Carbon credits as a means of financing ecological restoration of riparian forest, Sacramento River, California, USA

Les crédits de carbone comme moyen de financement de la restauration de la ripisylve, sur la rivière Sacramento en Californie, EU

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RÉSUMÉ

Entre 1991 et 2012, des organismes gouvernementaux américains ont replanté plus de 2500 ha de forêts alluviales le long du Sacramento, le fleuve le plus important de la Californie. Le but principal de ces travaux était de fournir un habitat aux espèces menacées d'extinction. Nous avons examiné si le service écosystémique de la séquestration du carbone pouvait rembourser les coûts de la restauration dans le cadre du nouveau marché d'échange de crédits de carbone en Californie. Profitant des sites plantés au cours de 2 décennies, nous avons construit une chronoséquence pour modéliser la croissance et la variabilité des crédits escomptés. Nous avons trouvé que la vente des crédits peut rembourser au minimum 71%, et au maximum 109%, des frais déboursés par des organismes publics, en fonction de l'intensité d'échantillonnage. D'autres incitations, telles que des subventions destinées à couvrir les coûts de plantation, seraient nécessaires pour encourager les agriculteurs à abandonner la production agricole en faveur de la création d'habitat.

ABSTRACT

Between 1991 and 2012, state and federal agencies revegetated more than 2500 ha of floodplain forests along the middle reaches of the Sacramento, California's largest river. The intent of this restoration was to provide habitat for critically endangered or threatened fauna. We investigated whether the ecosystem service of carbon sequestration, compensated through California's new compliance market for carbon credits, could provide income sufficient to pay back the costs of restoration after 20 years. We used a chronosequence of sites planted at different times to model the trajectory and variability of carbon credits earned. We found that carbon credits could repay 71%-109% of restoration costs by public agencies, depending on the intensity of sampling used to perform the carbon accounting. However, additional incentives, such as subsidies of restoration costs and payment of conservation easements, would be required to induce agricultural producers to change from farming crops to farming habitat.

KEYWORDS

Carbon credits, costs, ecosystem services, incentives, restoration

1 INTRODUCTION

In addition to its benefits to biodiversity, habitat restoration is increasingly viewed as a way to protect or restore the flow of ecosystem services to humans. Ecosystem services (ES) are the material and nonmaterial benefits humans derive from natural ecosystems, such as carbon sequestration, water purification, and recreational activities. Measuring, mapping, or modeling ES is becoming an essential step in deciding how to set conservation priorities and allocate resources for restoration. Meanwhile, ES goals are more and more frequently cited alongside traditional biodiversity goals as metrics of the success of conservation and restoration projects.

It is often suggested that compensating landowners for provision of ES could incentivize habitat restoration or at least diversify the available funding options. In the United States, carbon credit markets are newly available to owners of forest lands wishing to reforest, preserve existing forest, or change forest management to better sequester carbon. These credits may provide an incentive for forest restoration.

In this work, we assessed the feasibility of carbon credits as a funding mechanism for riparian forest restoration under these U.S. programs. We calculated the carbon credits earnable by a >20-year-old restoration effort in California, accounting for both the credits earned from carbon storage and the costs of planting, maintaining, and verifying the eligibility of the forest project. We used a chronosequence approach, choosing sites that differed in age but were similar in soil type, climate, planting density, and species composition, to illustrate the trajectory and variability of carbon credit income.

2 METHODS

2.1 Sites

All sites were planted in mixed riparian forest, a community type composed largely of Fremont cottonwood (Populus fremontii), box elder (*Acer negundo*), Oregon ash (Fra*xinus latifolia*), and willows (*Salix lasiolepis, Salix exigua* and *Salix gooddingii*), along with two understory shrubs, elderberry (*Sambucus mexicana*) and coyotebrush (*Baccharis pilularis*). Plantings were weeded and irrigated for the first three years and then left unmanaged.

Sites were distributed over 100 km, from 40°N 05'02", 122°W 05'45" near Red Bluff, California to 39°N 11'38", 122°W 0'40" near Colusa, California. All are on fine sandy loams of the Columbia series, classified as Oxyaquic Xerofluvents. The climate is Mediterranean, with a mean annual precipitation is 676 mm and mean annual temperature is 16.2°C. In June and July 2012, we sampled two to four sites in each of four restoration age classes that corresponded to approximately 5, 10, 15, and 20 years since planting (Table 1), plus a 3-year-old site where trees were just beginning to reach measurable heights. Within each site, three subplots of 750 m2 were randomly located. Ownership of the parcels was mixed and included U.S. federal agencies; currently, land under U.S. federal ownership is exempted from earning carbon credits.

2.2 Carbon accounting

To inventory carbon stocks and account for carbon credits, we used protocols adopted by the State of California Air Resources Board (C.A.R.B., 2013) and the Northeastern and Mid-Atlantic Regional Greenhouse Gas Initiative (R.G.G.I., 2013), which are identical with respect to determining credits in reforestation projects, and are hereafter referred to as "the Protocol." Sampling methods for measuring carbon stocks followed the recommended guidelines for California projects (Brown et al., 2004). In brief, we measured the diameter at breast height or the volumetric dimensions of all standing woody individuals, and converted them to above- and below-ground biomass and carbon using allometric equations. Herbaceous biomass, forest floor biomass, and soil carbon were measured in randomly located quadrats and soil cores. Credits were calculated against a baseline of business-as-usual, which for these sites was abandonment (and hence no forest growth). We used standard values from the protocol for risks of leakage and reversal, and for emissions associated with planting. We used the US auction reserve price for a ton of carbon (USD$11.34) to convert tons of carbon into income.

3 RESULTS

Carbon accumulated at a rate of approximately 3.25 tons ha^{-1} yr^{-1} in trees and 3.67 tons ha^{-1} yr^{-1} in all included pools, which encompasses standing live, standing dead, and soil carbon pools. Total soil carbon in the 20-yr age class amounted to 31.20±1.59 tons ha^{-1} or an accumulation of 8.48 tons ha^{-1} above baseline stocks. Standing live and dead biomass in the 20-yr age class was 72.76±7.87 tons ha^{-1}, while forest floor and lying dead biomass, which are pools not considered in the calculation of carbon credits, were measured at 5.17±0.75 and 3.62±2.02 tons ha^{-1}, respectively.

Due to the confidence deduction, which applies when the standard error of a carbon inventory estimate is more than 5% of the size of the inventory, our initial finding was that no credits were earned, all of them having been sacrificed to the confidence deduction.

However, we reanalyzed the data under two different scenarios, “least effort,” in which we assumed that the total area sampled at a site within an age class had occurred in a single subplot, and “optimal sampling,” in which it was assumed that sampling had occurred using a number of plots that minimized the total sampling area necessary to avoid the confidence deduction entirely in each age class.

In the “least effort” scenario, credits were only earned after year 10, with confidence deductions of 7.7% in years 11-15 and 3.5% in years 16-20. After adjustments for secondary emissions and contributions to the risk buffer pool, one hectare of restored forest earned credits equivalent to 127.5 tons of CO2e, valued at US$1446. Costs associated with this scenario were US$1823 ha-1 for initial planning, installation, and maintenance of the forest plantings, and US$204 for registration and verification of the credits over 20 years. The percentage of restoration costs returned by carbon credits was 71.3% in this scenario.

In the “optimal sampling” scenario, the total number of credits earned was 259.5 tons of CO2e ha-1 after 20 years of restoration, for a monetary value of US$2943. Costs associated with this scenario were higher due to the extra sampling effort and were estimated at US$2695 ha-1, of which US$872 was associated with registration and verification and the remainder with planting and maintenance. Restoration therefore recoups 109% of costs when no confidence deduction is imposed.

However, when the income from 20 years of habitat restoration is compared with a similar timeframe for orchard crop rotations (walnuts or almonds), which are commonly grown on these soils in this region, carbon credits are much less economically interesting.

4 CONCLUSIONS

We conclude that carbon credits are a viable means of funding riparian forest restoration in the United States when the work is done on lands already in conservation ownership, but that credits alone are unlikely to induce farmers to switch from cultivating orchard crops to farming carbon. Instead, other subsidies, such as payment of restoration costs and conservation easements, will be required.

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