economic improvement more sorely needed than on the region's numerous Native American reservations. In this ERI white paper, we analyze the potential of improving the economy of the Navajo Nation (Diné Bikéyah) through the sale of carbon credits for carbon sequestered in its Tribal forests. Although this analysis is preliminary in nature, it points to a possible income source that has previously not been explored on Tribal lands. The goals of the study were to:

1) perform a project analysis to quantify carbon emission reduction resulting from forest restoration treatments
2) perform a discounted cash flow analysis to determine the net present worth of fuel reduction programs, and
3) examine the financial feasibility of trading carbon sequestered in the Navajo Nation forests.

The results of this study indicate that the effect of revenues from carbon sequestration on forest management could be significant, even though they may not be possible at the present time on the Navajo Nation Tribal Forest or elsewhere. Five main conclusions can be drawn from our analysis:

- The inclusion of carbon revenues in forest management could help change the current economics of forest treatments from a negative situation to a positive one.
- The amount and trend (constant or rising) of future carbon prices will affect the financial gains associated with carbon emissions reduction. Based on our analysis, reducing the forest stands in the Navajo Nation Tribal Forest to a basal area of 40 (BA40) would generate the highest net present worth values under all the nine carbon price scenarios we examined.
- Restoration treatments will enhance long-term carbon storage and the target basal area of the treatments will affect the magnitude of this increase. Our results indicate that a BA 40 treatment is the most efficient. In 50 years, it will result in 189% more stored carbon than not doing any treatments, and will store nearly 100% more carbon than even a BA 70 treatment during the same time span.
- As the demand for carbon credits increases, it is critical to advance societal awareness of carbon in forest ecosystems and, consequently, the effects of management strategies on long-term carbon storage.
- Policymakers and land managers need to be aware of changes in carbon prices as well as stand fire hazard risk levels, and adjust their management practices accordingly to minimize catastrophic wildfires while maximizing their revenues from the management of timber production and carbon sequestration.

If carbon trading in the United States is formalized by federal legislation and/or regional carbon trading agreements that encourage and financially compensate forest restoration treatments, then carbon sequestration can be enhanced and maintained in forest ecosystems. This approach presents a solution for reducing CO_2 emissions and mitigating global climate change while avoiding future fire suppression costs, decreasing the threat of destructive wildfires to forests, and providing income opportunities and generating regional output and employment for not only the Navajo Nation, but Native American tribes and rural communities throughout the forested regions of the Intermountain West.

Keywords: carbon sequestration, carbon credits, ponderosa pine, Navajo Nation.

Introduction

Economic development in forested rural areas is a key component of ecological restoration activities in the frequent-fire forests of the Intermountain West, and nowhere is economic improvement more sorely needed than on the region's numerous Native American reservations. In this ERI working paper, we analyze the potential of improving the economy of the Navajo Nation (Diné Bikéyah) through the sale of carbon credits for carbon sequestered in its Tribal forests. Although this analysis is preliminary in nature, it points to a possible income source that has previously not been explored on Tribal lands. The goals of the study were to 1) perform a project analysis to quantify carbon emission reduction resulting from forest restoration treatments, 2) perform a discounted cash flow analysis to determine the net present worth of fuel reduction programs, and 3) examine the financial feasibility of trading carbon sequestered in the Navajo Nation forests.

Navajo Nation Tribal Forest

Despite its immense size, much of the Navajo Nation's 27,000-square mile land base is remote and only marginally productive. One area of the Nation's lands that is resource rich is the Navajo Forest. The Navajo Forest traditionally refers to the timberland areas of the Defiance Plateau and the Chuska Mountains, which account for nearly 600,000 acres across Arizona and New Mexico (Figure 1). Roughly 428,000 acres of the Navajo Forest are unreserved, accessible commercial timberland with at least 5% crown cover of commercial timber species and a growth rate of 15 ft^3/acre/year or more. This commercial timberland includes 55,445 acres of mixed conifer forest and 372,566 acres of ponderosa pine forest, which is the focus of this study. Accounting for 95% of the standing sawtimber volume, ponderosa pine is the most important timber species in the Navajo Forest. Site indices (base age 100) of the ponderosa pine stand type range from 41 to 100 feet on the Defiance Plateau/Chuska Mountains forest area (USDI 1995).

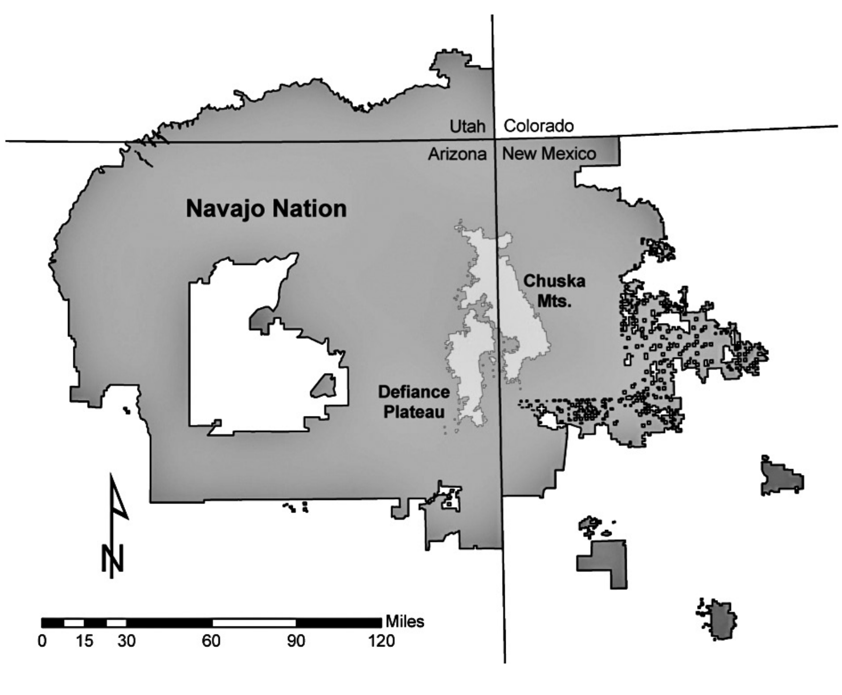


Figure 1. Defiance Plateau/Chuska Mountains forest area of the Navajo Nation.

Data Collection and Projections

The Navajo Nation Forestry Department granted us special permission to use the 1974, 1980, and 1989 Continuous Forest Inventory (CFI) data from the Navajo Forest timberland. The CFI database, measured by the staff of the Navajo Nation Forestry Department, is a collection of relatively high precision "snapshots" of forest conditions. (According to Bill Yemma, Bureau of Indian Affairs, the 2004 CFI measurements have not been prepared and, thus, were unavailable to us. However, Alexious Becenti, forest manager with Navajo Nation Forestry Department, told us that no significant treatments have occurred since 1989.) Given this situation, we used the 1974, 1980, and 1989 CFI data to conduct our analysis.

We entered the 1989 CFI data into MS Access for use in the USDA Forest Service Forest Vegetation Simulator (FVS; Crookston and Dixon 2005; http://www.fs.fed.us/fmsc/fvs/) and calibrated the periodic diameter growth and height growth increment models in the FVS using the 1974 and 1980 CFI data. We then analyzed the data and projected stand conditions to the year of the study--2009. We also used the Fire and Fuels Extension (FFE) of the FVS (Reinhardt and Crookston 2003) to simulate future fuel dynamics and potential fire behavior, and to simulate fuel treatments, including prescribed fire, thinning and mechanical treatments, and wildland fires.

To determine which areas of the Tribal forest would require restoration treatments to reduce the danger of damaging wildfires, we used a known classification system by Huggett and colleagues (2008) that measures torching index (TI) and crowning index (CI) to classify forest stands according to their fire hazard risk levels. For stands classified as 'in-condition," we decided that no restoration treatments were needed, but decided on mechanical thinning treatments for stands classified as "out-of-condition." We determined that 4,807 acres of the 372,566 acres of ponderosa pine forest were out-of-condition (medium-high fire risk or greater) and would need mechanical treatment to restore them (Table 1). These stands were dominated by dense, small-diameter stands of ponderosa pine with an average of 249.2 trees/acre, a basal area (BA) of 129.8 ft^2/acre, and a quadratic mean diameter of 9.8 inches.

Table 1. Acres of ponderosa pine timberland in each fire hazard level on the Navajo Nation timberland where lower values for torching index and crowning index correspond to higher hazardous fuel conditions.

Risk level	Torching index[a]	Crowning index[a]	Condition rating[a]	Acres	Assumed annual percentage burned
Very Low	≥25	≥25	In-condition	307,667.4	0.2%
Low	<25	≥40	In-condition	60,091.3	1.0%
Medium	<25	25≤CI<40	Out-of-condition	0	na[b]
Medium-High	≥25	<25	Out-of-condition	4,807.3	6.8%
High	<25	<25	Out-of-condition	0	na
Total				372,566.0	

[a] From Huggett et al. (2008)

[b] na = not applicable

Next, working with data describing the average annual forested acres burned from 1996-2006 in Arizona and New Mexico (USDA Forest Service Remote Sensing Applications Center 2009), we projected that 327 acres (6.8%) of medium-high risk ponderosa pine forest would burn annually (Table 1). In terms of fire severity, we projected that, within these medium-high fire risk stands, 75% of the overstory trees would be killed in a crown fire scenario. This corresponds with burn severity levels employed in the Forest Service report (Schwind 2008).

We chose BAs of 40, 70, and 100 ft2/acre to include a historically wide range of target BAs (Hunter et al. 2007). We assumed that a stand would be thinned in 2011 if it was projected to reach a fire hazard severity level that was out-of-condition by then. We also assumed that slash piles would be burned immediately after treatments. and only branch wood would be left on the site. We included carbon (C) emissions resulting from pile burning in our analyses, but we did not include C emissions from logging, trucking, and processing (see Finkral and Evans 2008).

Carbon Accounting Approaches

We used two carbon accounting approaches to study the potential for obtaining carbon credits from the Navajo Forest. The first approach is based on California's Climate Action Reserve (CAR) protocol for determining a forest project's risk reversal rating or the size of buffer pool that would be needed to secure carbon credits for a project. Our second approach uses the difference between sequestered carbon in treated and untreated scenarios. Both approaches are hypothetical in that their applications are unworkable under current conditions because 1) protocols in California do not apply to a Tribal forest in the Four Corners region of the Southwest, 2) there is an extremely limited carbon market for avoided deforestation due to wildfire, and 3) carbon credit prices are currently at all-time low.

Climate Action Reserve Reverse Risk Accounting

The CAR Forest Project Protocol 3.2, which provides requirements and guidance for quantifying the net climate benefits of activities that sequester C on forestland, recognizes Improved Forest Management projects and defines them as "management activities that maintain or increase carbon stocks on forested land relative to baseline levels of carbon stocks" (Climate Action Reserve 2009).

A buffer pool of carbon, which is measured in climate reserve tonnes (CRT), is required under the CAR approach. We, therefore, had to assess the Tribal forest project's reversal risk rating to determine how many CRT would be required for a buffer pool. The size of the contribution to the buffer pool depends on the forest project's risk rating for reversals, which are defined as the decrease between baseline C stocks and post-treatment C stocks from one year to the next. Forest project risk categories also include financial failure, management (illegal harvesting, conversion to non-forest uses, and over-harvesting), social (changing government policies, regulations, and general economic conditions), and natural disturbance (wildfire, disease/insects, and other episodic events).

According to the CAR protocol, wildfire risk differs depending on the level of treatment—that is, the wildfire risk rating, in our case 6.8% for medium-high risk ponderosa pine forest, is multiplied by 50% (high fuel treatment/BA40), 66.3% (medium fuel treatment/BA70), 82.6%, (low fuel treatment/BA100), and 100% (no fuel treatment). For the rest of the forest project's reversal risk ratings, we employed the default .multipliers provided in the CAR protocol to address the following risks: financial failure (5%), conversion (2%), over-harvesting (2%), social (2%), disease or insect outbreak (3%), and other catastrophic events (3%).

Baseline Accounting: With and Without Restoration Treatments

Using a baseline accounting approach, we identified and measured C stocks on the basis of whether they were treated or not. To do so, we employed the FVS and ran simulations with and without restoration treatments on the Navajo Forest for the next 50 years (years 2011-2061). Adapting a U.S. Department of Energy methodology that provides a way to record baseline emissions and emission reductions (USDOE 2007), we were able to account for C in growing stock and wood products. We assumed that only C stored in the standing merchantable timber and pulpwood, or in harvested sawtimber products, would be counted as C credits, and no C revenues would be derived from other forest components such as soil, dead trees, coarse tree roots, litter layer, and understory vegetation. We did not include carbon emitted during the combustion or decay of harvested wood or wood products in our calculations.

We estimated that the costs associated with treatments were \$125/acre for thinning, \$120/acre for piling of fuels, and \$80/acre for burning of slash piles (Joe Seidenberg, Ecological Restoration Institute, unpublished data collected from national forest offices in northern Arizona, 2008). We used these same costs regardless of treatment level. For timber prices, we used the 2008 timber cut and sold prices on national forests in Region 3, which were \$1.02/CCF for pulpwood and \$13.09/CCF for sawtimber (Forest Service 2008). We projected the annual compound softwood sawtimber and pulpwood stumpage prices in the Interior West in the late 1990s and 2050s at 1% and 0%, respectively (Haynes 2003). Labor costs were assumed to increase at a real rate of 1.5% per year (Council of Economic Advisers 2009). We did not include any costs for trading carbon through a central exchange (i.e., membership fees, costs of transactions, measuring, monitoring, and verification).

To perform discounted cash flow analyses, we used a range of real alternative rates of return (ARR) of 2%, 4%, 6% and 10%, which represent average real, before-tax rates of return. The ARR is the earning rate available on an investor's best alternative and the interest rate at which one can invest elsewhere. Therefore, new projects should earn at least the ARR. It is also the discount rate economists use when performing a net present worth (NPW) analysis (i.e., the present value of a project's revenues minus the present value of its costs during the project life). Using the biological data derived from the FVS for the discounted cash flow analyses, we then calculated and compared NPW, including timber and C revenues.

We investigated a total of nine C price scenarios (Table 2). The wide range of C price scenarios included both constant- and rising-price trajectories, a constant initial price of \$3/ton of C in 2010 (Scenario 1), and a fairly aggressive price path with initial price of \$67/ton, rising at \$1.30/ton per year (Scenario 9).

Table 2. C price ($/ton) scenarios for ponderosa pine on the Navajo Nation timberland.

Scenario number	Trend	Initial price in 2010 ($/ton of C)	Annual price growth	Price cap
1	Constant	$3	0	None
2	Constant	$10	0	None
3	Constant	$17	0	None
4	Constant	$50	0	None
5	Constant	$100	0	None
6	Constant	$167	0	None
7	Rising	$10	1.5%/yr	None
8	Rising	$10	4%/yr	$100
9	Rising	$67	$1.30/yr	$250

Note: C price scenarios 1 and 3-9 are based on the core price scenarios projected by the USEPA (2005). Scenario 2, $10/ton of C, was added to coincide with the goal of the DOE's Carbon Sequestration Program aiming at reducing the cost of C sequestration from $100-$300/ton to $10 or less per ton by 2015 (USDOE 2010).

RESULTS

Climate Action Reserve Reverse Risk Accounting

Using the CAR reversal risk ratings outlined above, we performed the risk rating analysis and determined the project's reversal risk rating was 18.7% for high-level treatments/BA40, 19.7% for medium-level treatments/BA70, 20.6% for low-level treatments/BA100, and 21.6% for no fuel treatments. These, then, would be the percentage of CRT in the Tribal forest required for the buffer pool under the different treatment scenarios.

Baseline Accounting: With and Without Restoration Treatments

We compared the growth of the standing timber volume resulting from the three levels of treatments with that of a no-treatment option. Our results indicate that treatments would stimulate the timber growth of the residual stands. During the 50-yr study time period, an additional 180.9 to 492.1 CCF/acre could be produced from thinnings (Table 3, Figure 2). Furthermore, we estimated that an additional 121.7 to 327.2 tons of C/acre would be stored under various restoration treatments (Table 3, Figure 3). In fact, the three treatment options outperformed the no treatment option throughout the study period. At the end of 50 years, in comparison to no treatments, the estimated increases in carbon storage were 189%, 88%, and 45% for the BAs of 40, 70 and 100, respectively. The downward curves of timber volume and C sequestration for no treatment in Figures 2 and 3 indicate the mortality of overstory trees resulting from wildfires.

Table 3. Volume (CCF/acre) removed from the treatments, and additional standing tree volume (CCF/acre) and C stored (tons/acre) due to the treatments projected for the following 50 years for ponderosa pine on the Navajo Nation timberland, 2009.

	Volume removed from the treatment (CCF/ac)		Standing volume during the 50-yr study period (CCF/ac)		C storage during the 50-yr study period (tons/ac)	
Treatment level	Pulpwood	Sawtimber	Additional	Additional/yr	Additional	Additional/yr
Target BA 40	4.28	13.22	492.17	9.84	327.18	6.54
Target BA 70	4.28	3.09	311.85	6.24	207.98	4.16
Target BA 100	1.05	0	180.93	3.62	121.58	2.43

Figure 2. Production functions of timber volume (CCF/ac) for no treatments, and residual BAs of 40, 70 and 100 for ponderosa pine on the Navajo Nation timberland, treated in 2009.

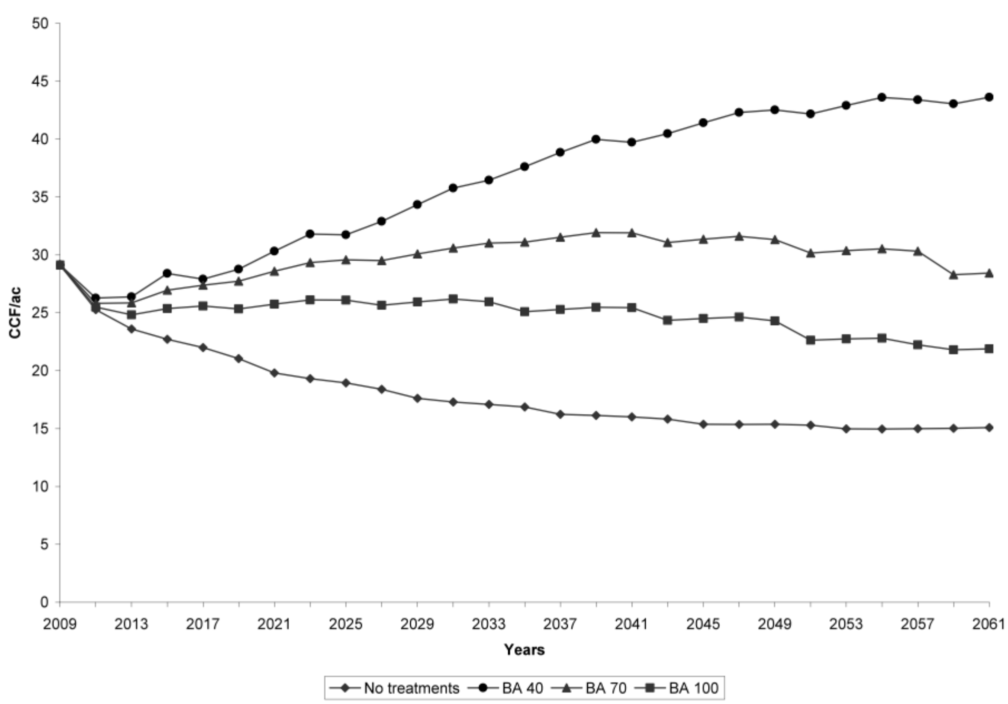
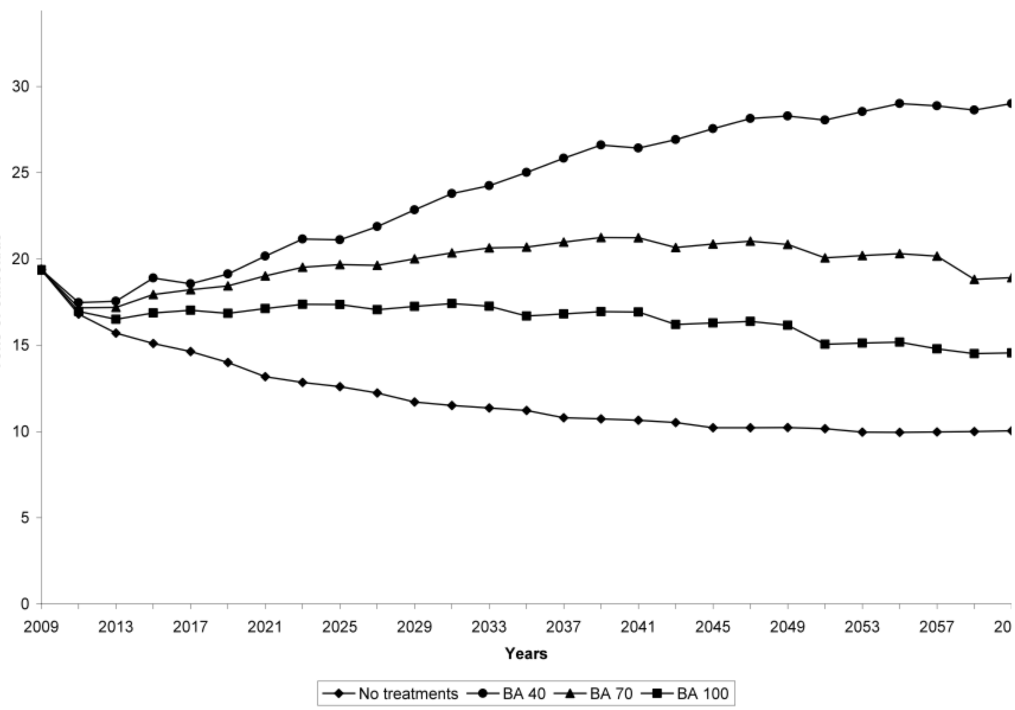


Figure 3. Production functions of C sequestration (above-ground biomass; tons/acre) for no treatments, and residual BAs of 40, 70, and 100 for ponderosa pine on the Navajo Nation timberland, treated in 2009.



Net Present Worth and Break-Even Calculations

We calculated and compared per-acre NPWs the two C accounting approaches (Table 4). (The NPWs derived from timber revenues only were denoted as NPWt, while the NPWs derived from both timber revenues and C credits were denoted as NPWtc.) Under the CAR approach, using a 4% ARR as an example, when timber was the only marketable output, the NPWt for 40, 70, and 100 BA treatments were -$142.32/acre, -$267.38/acre, and -$308.57/acre, respectively. The negative NPWt indicates that timber revenues alone were not enough to offset the costs of treatments due to low stumpage values. When both timber production and C sequestration were marketable outputs, with a C price of $3/ton (Scenario 1) and an ARR of 4%, the NPWtc of 40, 70, and 100 BA treatments increased to -$116.69/acre, -$256.23/acre, and -$306.31/acre, respectively. However, including C revenues would turn a negative NPWt of -$142.32/acre to a positive NPWtc of $2.90/acre when the price of C is $17 for BA40 (Scenario 3).

Under the second accounting approach, if target BA was 40, regardless of ARRs and C prices, NPWtc were all positive, except when ARR was 10% and C price was $3/ton (Scenario 1). In comparison to target BA40, NPWtc with BAs of 70 and 100 were smaller. Using an ARR of 2% and a C price of $10/ton (Scenario 2) as an example, the NPWtc were $1,637.35/acre, $887.51/acre, and $361.31/acre for target BAs of 40, 70 and 100, respectively. As expected, NPWtc calculated using the second accounting approach were significantly higher than those derived using the first accounting approach because of the difference in the calculation of wildfire risk reduction and eligible C credits.

Figure 4.

	Real alternative rates of return			
Treatment level	2%	4%	6%	10%
1st accounting approach: reduced buffer pool under the CAR protocol				
BA 40	14.21	16.66	18.18	19.52
BA 70	61.68	71.94	78.60	85.01
BA 100	318.66	408.97	483.85	582.36
2nd accounting approach: increased C stocks based on with and without analysis				
BA 40	0.83	1.36	2.06	3.83
BA 70	2.38	3.81	5.65	10.38
BA 100	4.70	7.44	11.03	20.72

Using an Excel solver spreadsheet tool, we generated break-even C prices to determine when timber and C revenues would just cover costs for the treatments. Under the CAR accounting approach, when ARR was 2%, break-even C prices ranged from \$14.21/ton to \$318.66/ton. They ranged from \$19.52/ton to \$582.36/ton as the ARR increased to 10%. Under the second accounting approach, break-even prices were much smaller ranging from \$0.83/ton to \$4.70/ton using a 2% ARR or \$3.83/ton to \$20.72/ton using a 10% ARR. The decrease in break-even C prices was the result of increased eligible C credits under the second accounting approach.

Discussion And Conclusions

The idea of implementing restoration treatments to reduce the potential for massive C emissions from catastrophic fires, and then claiming the amount of C emissions avoided as tradable C credits and using those revenues to cover treatment costs has been discussed for this region (Egan and Seidenberg 2009). However, the reality of the current situation suggests this scenario is unlikely at this time. The price of carbon, for instance, has been at \$0.10/tonne of CO_2 (\$0.33/ton of C) on the Chicago Climate Exchange since January 2010, which is much lower than the lowest C price scenario of \$3/ton investigated in this study. In addition, the various costs of participating in carbon trading have been an economic constraint for many forest landowners hoping to incorporate carbon management into their forest planning.

Nonetheless, the results of this study indicate that the effect of revenues from C sequestration on forest management could be significant, even though they may not be possible at the present time. Four main conclusions can be drawn from our analysis:

- The inclusion of C revenues in forest management could help change the current economics of forest treatments from a negative situation to a positive one.

- The amount and trend (constant or rising) of future carbon prices will affect the financial gains associated with C emissions reduction. Based on our analysis, BA 40 treatments would generate the highest NPWs under all the nine C price scenarios.
- Restoration treatments will enhance long-term C storage and the target BA of the treatments will affect the magnitude of this increase. Our results indicate that a BA 40 treatment is the most efficient. In 50 years, it will result in 189% more stored carbon than not doing any treatments, and will store nearly 100% more carbon than even a BA 70 treatment during the same time span.
- As the demand for C credits increases, it is critical to advance societal awareness of C in forest ecosystems and, consequently, the effects of management strategies on long-term C storage.
- Policymakers and land managers need to be aware of changes in carbon prices as well as stand fire hazard risk levels, and adjust their management practices accordingly to minimize catastrophic wildfires while maximizing their revenues from the management of timber production and carbon sequestration.

If carbon trading in the United States is formalized by federal legislation and/or regional carbon trading agreements that encourage and financially compensate forest restoration treatments, then carbon sequestration can be enhanced and maintained in forest ecosystems. This approach presents a solution for reducing CO_2 emissions and mitigating global climate change while avoiding future fire suppression costs, decreasing the threat of destructive wildfires to forests, and providing income opportunities and generating regional output and employment for not only the Navajo Nation, but Native American tribes and rural communities throughout the forested regions of the Intermountain West.

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Supplemental Material

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Ecological restoration is a practice that seeks to heal degraded ecosystems by reestablishing native species, structural characteristics, and ecological processes. TheSociety for Ecological Restoration International defines ecological restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability….Restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration International 2004).

Throughout the dry forests of the western United States, most ponderosa pine forests have been degraded during the last 150 years. Many ponderosa pine areas are now dominated by dense thickets of small trees, and lack their once diverse understory of grasses, sedges, and forbs. Forests in this condition are highly susceptible to damaging, stand-replacing fires and increased insect and disease epidemics. Restoration of these forests centers on reintroducing frequent, low-intensity surface fires—often after thinning dense stands—and reestablishing productive understory plant communities.

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of dry, frequent-fire forests in the Intermountain West. By allowing natural processes, such as fire, to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

The ERI Issues in Forest Restoration series provides overviews and policy recommendations derived from research and observations by the ERI and its partner organizations. While the ERI staff recognizes that every forest restoration is site specific, we feel that the information provided in the series may help decisionmakers elsewhere.

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