Is it Economical to Manage Jointly for Wood and Carbon Under the Climate Action Reserve Protocol?

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Abstract
To quantify the benefits and costs of modifying forest management for additional climate benefits, Cal Poly's Swanton Pacific demonstration forest was used to test the Climate Action Reserve's protocol and identify management strategies for both wood and carbon markets. Residing in the Southern Sub-district with its clearcutting restrictions, Swanton offers an ideal test site for landowners transitioning from even-aged to uneven-aged management. However, the increased minimum baseline condition for the region effectively precludes joint production of wood and additional carbon. The much lower baseline on the North Coast could allow for a joint production strategy that could meet some landowners' goals.

Key words: baseline condition, carbon registry, climate action reserve, CO_2e, forestry-offset

Introduction

The perception of an impending 'cap and trade' system for greenhouse gases in the United States has spurred the growth of tradable carbon-storage credits, or offsets, from a wide range of proven and new sequestration technologies. One of the most obvious is to add forests, known as forestry-offset projects, since trees are the only plants that retain woody tissue comprised of about 50 percent carbon by weight. Another reason for interest in forests for sequestering carbon is they are relatively inexpensive to establish and also provide a host of other environmental services. Nevertheless, there are a number of obstacles in the path toward full use of forestry-offset projects in meeting national and international policy goals on reducing atmospheric greenhouse gas (GHG) emissions.

For carbon-storing forestry-offset projects to be viable, the net revenue from carbon services must be competitive with expected cash flow for the forest landowner. This can be fairly low for forest landowners who prefer a reduced or zero harvest rate but will be much higher for forest landowners managing their land for maximum sustained harvest levels. The costs of additional inventory and monitoring actions required by carbon exchange protocols loom as a major issue in competitiveness (Mader 2007, Rudell et al 2007). Assuming that additional carbon inventories can be counted as a tradable benefit, Simpson (2008) reports that minor modifications for carbon storage of loblolly plantation management on a 30-year rotation can increase rates-of-return from 7.0 percent to 9.2 percent (NPVs from \$364/ac to \$520/ac) with just \$5/tonne CO_2e prices, if all three CCX forestry-offset

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protocols are used. He also noted that carbon monitoring and trading costs were 25 percent of the carbon revenue and that thinnings have a negative effect on carbon revenues. The CCX offset market closed in 2010 and is quite different than the CAR protocols (CAR 2010) that are better known in California. The goal of our research is to provide small to medium-sized forest landowners with information on carbon credits available under uneven-aged management, the costs of offering carbon credits on the market, and the likelihood of receiving sufficient revenues that justify the investment.

Forestry-offset projects – the basics

Although forestry-offset projects have been voluntarily used worldwide to comply with Kyoto, they remain controversial due to the transitory, albeit long-term, nature of trees. The CCX, and the more recent CAR protocols, use verifiable standards that forestry-offset projects must satisfy in order to "sell" carbon credits. The interpretation of the following four accounting issues are very important in how many offset credits are considered marketable for any individual project.

1. Permanence – sequestered carbon must be long-term to be of value in mitigating climate change.
2. Additionality – forest management must result in additional carbon storage in the forest and where the harvested products are used that would not have occurred with business-as-usual ("Common Practice"), estimated over a 100-year time horizon.
3. Baseline – carbon that would have been stored in lieu of new activities to store additional carbon, aka, *business-as-usual.*
4. Leakage –increased carbon storage can induce reduced carbon storage due to higher local timber prices, those leakages must be subtracted from the measured local benefits.

There are a growing number of carbon registries for forestry and other offset projects.[2] The CAR protocol is one of the newest (Version 2.1 in 2007, Version 3.2 in 2010); this study used Version 3.2.

Climate Action Reserve offset projects

The Climate Action Reserve (CAR or the "Reserve"), the successor to the California Climate Action Registry, is a non-profit organization created by the State of California in 2001 to "promote and protect businesses early actions" designed to reduce or offset their GHG emissions (CAR 2010). The Reserve is financed by GHG emitters interested in creating tradable offset credits that will presumably be less expensive than other forms of GHG reductions. It includes a number of detailed and very specific protocols, setting high standards for those applying to sell carbon storage credits. Climate Reserve Tonnes (CRTs or "carrots") can be sold to parties that want to offset current emissions or resell these offsets when there is a state or national system of required emission reductions.

[2] for example, American Carbon Registry (Environmental Resources Trust. Winrock International 1996), Verified Carbon Registry System (Verified Carbon Standard Association, Version 2, October 2006); Markit Environmental Registry (formerly TZ1. 2009).

Figure 1 illustrates the distribution of the CAR's offset projects. "Listed" projects are those that have been submitted to the Reserve but have not been verified yet by a Reserve-approved auditor. Once verified, the project is then "Registered" with a specific number of CRTs per year (known as "vintages"). The most common Reserve projects are offsets for landfill gases, nearly half of which have been registered. There are three types of forestry offset projects: (1) Reforestation, (2) Improved, formerly Conservation-Based, Forest Management (IFM, CFM), and (3) Avoided Conversion. Forestry-offset projects are the third largest in number among all projects. Although IFM/CFM are the most common among forestry-offset projects, only four have been registered: Lompico Forest Carbon Project in Santa Cruz with 11,708 CRTs in 2010, Garcia River Forest in 2004 with 715,268 CRTs from five vintages, The van Eck Forest with 274,403 CRTs from four vintages (2006 to 2009), and Big River/Salmon Creek Forests in 2007 with 736,517 CRTs from three vintages. Thus far, all registered forestry-offset projects are in the coast redwood region of California, and all three CFM registered projects are in the North Coast redwood region. However, none of these projects involve managing for carbon without significant reduction in (or elimination in Lompico's case) timber production.

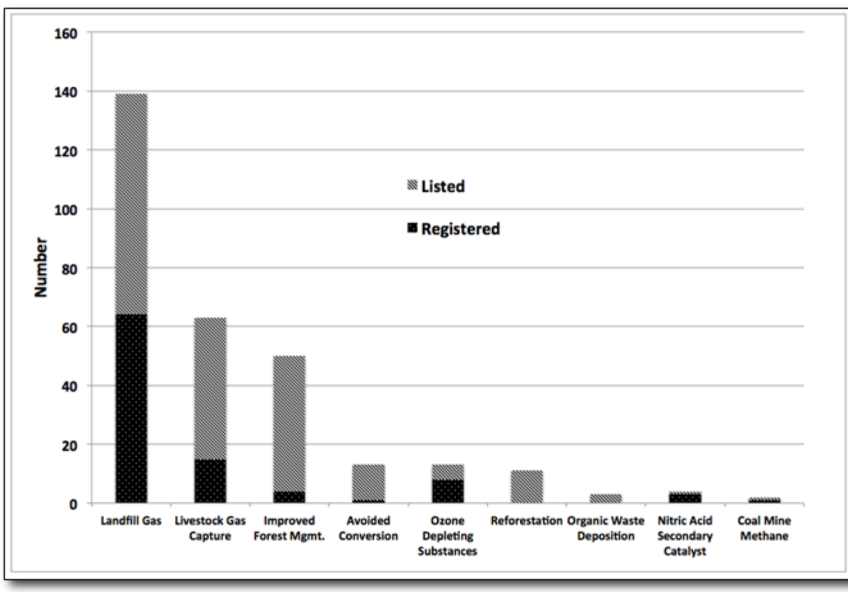

Figure 1—Climate action reserve offset projects.

Climate Action Reserve forestry-offset protocol

CAR's forest-offset protocol has gone through five iterations with the first announced on June 13, 2005 and the current version (3.2) approved on August 31, 2010. Listed and Registered projects can differ in requirements and standards depending upon the protocol version pertinent at the time of listing. Calculating CRTs under the IFM protocol is an involved and costly process. The process described hereafter greatly simplifies what is a much more detailed calculation.

One starts with an inventory of the subject forest property; this sets the year of the CRT vintage. Precision has a significant effect on available CRTs, where a sampling error (SE) greater than 20 percent eliminates any carbon credits, from 5.1 to 20 percent reduced CRTs by 5 percent, and 5 percent SE or less has no deduction. Inventories should include all standing timber with volumes estimated using CAR-approved cubic foot volume equations for tree boles. Next total above-ground metric biomass is calculated where bark and live crown biomass is added based on species and diameter. Carbon biomass is 50 percent of total above-ground bone-dry biomass which is then converted to metric tonnes (0.001 tonnes/kg). Under the current protocol, carbon weight must be converted to CO_2 equivalent (CO_2e) to represent the atmospheric effect of CO_2 emissions on climate (carbon tonnes x 3.67). Thus the Actual Above-ground, Live Carbon Stock (AC) in year y is calculated as follows:

$$AC\ (CO_2e) = \Sigma\ (cfvol_i)(kg/cf_i)(0.5\ C)(.001\ C\ tonnes/kg)(3.67\ CO_2e/tonne),$$
where i = species

The CAR protocols are based on creating offsets for owners who hold higher than 'average' inventories (common practice). While half of all parcels are going to be above the regional average in any case, the 100 year contract would require owners to maintain a high inventory for the following century.

Once AC is calculated, one then determines the minimum baseline (MBL). First, the carbon stock based on the Common Practice (CP) for the Assessment Area of the subject project is obtained from Appendix F of the protocol. The Common Practice for Version 3.2 was estimated using Forest Inventory and Analysis (FIA) plots on private forestlands. The equation for MBL depends on whether the initial carbon stock (actual above-ground carbon stock, AC) is greater or less than CP. The following MBL equation is used when AC > CP.

$$MBL = \max\ (CP, \min(AC, CP+AC-WCS),$$
where WCS is the weighted average of above-ground AC for all landholdings in addition to the subject property. If there are none, then AC = WCS, resulting in MBL = CP.

At this stage, it is important to estimate whether there exists any additionality as a result of the Initial Carbon Stock (ICS) being greater than the MBL If not, the remaining calculations are unnecessary since there is no additionality available in the ICS. Further, additionality per CAR protocol is only derived from existing, not predicted (from growth & yield modeling), carbon stocks.

If additionality appears to exist, one proceeds to model the baseline carbon stock (BC) for all required (in other words, live, above-ground timber) and optional carbon pools (e.g., shrubs, soil) through a series of growth and yield cycles over 100 years. This is needed to demonstrate that carbon credits (CRTs) can be maintained based on reliable predictions. The model must reflect all legal and financial constraints. The average of the growth and yield results is used for the BC calculation and must not fall below MBL.

If AC is predicted to still be greater than BC, one then adds below-ground biomass and standing dead biomass estimates to AC, along with other optional carbon pools. Interestingly, the equation for below-ground biomass (BBD) is an exponential functional of above-ground biomass (ABD) regardless of species [$BBD = \exp(-0.7747 + 0.8836 \times \ln(ABD))$]. Equation 6.1 provides the calculation that leads to CRTs, or Quantified Reductions (QR) for each year's (y) carbon stock:

QR_y – $[(\Delta$ □$C_{onnsite}$ - $\Delta BC_{onnsite}) + (AC_{wood\ products,\ y} - BC_{wood\ products,\ y})$ x 80 percent + $SE_y] + N_{y-1}$

where,

$\Delta AC = (AC_{onnsite,\ y})(1\text{-confidence deduction}_y) - AC_{onnsite,\ y-1})(1\text{-confidence deduction}_{y-1})$, if y is the first year, then $(AC_{onnsite,\ y-1}) = 0$.

$\Delta BC = (BC_{onnsite,\ y})(1\text{-confidence deduction}_y) - BC_{onnsite,\ y-1})(1\text{-confidence deduction}_{y-1})$, if y is the first year, then $(BC_{onnsite,\ y-1}) = 0$.

$AC_{wood\ products,\ y}$ = actual carbon in wood products produced in year y projected to remain stored for at least 100 years.

$BC_{wood\ products,\ y}$ = average annual baseline carbon in wood products that would have remained stored for at least 100 years.

SE = Secondary Effect GHG emissions caused by the project activity in year y.

N = Any negative carryover from the prior year (see footnote 9, p. 38 Version 3.2).

The first two terms are referred to as the Primary Effect. Wood products can either be processed by mills, with adjustments for mill efficiency, or "stored" in landfills for some types of projects. The 80 percent adjustment is intended to model market response to reduced wood product production where every tonne diverted to carbon storage will be compensated with an increase in harvesting 0.2 tones on other lands, i.e., leakage. While the 20 percent leakage may be a realistic estimate of local substitution, leakage at the timber market scale for North America has been estimated at over 80 percent (Murray et al. 2004). Wood residues that are harvested but used to generate energy are also ignored in the CAR accounting system. Over a 100 year lifetime, wood used for energy can constitute over half of initially harvested volume (Smith 2009).

Once QR is calculated, all remaining deductions (mainly risk of loss/reversal) are formula-driven. These deductions address the financial, managerial, social and natural disturbance risks that could result in release of CRTs. Finally, CRTs are reduced by the calculated risk percentage, and contributed to a Buffer Pool. However, as with leakage, little or no scientific support or rationale is offered for these constants. Table 6.4 of the Protocol provides a step-by-step procedure for these calculations.

The Lompico Project – an example

To exemplify the Version 3.2 protocol, the Lompico project was chosen for two reasons. First, it's the only CAR forestry-offset project adhering to the current protocol; the other earlier registered forestry projects were not required to provide as much information. Second, Lompico is in the Southern Sub-district of the Coast district where this study's project is located. The only drawback to Lompico for our purposes is their management objectives exclude timber harvesting.

Lompico, located about 10 miles north of Santa Cruz, was purchased by the Sempervirens Fund from Redwood Empire Co. as part of the Fund's mission to preserve redwood forestland. Carbon storage from precluding timber harvests on 285 ac of Timber Production Zone (TPZ) parcels within the 425 ac ownership was the basis for their application for IFM carbon credits through the Reserve.

First, Common Practice (CP) was determined to be 280 CO_2e tonnes/ac according to the protocol in order to establish the minimum baseline (MBL). Version 3.2 increased CP to 280 CO_2e tonnes/ac from the earlier version's 224. The new CP is quite high for the average of managed timberlands in the Santa Cruz and San Mateo Assessment Area, an issue that will be addressed again later in the paper. Second, the Fund's initial carbon stock in 2007 was estimated at 322 CO_2e tonnes/ac (with a 5.6 percent SE). Next, growth and yield modeling was performed based on thinning 30 percent of the timber greater than 18" DBH, giving a baseline condition (BC) that averaged slightly above MBL. Subtracting BC from the ICS resulted in 42 CO_2e tonnes/ac (11,970 total) of additionality for the 2007 vintage (*fig. 2*). Further additionality is derived from timber growth from the inventory date to the CAR application - 2008 and 2009 vintages of about 4 CO_2e tonnes/ac each year.

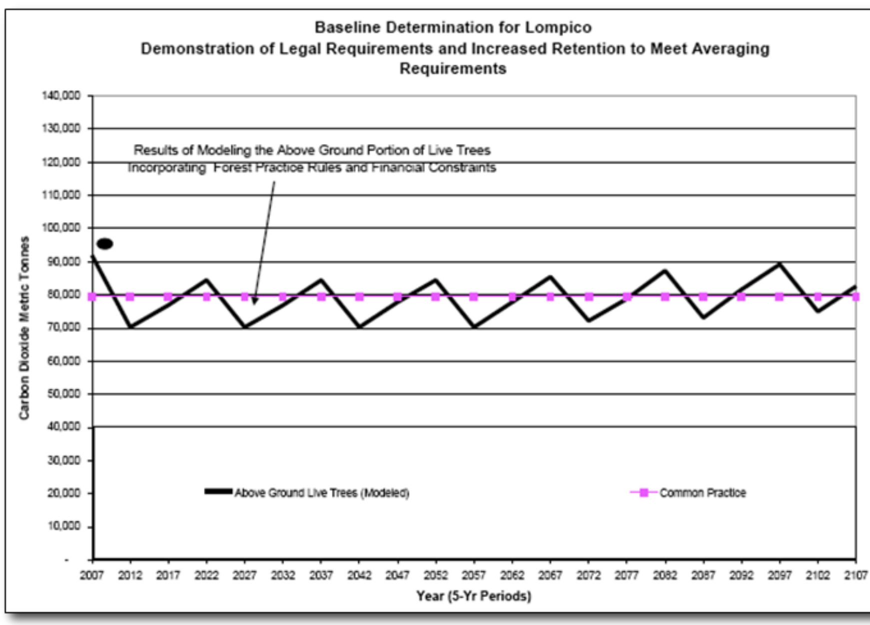

Figure 2—Lompico modeled baseline condition for live, above-ground carbon stocks.

What remains to determine CRTs after the calculation of the carbon stock is much smaller in magnitude but more detailed in procedure. After calculating the below-ground carbon stock, the second part of the Primary Effect is to calculate net wood product carbon stocks - planned harvests less baseline harvests. This is followed by estimates that are essentially deductions required to ensure permanency and avoid risks of human and naturally caused losses. In Lompico's case the net harvest carbon storage was negative because of the Fund's non-harvest philosophy. In the end, Sempervirens Fund was successful in selling 11,798 CRTs.

Swanton Pacific Demonstration Forest – Valencia Unit

Cal Poly owns two properties in Santa Cruz County for education and research – Swanton Pacific Ranch (3200 ac) near Davenport, and Valencia (620 ac) near Aptos. The Valencia unit is almost completely forested with the following characteristics:

- 480 ac of redwood-fir production lands.
- 60 percent redwood, 10 percent Douglas-fir, 30 percent hardwoods.
- Average high Site Class III.
- Areas with two to three age-classes from light thinnings in the 60s and 70s.
- Well-stocked, over 40 mbf/ac in conifer volume, 260 BA.
- FSC certified, approved NTMP.

Both forested properties are managed for educational and research purposes. Southern Sub-district Rules prohibit even-aged management. Valencia is managed for an uneven-aged structure using Guilden's BDq model is to guide silvicultural decisions (Guilden 1991). *Fig. 3* displays the current Valencia structure for the average stand compared to the BDq guide curve, with the following residual stand parameters: BA = 175 ft^2/ac, max DBH = 34", DeLiqourt's q = 1.15.

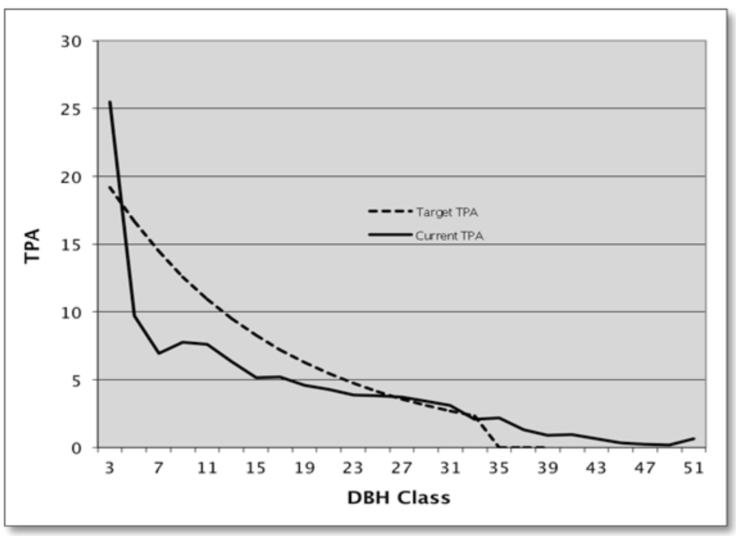

Figure 3—Current average Valencia stand structure compared to the target stand structure.

Although Valencia has a CFI system in-place and was scheduled for re-inventory, the Lockheed fire at Swanton delayed it making it necessary to install a separate inventory for this project. A VPS inventory was conducted in August 2010 according to the CAR protocol at a cost of $5000, resulting in the volume estimate stated above. Inventory costs were somewhat less than normal since DBH and height data were available from past CFI inventories. The sampling error was only 1.8 percent, thus no CAR deduction is necessary. The live, above-ground carbon stock was calculated to be 376 metric tonnes/ac of CO_2e.

As shown in the Lompico Carbon Project, the Santa Cruz Assessment Area's CP is 280 CO_2e tonnes/ac (MBL). Since Valencia's ICS > MBL, it may appear that additionality exists, but the average baseline carbon stock projected over 100 years must also exceed MBL. No reasonable harvest level could be found such that the average baseline carbon stock exceeded MBL. This is not economical since current stumpage prices of around $500/thousand board feet (BOE 2011) are far above the $10/metric ton of CO2 (roughly equivalent to a stumpage price of $75/mbf).

North Coast uneven-aged management for wood and carbon

The initial concept for a carbon project on Cal Poly's forest properties in Santa Cruz County presumed revenue possibilities existed based on earlier Protocol versions. However, the current version raised CP so high as to preclude joint timber and carbon management at Valencia. A possible explanation for this high value will be discussed at the end of this paper. Nevertheless, an opportunity for combining wood and carbon production exists on the North Coast where CP on equivalent "low" site quality is drastically lower - 165 CO_2e tonnes/ac (even North Coast high site is only 188 tonnes). Therefore, we propose to describe Valencia's carbon-offset potential as if it were in the heart of the coast redwood region, where Sub-district rules do not apply.

Figure 4 illustrates two sustained yield analyses: (1) baseline condition (BC) growth and harvests that are sustainable where the average carbon stock is at or above Common Practice (MBL), and (2) the average actual carbon (AC) resulting growth and yield modeling using residual stand BDq parameters stated above. The BC analysis reduced growing stock to about MBL, required a longer 15-year growing cycle. The average carbon stock was about 165 CO_2e tonnes/ac, or about 20 tonnes/ac greater than the Sub-district's MBL.

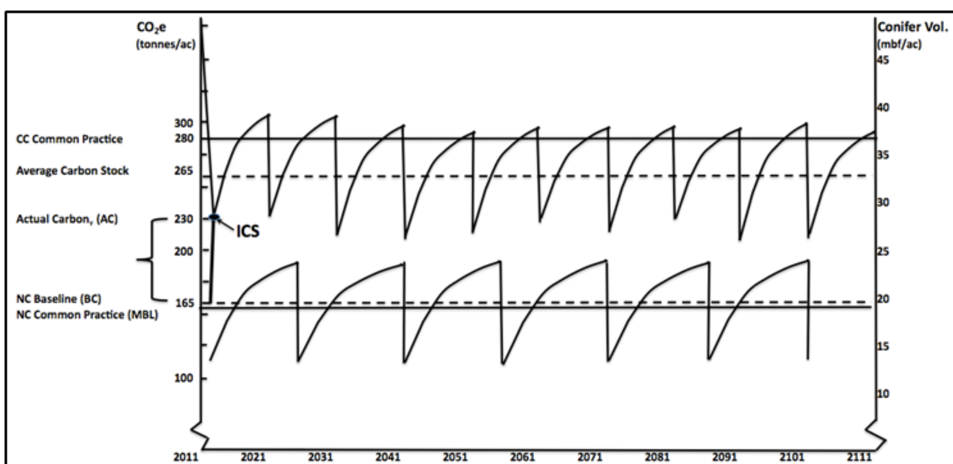

Figure 4—Sustained yield analysis for both baseline condition and uneven-aged timber management objectives.

Sustained yield analysis for the actual carbon stock started with a thinning that somewhat aggressively reduced live, above-ground CO_2e from 376 to about 230 tonnes/ac by harvesting nearly all trees above max DBH and drastically reducing the hardwood component. This reduced standing volume from about 43 mbf/ac total to about 28 mbf/ac. Afterward, a 10-year thinning cycle varies roughly between a residual volume of 28 mbf/ac and growing to 38 mbf/ac. The result is a growth rate of approximately 1000 bf/ac/yr, or 3.5 percent/yr. At a stumpage price of at least \$500/mbf, that is an annualized revenue of \$240,000. It would not make economic sense to substitute this one-time carbon revenue for this wood product income stream, even at conceivably higher carbon prices.

If a forestland owner in the North Coast region were to manage a property like Valencia on an uneven-aged management regime as prescribed, there would be an Initial Carbon Stock (ICS) well-above the North Coast MBL, providing about 65 tonnes/ac of additional live, above-ground CO_2e carbon stock. Further additionality from below-ground carbon adds about another 5 tonnes/ac. (Note that residual carbon stocks drop slightly below 230 requiring either adjustments to the sustained yield analysis or slightly reducing ICS.)

The remaining term in the Primary Effect is the solidwood product carbon stock. Equation 6.1 (CAR 2010) gives credit for actual carbon sold from harvests after project initiation, plus the average from predicted harvests, minus the average from baseline predicted harvests. The vast majority of the timber would be sold with the residues treated as if landfilled. After adjusting for mill efficiency and market response, solidwood product carbon stock could add roughly another 35 CO_2e tonnes/ac, mostly coming from the initial harvest of about 17 mbf/ac.

Given manuscript size limits, the remaining secondary effects are not described in detail. In the end, at least 80 CRT tonnes/ac. should be verifiable, or 38,000 tonnes toal. At recently heard OTC CO_2e prices of \$10/tonne, or a one-time revenue of \$380,000 to compensate for the unharvested volume that must be protected from all disturbances for 100 years. Even allowing for estimation error, such revenue certainly justifies the cost of application and additional inventories, if necessary. However, one must keep in mind that annual reports, periodic inventories and audits are required to certify that the live tree CRTs sold remain on site.

Final thoughts

Joint management for carbon and timber under the current CAR protocol can be profitable under specific conditions. There appears to be profitable opportunities for joint management in regions where the “common practice” reflects stocking levels from a balanced range of stand ages. Such is the case in the North Coast redwood region; not so in the Sub-district region where heavy cutting 80 to 100 years ago spurred regulations requiring higher average stocking, the basis for the CAR’s regional baseline. It would not be economical for Sub-district forestland owners to substitute carbon for wood production goals at current or conceivable product prices.

Although Sub-district common practice carbon stocks are expected to be higher than on the North Coast, the magnitude of the difference seems unjustified, especially when comparing CO_2e estimates with equivalent volume and basal area averages in Appendix F. One explanation may be due to stratifying FIA plots only by private land. However, in Santa Cruz and San Mateo counties, zoning regulations further limit lands where timber management is permitted.

This study did not test whether even-aged management offers a joint production opportunity but the large price differential between redwood stumpage and generic carbon prices suggests disadvantages. However, for forestland owners who are considering a switch to uneven-aged management may be further encouraged to do so with these results. This result should be transferrable to other forest types where lower growth rates are offset by lower, more carbon substitutable, wood prices.

Finally, one wonders what effect contracting to sell CRTs would have on property values. Since these contracts “go with the land” (somewhat like a conservation easement) limiting management options, property values would be reduced, though partially compensated from carbon revenues. Further value reductions are likely when a prospective buyer discovers that they are committing to annual reporting, inventories and audits.

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References

Climate Action Reserve (CAR). 2010. **Forest Project Protocol. Version 3.2.** Los Angeles: Climate Action Reserve.

Guldin, J.M. 1991. **Uneven-aged BDq regulation of Sierra Nevada mixed conifers.** Western Journal of Applied Forestry 6(2): 27-32.

Mader, S. 2007. **Climate project: review and compare carbon accounting protocols for forestry.** California Forestry Association Technical Memorandum. (Place of publication unknown): CH2M Hill, Inc.

Murray, B. C.; McCarl, B.A.; Lee, H. 2004. **Estimating leakage from forest carbon sequestration programs.** Land Economics 80: 109-124.

Ruddell, S.; Sampson, R.; Smith, M.; Giffen, R.; Cathcart, J.; Hagan, J.; Sosland, D.; Godgee, J.; Heissenbuttel, J.; Lovett, S.; Helms, J.; Price, W.; Simpson, R. 2007. **The role for sustainably managed forests in climate change mitigation.** Journal of Forestry 105(6): 314-319.

Simpson, H. **CCX forestry carbon offset programs.** Texas Forest Service, August 11, 2008.

Smith, W.B., technical coordinator; Miles, P.D., data coordinator.; Perry, C.H., map coordinator.; Pugh, S.A., Data CD coordinator. 2009. **Forest Resources of the United States, 2007.** Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 p.

Wear, D.N.; Murray, B.C. 2004. **Federal timber restrictions, interregional spillovers, and the impact on US softwood markets.** Journal of Environmental Economics and Management 47(2): 307-330.