Geoforum 75 (2016) 99–109

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

Forest offsets and the California compliance market: Bringing an abstract ecosystem good to market

Erin Clover Kelly, Marissa Bongiovanni Schmitz *

Humboldt State University, 1 Harpst Street, Arcata, CA 95521, USA

ARTICLE INFO

Article history:
Received 10 March 2016
Received in revised form 8 June 2016
Accepted 17 June 2016
Available online 19 July 2016

Keywords:
Forest offsets
Ecosystem services
Carbon markets
Cap-and-trade
Commodity chain analysis
Access theory

ABSTRACT

Improved Forest Management (IFM) projects under the California cap-and-trade market allow production of new, non-traditional commodities: forest carbon offsets. Earlier analyses have considered forest offsets generated through tree planting in the Global South, as vehicles for sustainable development. However, the California IFM program is testing offset production in new geographic and forest management contexts: with offsets produced and consumed within the US on working (timber producing) forests. With data drawn from California IFM project design documents and in-depth interviews with carbon project developers, this study traces the development, sale, and maintenance of forest offsets, in order to map access to benefits along the commodity chain. Results reveal that the cost and complexity of rendering biological services 'real' for market legitimacy are reducing benefits to marginal landowners, who lack needed capital, knowledge, and technology to bring offsets to market. An important insight of this study is that the state has maintained power over program participation and offset supply through control of the forest offset methodology, creating a production process largely mediated by the state, adding risk and uncertainty to market participation. Findings provide an empirical example of neoliberal nature and offer broader lessons on governance and benefit distribution for ecosystem service commodity chains.

1. Introduction

Atmospheric greenhouse gas (GHG) reduction markets are generating production of new and unusual goods called forest carbon offsets. Previous analyses have explored their creation in small, nascent markets in the Global South, through vehicles for sustainable development like the Clean Development Mechanism (CDM) (Brown and Corbera, 2003; Corbera and Brown, 2010). However, the 2012 launch of a regulatory cap-and-trade market in California expands their production into untested geographic and forest management contexts. This is done through an improved forest management (IFM) protocol, which incentivizes offset production on forests that are generally subject to commercial timber harvest. Three years into cap-and-trade market operation, it is now possible to assess California regulatory IFM market participation. We employ both a commodity chain analytic framework and Ribot and Peluso's 'theory of access' to trace the development, sale, and maintenance of forest offsets, to test who benefits and how from new carbon-based revenue streams (Ribot, 1998; Ribot and Peluso, 2003). With data collected through review of California regulatory IFM project design documents (PDDs) and in-depth interviews with carbon project developers, we ask: how are forest offset production and benefit flows operating in a managed forest context in the Global North?

We draw several findings from this research. First, IFM projects under California's cap-and-trade market must address the challenge of rendering intangible goods 'real' for market legitimacy, echoing production hurdles in the Global South (Brown and Corbera, 2003). In California, legitimacy is achieved through costly and technically complex forest carbon inventory and verification, limiting participation of small-scale and economically marginal landowners and creating opportunities for technical experts and project financiers, who provide needed capital, knowledge, and technology to bring offsets to market. Second, because California's IFM program was designed to accommodate working forests, market participants must often negotiate parallel commodity chains—those of forest offsets and traditional timber products—altering the actors and dynamics involved in offset production and creating a calculus between potentially competing revenue streams. Third, a significant insight from this study is that the state has maintained power over project design and offset sale through control of the

* Corresponding author at: University of Minnesota, 115 Green Hall, 1530 Cleveland Avenue North, Saint Paul, MN 55108, USA.

E-mail addresses: eck107@humboldt.edu (E.C. Kelly), marissa@umn.edu (M.B. Schmitz).

http://dx.doi.org/10.1016/j.geoforum.2016.06.021
0016-7185/

forest offset methodology, resulting in a production process largely mediated by the state and dependent on legislative acts, adding risk and uncertainty to market participation.

This manuscript begins by considering forest carbon sequestration literature, both in the Global South and in California. We then review commodity chain analysis as a framework for investigating access to market benefits. Next we present the results of this research, including documentation of market participants in California's forest offset commodity chain, as well as detailed descriptions of the steps and relationships involved in offset production. This leads to a discussion of *how* and *by whom* benefits are accessed from California's carbon offset market. We conclude with broader lessons about commodification of abstract ecosystem goods.

1.1. Forest carbon production in the Global South

Early forest carbon markets were promoted as vehicles for sustainable development and tropical deforestation reduction, and involved offsets produced in the Global South, purchased by actors in the Global North. A prominent example is the Clean Development Mechanism (CDM), developed in response to the 1997 international climate mitigation treaty signed at Kyoto, which allows Northern countries to offset GHG emissions by financing offset projects in the Global South. Under CDM, forest landowners are paid to sequester carbon through afforestation and reforestation (i.e. tree planting). A later carbon governance mechanism, Reduced Emissions through Deforestation and Forest Degradation (REDD), was developed through United Nations Framework Convention on Climate Change talks in 2005, and expanded to REDD+ at the Bali negotiations of 2007. Under REDD+, payments flow from North to South in order to reduce forest harvesting and improve forest management.

Research of forest carbon production in the Global South has included the politics of negotiating program methodologies (Boyd et al., 2008), policy-related barriers to participation (Thomas et al., 2010), and the complexity and risk of forest carbon project development (Lecocq and Ambrosi, 2007). This literature has frequently centered on market access. For example, Corbera and Brown pointed-out that participating landowners are made dependent on third-party experts who render biological services tradable in markets through rigorous measurement and verification (2003, 2010). Economic geographers have critically analyzed the commodification of ecosystem services (ES) more broadly, considering both the challenges and consequences of fitting ES into the logics of neoliberal markets. Castree articulates six preconditions for converting ES into tradable goods: privatization, alienability, individuation, abstraction, valuation, and displacement (Castree, 2003). These denote separations that enable ES—such as sequestered carbon, biodiversity, or water—to be quantified, tracked, and ultimately sold-off as "credits," which serve as their market proxies. With forest carbon, separation is achieved through inventory, verification, and registration, steps which measure and subjectively validate offsets for market sale. Because these processes authenticate offsets as commodities, researchers have described them as "legitimizing institutions" (Corbera and Brown, 2010, p. 280) and as "power tools of carbon finance" (Bumpus, 2011, p. iv).

Yet transforming carbon into saleable goods has profound ecological and social consequences. Knox-Hayes argues that ES commodification can exert pressure on ecosystems for accelerated production, leading to programs that are ecologically "ineffective or potentially counterproductive" (2013, p. 118). Others have highlighted the re-casting of global forest governance through carbon programs, which is accomplished by altering property rights and tenure regimes in favor of certain actors, allowing financers, multinational corporations, and conservation NGOs to exert control over land management decisions while undermining local authority (Cabello and Gilbertson, 2012). For example, Cavanagh and Benjaminsen found that NGO-funded reforestation efforts on national parkland in Uganda led to violent evictions of forest residents (2014). Also explicit are equity concerns, in particular for Indigenous Peoples whose customary tenure rights may be insecure and whose means of livelihood may be targeted as the source of forest degradation (Dressler et al., 2012; Naughton-Treves and Day, 2012). Local practitioners and implementers of REDD+ have sought to account for community and Indigenous groups' voices, to establish tenure rights and more equitable distribution of forest benefits (see case studies in Naughton-Treves and Day, 2012). Global REDD+ policies have also attempted to decentralize some elements of decision-making and to create community-level responsiveness, often mediated by policies at national or subnational levels (Angelsen et al., 2014; Ituarte-Lima et al., 2014).

The California market provides an opportunity to examine offsets produced and sold in a very different context—on managed forests within the US, under a regulated market, with different challenges, and presumably fewer uncertainties around land tenure and access rights than CDM and REDD.

1.2. California regulatory cap-and-trade market: creating new revenue streams for forest managers

While forest carbon markets in the Global South were established largely to facilitate sustainable economic development, California's regulatory forest offset market embodies different aims, namely the production of offsets sufficient in quantity and rigor to facilitate cap-and-trade market functioning. California's now nationally-expanded forest offset program is directed by an innovative IFM protocol, which was negotiated between politically powerful land trusts aiming to reduce private forestland fragmentation, and large commercial landowners who prioritized offset production on industrial timberlands (Schmitz and Kelly, 2016). This methodology creates a new potential revenue stream for working forests by allowing active timber harvest on project properties with partial crediting for carbon stored in durable wood products. Yet it also promotes production of ecological co-benefits, such as wildlife habitat, watershed improvement, and private land conservation, through provisions that encourage 'natural' and sustainable forest management. By establishing the rules for program participation and prescribing a uniform carbon accounting framework (or performance standard) across all market entrants, the IFM protocol provides a backbone to the forest offset production process.

Yet landowner willingness to participate in California's regulatory forest offset market has until now been highly unknown. Research suggested that compared to predecessor voluntary forest carbon programs, California's regulatory IFM protocol may have a conservativeness, costliness, and prescriptiveness unfavorable to average landowners (Galik and Mobley, 2009; Galik et al., 2012; Gunn et al., 2011; Remucal et al., 2013; Russell-Roy et al., 2014). Caldwell et al. state that for this market: "carbon projects are not viable for all landowners and impose significant constraints on land-use" (2013, p. 60). Numerous feasibility studies indeed suggested small-scale landowners were unlikely to meet rigorous requirements for accounting, monitoring, and permanence (Charnley et al., 2010; Fischer and Charnley, 2011; Fletcher et al., 2009; Markowski-Lindsay et al., 2011; Miller et al., 2012; Thompson and Hansen, 2012; Wade and Moseley, 2011).

However, California's IFM protocol has compatibilities with more traditional timber management strategies, suggesting carbon and wood product production may supplement each other in specific situations, for instance commercialization of less marketable timber types and forest tracts and stabilization of return on investment during economic downturns (Jenkins, 2013; Caldwell et al., 2014). Others have described carbon revenue as an innovative conservation funding source for larger land trusts (Brown, 2014; Kay, 2015). This suggests that while small-scale landowners may lack access to the regulatory forest offset market, carbon-based income could be integrated alongside more traditional timber revenue streams among larger landowners, both for and non-profit. We test this by analyzing early trends in landowner engagement with the IFM protocol in Section 2.1.

1.3. Commodity chain analysis

Commodity chain analysis (CCA) offers a lens for researching forest carbon markets, centering on relationships of power and access to market benefits. It arises from the work of world system theorists, who articulated the production and consumption of global goods to highlight the machinations of global capitalism and differential benefits among actors involved in the commodity chain (Gereffi and Korzeniewicz, 1994; Hopkins and Wallerstein, 1986). CCA and related frameworks—including commodity network analysis, the *filiere* approach, and global value chain analysis—encompass a range of analytic tactics and theoretical assumptions. We employ CCA as a methodology to generate a detailed, descriptive analysis which traces "the whole range of activities from production to consumption and the linkages that bind them" (Raikes et al., 2000, p. 4). This allows one to 'unveil' commodity chain dynamics potentially shaped by wide-ranging formal and informal rules (or "mechanisms"), including capital, knowledge, technology, social relationships, identity, and access to the political process (Ribot, 1998). CCA thus assumes that rights to resources may not translate into access to benefits: instead some with rights to resources may lack access to markets, while others without formal resource claims may find ways of benefiting (Ribot, 1998).

Researchers have found a wide range of applications for CCA, including evaluation of policy alternatives and "making sense" of complex commodities in their social and political context (Jackson et al., 2006). For example, Cowlishaw et al. (2005) evaluated a bushmeat market in Ghana in order to find possible intervention points for conservationists concerned about species depletion. Suykens (2010) considered the production of Beedi cigarettes in India between the government and Maoist rebels and implications for maintaining joint production regimes in places of conflict. Through a CCA of matsutake mushrooms in Yunnan, China, He investigated ways of re-distributing resources along the commodity chain to improve benefit sharing (2010).

The growing scope of CCA literature has generated new questions, including whether early distinctions between 'producer-driven' and 'consumer-driven' commodity chains are still relevant and comprehensive characterizations of commodity chain governance, i.e. the dominant force determining what is produced and at what cost (Raikes et al., 2000). Raikes et al. ask whether "other parties, for example governments and other regulatory agencies [might not] also exercise substantial power" (Raikes et al., 2000, p. 7). Similarly, Klooster investigates whether forces external to the commodity chain, for example voluntary certification schemes, might increasingly function as governance tools by dictating standards that, though voluntary, become de facto requirements for market entry through consumer demand (2005). We apply CCA to forest carbon offsets—goods whose demand, production requirements, and governance institutions stem from regulatory requirements—to examine commodity chain dynamics and functioning in the unorthodox context of ecosystem service production.

1.4. Methods

1.4.1. Market database: identifying market actors

We employed mixed-method research design starting with project design document (PDD) analysis for all listed IFM projects (n = 147), to investigate the landowner and forest management contexts of offset production. We began by examining carbon registry web-based databases, where PDDs are publicly available for download. We read all PDDs and compiled an extensive list of project attributes in Microsoft Excel, including landowner name, project acreage and location, technicians and consultants employed, and proposed project management activities. Projects were continually added through December 2015, as new projects entered the market. From these data we produced descriptive statistics to summarize early market participation. An unexpected component of this study included documentation of a flood of new project listings in October 2015 (n = 70), when the California Air Resources Board (ARB) implemented consequential IFM protocol revisions, followed by a lull in the market. We included this influx in our analysis and consider what this reveals about commodity chain governance in Section 3.3.

1.4.2. Interviews: describing the steps in the commodity chain

In-depth interviews with thirty-seven individuals—including timberland managers, forest carbon project development specialists, and protocol design stakeholders—allow us to ground our analysis in descriptive accounts of market participation (Table 1). We selected individuals through purposive and snowball sampling, using PDDs to identify actors participating in forest offset production and then asking for referrals to additional participants. All but one interview were conducted in-person; most took place at participants' offices. Interview guides were used throughout to ensure certain topics were addressed, including the logistics of creating projects under the California IFM protocol, as well as barriers and opportunities to market entry. Some questions were broad, such as "Can you describe how your forest carbon inventory was conducted?" Or "What were the most challenging components of project development?" Others probed specifics, especially related to choice of project development specialists and costs. One challenge was that participants at times withheld sensitive information, particularly related to project developer contract terms and fees. We address this by comparing our findings to those of Kercher and Keeton, who previously reported on cost and revenue data for the California regulatory forest offset market (2015). Interviews lasted one to two hours each and were audio recorded for full transcription. Transcribed responses were organized and coded according to the methods of Corbin and Strauss (2014). This involved identifying patterns across participants, including common themes, such as the cost and complexity of project development,

Table 1
Interviewee groups for the study.

Interviewee label	Number of participants	Participant breakdown
Timberland managers	11	NGOs n = 6 Forest industry: n = 3 Tribal: n = 2
Forest carbon project development professionals	16	Consulting foresters: n = 7 Carbon developers: n = 6 Registry: n = 1 Verifier: n = 1 State: n = 1
Protocol development stakeholders	10	Workgroup participants: n = 6 Stakeholders outside the workgroup: n = 4

as well as important points of contrast, for example diverging perspectives on carbon developers.

2. Getting the good to market: "the road to credits is long and uphill

The forest offset commodity chain reveals the steps and likely actors involved in offset production, from feasibility to maintenance of the carbon commodity (Fig. 1). An important distinction is that forest offsets do not physically travel along the commodity chain; instead, sequestered carbon is stored 'on the stump,' while accounting claims are rendered into salable units via technically rigorous authentication steps including inventory, verification, and registration. This production process, which was described in interviews as a 'long and uphill road' from inception to credit earnings, is directed by IFM protocol requirements. Fig. 1 also includes a tandem, wood products commodity chain, because the IFM protocol was intended to accommodate working forests, and most offset producers indicated they were harvesting timber.

2.1. Actors in the commodity chain

Forest landowners play important roles in the commodity chain as offset producers. We identified 147 listed regulatory IFM projects totaling 5,278,703 forested acres across the US, as of December, 2015 (Table 2). Participating landowners include industrial and nonindustrial private forest (NIPF, or "family") owners, institutional investors such as Timber Investment Management Organizations (TIMOs), large conservation landowners such as land trusts,

Table 2
Listed regulatory IFM projects in California's cap-and-trade program.

Landowner type	IFM projects	Total acres enrolled	Median project acreage	Average stocking level relative to regional average (%)
Land trust	26	232,416	5611	135
Forest industry	27	1,088,276	14,622	111
Institutional investor	46	1,937,227	24,595	133
NIPF	16	99,076	2779	155
Tribal	13	1,435,393	49,193	171
Other	19	486,315	5763	157
Total	147	5,278,703	13,706	135

and tribes (Table 2). We separately categorize certain timberland owners—including hunting clubs, a parish, a university research forest, a sculpture garden, and a mountain residential community—as 'other,' to document forest offset niche attraction among atypical landowners. Many enrolled properties were well above regional averages for forest carbon stocking, ranging from 171% of average for tribal landowners to 111% of average for forest industry (Table 2).

Most participating landowners, including all forest industry and tribal projects, are harvesting timber. Only twelve projects are explicitly no-harvest, and nine of these are conservation landowner-owned. However, disclosure of timber harvest intent is not required—those not overt about this are categorized as undetermined. In all, 127 of the 147 projects or 86% indicate they will participate in both carbon and wood products commodity chains

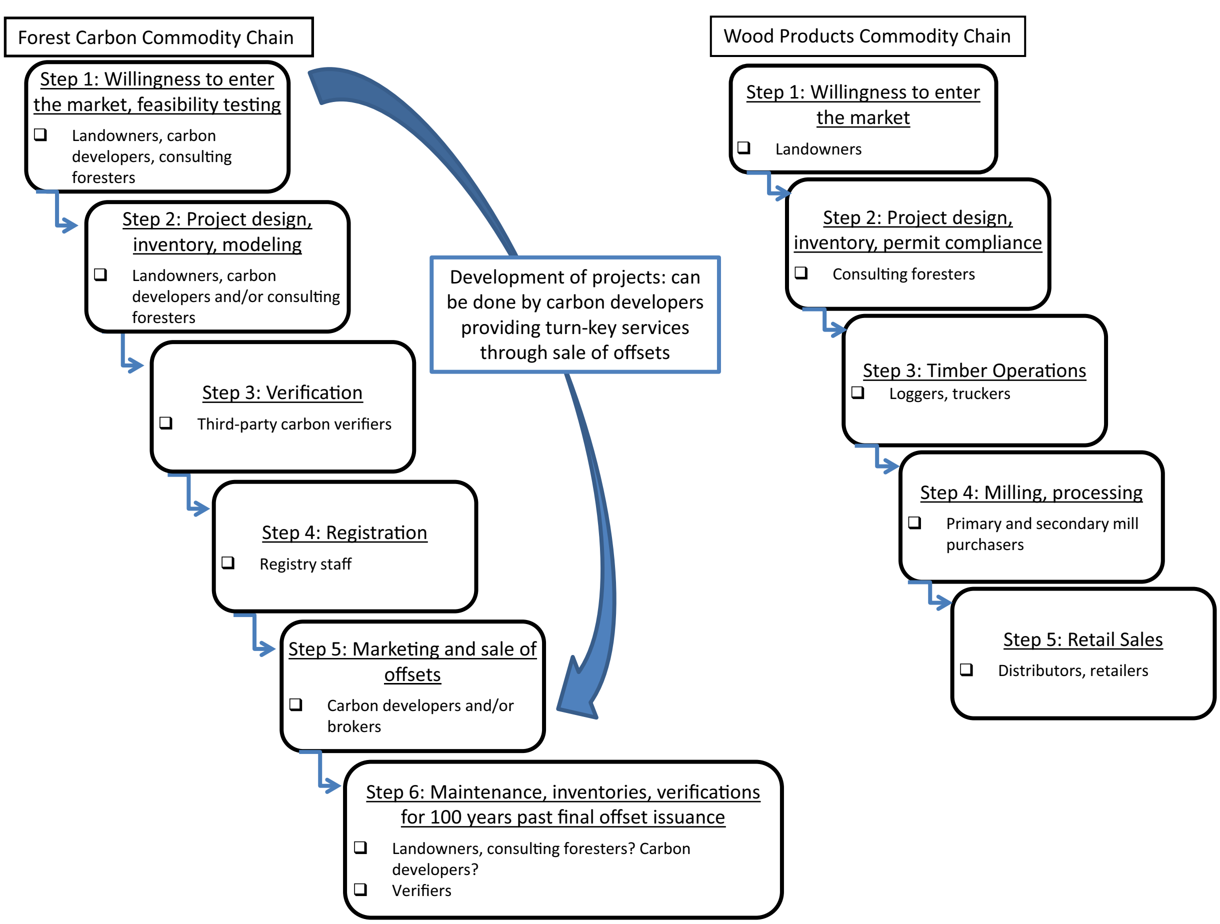

Fig. 1. Forest offset and wood products commodity chains.

Table 3
Harvesting for timber: yes = harvesting, no = 'forever wild', undetermined = no current timber harvest plan but potential future harvest.

Landowner type	Harvesting timber			Total
	Yes	No	Undetermined	
Land trust	17	9	0	26
Forest products	27	0	0	27
Institutional	44	1	1	46
NIPF	10	0	6	16
Tribal	13	0	0	13
Other	16	2	1	19
Total	127	12	8	147

Table 4
Use of professional carbon developers, consulting foresters, or in-house staff for project design.

Landowner type	Project design model			Total
	Developer	Consultant	In-house	
Land trust	9	7	10	26
Forest products	3	0	24	27
Institutional	41	2	3	46
NIPF	7	7	2	16
Tribal	8	3	2	13
Other	13	4	2	19
Total	81	23	43	147

(Table 3). Most projects employ selection timber harvest techniques, though even-aged management ("clearcutting") also occurs, and was indicated on PDDs for 40 projects, particularly among forest industry.

Third-party professionals in the commodity chain include those who have long been involved in forestry, as well as newcomers who have recognized a new revenue stream in carbon offsets. *Consulting foresters* generally operate in both the timber market and the emerging carbon market, often work locally near project properties, and operate on a fee basis. 23 of 147 IFM projects or 16% have been developed by consulting foresters (Table 4). These projects are exclusively in the Pacific Northwest, and particularly Northern California, where projects are most numerous. Many consulting foresters have established relationships with landowners—particularly NIPFs and tribes—based on the more traditional timber management commodity chain (see Fig. 1). *Carbon developers* do not generally have affiliation with traditional forest management (timber production). Instead they use nationwide forest stocking level datasets and geospatial technology to identify and solicit landowners—such as TIMOs, NIPFs, and tribes—with higher-stocked forests. Carbon developers frequently provide upfront financing and deliver "turn-key" services in exchange for equity shares in future offset sales.[1] Thus far over half of projects (55%) indicate they are contracting with developers for full project development assistance (Table 4).

Forest *carbon verifiers* are highly trained, specialized environmental claims auditors, limited to several approved firms; however, heightened demand for verifier services has increased use of geographically dispersed agents who undertake forest carbon verification for contract. *Registry staff* operate non-profits that oversee much of the project development process, approving project registry listings, auditing verifications, and ultimately awarding and maintaining offsets as traceable goods via public registries. ARB has delegated to registries substantial, though not comprehensive, program implementation authority, which we discuss further in Section 2.5. Finally, *carbon brokers* facilitate the sale of forest offsets to regulated (GHG-emitting) industries, services important to some (though not all) offset producers in absence of a formal credit exchange platform.

The novelty and complexity of carbon project development means that most landowners will play only passive roles in project development. In-house development among larger industrial and conservation landowners, particularly California timber interests and land trusts, is the exception (Table 4). Here, landowners have high capacity and familiarity with California IFM protocols. Average market participants instead depend on partnerships with specialists who transmit knowledge of market opportunity, assess project feasibility, and perform technical work to bring projects to market.

Choice of specialist has implications for project financing, revenue potential, and route to market, and we found varying characterizations of the relative costs and benefits of alternative options. Consulting foresters sometimes applied terms like "carbon cowboys" to developers. However, distinctions were typically made between developers who emerged early in the market, purportedly seeking to capitalize on new revenue opportunities with little knowledge of forestry, and niche experts with knowledge of both carbon offsetting and forestry. Consulting foresters voiced benefit to partnerships with these latter actors, highlighting their production of technically competent projects, comprehensive management of a complex and prolonged development cycle, and financing of steep up-front costs. One caveat was concern for overpayment via equity sharing contracts, a sentiment noted by several foresters. One explained this point in the context of a fluctuating carbon price:

> You can't forecast what you're signing-up for [with developer contacts]. What does it mean to give up 30% of my carbon? Well, two years ago it meant $7 carbon, now it's $10.50. In six months it might be $15. We would say if you can afford it, you should not structure a deal that way, because it's not to your benefit.
>
> [Interview 29, consulting forester]

Yet characterizations frequently centered on the merits of carbon developer partnerships, which resulted in pooling knowledge and risk-sharing in a non-traditional marketplace, benefits seemingly valued by small and large landowners alike. Explained one forest industry actor:

> The owner of the [forest] company, I'm sure, viewed this as an emerging market, right? I mean, it's still somewhat hard to explain to guys who are used to nice packages of wood, labeled, counted, and measureable, that I'm selling a product that's somewhat intangibly stored out there in the forest . . . The idea of taking a business model of a company whose view is, 'I'm selling you a thousand board feet,' to 'I'm selling you a ton and a promise to keep it.' [The owner] I don't think, felt real confident in doing this alone. So that's where [the developer] came into our discussions, and it's been a useful partnership.
>
> [Interview 18, forest industry]

The following sections explore the commodity steps and relationships more fully through access mapping as articulated by Ribot, including (a) identifying actors involved in production, (b) reviewing benefit distribution and costs and (c) discussing access mechanisms (1998).

[1] Equity-sharing involves contractual agreement to share carbon revenue for a set duration. Terms are closely guarded and individually negotiated, however interviews suggested five to ten year terms with 25–50% profit-sharing approximated typical terms.

2.2. Step 1: assessing feasibility

Feasibility analyses may be conducted by carbon developers, consulting foresters, or the landowners themselves. Many landowner-developer partnerships begin when developers proactively offer to conduct forest offset feasibility testing, often through cold-calling lists of landowners aiming to gain access to their forest inventories. In these cases, prospective projects are assessed against very specific criteria—landowner ability to commit for 100 years past final offset issuance, willingness to comply with protocol maintenance and monitoring requirements, and revenue potential in excess of development costs (see also Kerchner and Keeton, 2015). Participation is possible at any stocking level, however only those with higher stocking than regional average for given forest types (known as "common practice") earn upfront revenue. According to developers, as few as 5–10% of investigated projects are profitable enough to justify development expenses, and those that are may still be stymied by onerous program constraints, market uncertainty, and opportunity costs.[2] One consulting forester explained his landowner's reluctance to proceed, based on these issues:

> At the end of the day ... they said "What on earth are we getting involved in this thing for? It just doesn't pay us any money. And we're committing for a hundred years? And we're submitting to all this oversight and regulation and everything else?" So they yanked their project. And that's part and parcel to the process. It's not really comparable to cutting down the trees.
>
> [Interview 24, consulting forester]

The point that timberland owners frequently have competing economic opportunities with fewer risks and encumbrances than carbon offset development was a common theme among participants. While the market was designed to accommodate timber harvest, it creates opportunity costs, because offsets are growth-based while harvest is extractive.

2.3. Step 2: project design and inventory

Project design involves fitting carbon projects to the requirements and accounting prescriptions established in the forest protocol, a document described as "very complex" and "demanding" by foresters. This critical and costly step determines both quality and quantity of salable offsets over project lifespans.[3] However ambiguity of the protocol was said to complicate project development by requiring compliance with a "moving target," according to one consulting forester (Interview 24, consulting forester). A practice of interpreting the protocol "like case law," in which discretionary decisions made by registry and ARB staff repeatedly shifted program rule interpretation, was said to introduce risk into the project development process:

> Landowners and project developers and technical consultants make decisions about how to proceed and then ARB decides to put out a guidance document that changes the way you understood, and that everyone understood, what the protocols and the regulations said. So you could find yourself making a mistake.
>
> [Interview 29, consulting forester]

Such interpretive decisions were said to have significant impact on project viability and performance. This was particularly true when decisions altered treatment of project-level stocking data, as collected through boots-on-the-ground measurement. These inventories are cornerstones of offset quantification and were described as intensive and costly, needing higher levels of statistical confidence than inventories for other forest management contexts. Therefore, while both the carbon and timber management commodity chains have inventory requirements, the carbon inventory is more intensive. Explained one consulting forester:

> [With timber inventories] the need to know with a level of accuracy is less [because] an estimate of timber gets trued-up when you take the logs to the mill. With carbon, what you're selling is your inventory. There's not any solid thing that you're taking to anybody else. They're buying the creditability of your inventory.
>
> [Interview 8, consulting forester]

Preexisting robust inventory data, which larger landowners often maintain, was viewed as an asset for carbon development. However, even larger landowners described insufficiencies here and called meeting inventory confidence the "single biggest challenge" to project development (Interview 20, forest industry). Smaller landowners, too, recounted having to redo inadequate inventories, whether because of clarification of protocol requirements or because inexperienced developers underappreciated the difficulties of passing verification. Technicians learned over time that carbon inventories required more plots relative to timber inventories, meaning increased costs upfront and over project lifetimes, as plots are re-inventoried.[4]

2.4. Step 3: project verification

Inventory verification is a critical stage in preparing offsets for market, through which economically disinterested third-party verifiers review all aspects of project design, inventory, and quantification, and attest to the validity of carbon sequestration claims. Developers report costs between $30,000 and $60,000 for this process, depending on project size and complexity, making verification the costliest and therefore riskiest step, because it comes before salable credits are awarded.[5] Successful verification is not guaranteed, but hinges on the quality of project inventory data. Like other aspects of project design, verification criteria and related costs have evolved as field-testing led to protocol changes meant to increase rigor. Explained one forester:

> In [an early protocol] verification was more qualitative, you know a review of inventory methodologies, and less quantitative—so less going out to the forest and checking to see that the measurements that were being reported were indeed accurate. So now [passing verification] continues to be a big challenge for projects today.
>
> [Interview 8, consulting forester]

More rigorous verification was often promoted by verifiers themselves, based on personal experiences with early forest carbon verifications, in attempts to add accounting accuracy and reduce gaming potential. Thus the IFM protocol reflects the influences of verifiers and other experts who pushed for increased conservativeness and stricter third-party oversight.

[2] Project viability was said to be highly variable: a 500 acre property could be profitable, while a 200,000 acre property might not be, depending on stocking level, growth potential, and a given property's 'common practice' metric.

[3] Kercher and Keeton estimate project design cost at $29,000 (2015, p. 75).

[4] Consulting foresters quoted inventory costs between $18,000 and $23,000, but noted significant variation according to inventory design and intensity. Kercher and Keeton list $15,000 for inventory cost (2015, p. 75).

[5] Kercher and Keeton list $25,000 as the cost for initial verification; our results suggest this reflects earlier prices of forest carbon verifications, before verifiers "realized what was involved" (Interview 29, consulting forester).

2.5. Steps 4 and 5: registration and market sale

With successful verification, projects are "registered," i.e. entered into public databases called registries. Registration functions as a final authentication stamp, signaling offset availability to potential buyers. A small but important distinction is that registries issue Registry Offset Credits (ROCs) which may be transacted in the marketplace, but which must ultimately be replaced with Air Resource Board Offset Credits (ARBOCs), the official instruments for cap-and-trade market compliance. Developers indicated that most offset purchasers view ROCs as quasi-credits, and prefer to transact ARBOCs, which can take months for ARB issuance. Inability of registries to grant actual compliance instruments, though they were delegated many other authorities in offset program implementation, was a source of frustration among developers, who viewed it as an unnecessary impediment to market functioning.

Nonetheless foresters and developers described registration as a rewarding finale to a development cycle that could take one to two years with total costs between $200,000 and $500,000, because it enabled market entry and first time revenue receipts.[6] However the complexity and importance of terms negotiated at this step created a host of challenges. One concern was that lack of a formal exchange desk meant that landowners and consulting foresters were ill-equipped to actually sell offsets. For some, this meant reliance on new actors, *carbon brokers*, who bundle offsets together for emitters via privately negotiated transactions for a fee. Others contracted with carbon developers, who facilitate this step via their suite of services. Explained one forester: "There's no marketplace ... That's why I'm sort of wooing [carbon developers]: 'Hey we might have some credits we need to sell here. You guys might want to look for a buyer'" (Interview 24, consulting forester). Foresters commented too on developers' roles marketing offsets in a competitive marketplace, by applying cachets like "wild carbon credits" and "charismatic forests," to promote co-benefit potential among buyers. Similarly, promotional narratives attributing forest offsets to particular types of landowners, particularly tribes and "family" forest owners, were also employed in offset marketing. However, the extent to which landowners required this service was unclear. One industrial landowner indicated that his company already had a "high profile" from Forest Stewardship Council (FSC) certification and asked: "Why do we need to pay a guy to bang our drum? We probably don't" (Interview 20, forest industry).

Strategy in market entry was a common theme among interviews. Most participants mentioned the importance of timing, i.e. determining when to sell offsets amid fluctuating and poorly forecasted prices. This appeared especially true for initial sales, which typically provide a tranche of credits upfront for carbon stocking in excess of regional averages, which dwarfs future earnings potential.[7] The appeal of this windfall may cloud landowner judgment. Explained one forester:

> The biggest oversight [I've seen] is where the [landowner] just can't see past the dollar signs of market entry. They do the math ... and say, "You could have 2.5 million credits coming in the market at $11.50 and wow, that's *payday* ..." Well, you might sacrifice 20–30% of that payday if you go into the market wrong, and you don't get to go back and say, "No, no, give me those credits back that I sold you for $7. I really want to sell them to you for $10 now."
>
> [Interview 1, consulting forester]

Most agreed on the significance of offset generation in year-one, mentioning both profitability and importance for meeting long-term project costs. This is because, typically, the majority of offsets are accounted for and purchased at the time of initial sale, though expenses continue throughout project lifespans. Several foresters noted implications for projects without full ownership of their credits, such as those in equity-sharing agreements with developers. Explained one:

> The bulk of your credit generation is coming in that first year. You get that first year flush, and that's your nest egg. You should be taking that and investing that money, so that you can pay for monitoring and all the stuff down the road .... If you're losing 25% upfront ... that's really tough for the life of that project.
>
> [Interview 37, consulting forester]

Strategy is employed not only for timing and revenue considerations, but also for distribution of risk and responsibility via customizable purchase contracts. These specify accountability for voluntary reversals (losses in forest stock due to over-harvest or premature project termination) and invalidation (finding of regulatory violation or quantification error by ARB). Developers indicated these agreements frequently assign risks to offset producers, as opposed to offset purchasers, perhaps in an effort to mitigate buyer risk from impermanence, i.e. the reality that forests are vulnerable to threats such as fire and insect outbreaks against their carbon stocks, widely viewed as an "Achilles Heel" of forest offset production. The option to shorten offset invalidation windows through double or triple verification, and the ability to underwrite offsets with an innovative insurance product, offer ways to reduce risk. However, landowners must weigh potential benefits of these strategies, such as increased profit and reduced personal culpability, against increased production costs.

2.6. Step 6: permanent maintenance

Maintaining forest offsets over project lifetimes is a long-term responsibility that deserves added emphasis, for the IFM commodity chain does not end with market transaction. Significant and ongoing landowner commitments begin almost directly post offset sale, including mandatory annual monitoring and reporting and regular re-inventory and verification requirements, obligations projected to cost between $250,000 and $500,000 net present value over the life of the project. However, who will perform this technical work and under what contractual arrangements is yet undetermined. Consulting foresters speculated that smaller landowners were particularly ill-equipped for, and perhaps "naïve" about, ongoing technical requirements. Some discussed the role carbon developers could play, though with ambivalence. Several voiced concerns that landowners would be "left in the lurch" by developers once contracts expired, while others viewed them as obvious resources for long-term management, even if specific models were uncertain. Explained one proponent:

> [Developers] have based their businesses on providing these services, so presumably they'll be around for a while, whereas I'm just sort of here doing it as a consultant. I'm not trying to convince anybody I'm going to be their long-term carbon manager ... I'm helping getting them going, but these things have to be institutionalized some-how or another.
>
> [Interview 24, consulting forester]

Maintenance of forest offsets is also the stage at which reversal and invalidation risks will be felt most acutely. Indeed, wildfires in the Pacific Northwest have already affected several developing IFM projects, either fully or partially reducing stocking levels (registry staff, personal communication). If/when reversals occur post credit

[6] Kercher and Keeton estimate total project development costs of $105,000 (2015, p. 75); this is notably low compared to our interviews.

[7] Initial offset generation averages 57 offsets per acre (with some projects exceeding 100 offsets per acre); while ongoing credit generation potential is projected by developers to be far lower, at 0–3 credits per acre per year (http://www.climateactionreserve.org/resources/presentations/, accessed April, 2015).

sale, lost carbon tons can be replaced with insurance pool credits, generated through regular mandatory contributions by IFM projects, provided reversals are deemed 'involuntary.' Reversals stemming from landowner management decisions are also possible—due to overharvest, non-compliance with program requirements, or negligence—and can theoretically lead to landowner personal responsibility. Interviewees referred to these penalties as "substantial" and "concerning," and stressed uncertainty in how violations will be treated in practice. Questioned one: "If you don't do fire suppression, are you negligent if you have a fire? Or if you don't thin your stands and reduce your fuel load, are you negligent or did you just not do something?" (Interview 29, consulting forester). A high profile invalidation by ARB, early into market operation, suggested also that this particular risk was more real than rhetorical. Other aspects of future forest management are also unclear. Interview data suggests most initial participants are economically motivated actors who pair carbon sequestration revenue with timber production, yet how these landowners may respond to shifts in wood products markets or protocol revisions that impose new baseline scenarios or forest management restrictions, is unknown. Similar questions surround procedures for property sales and landowner succession, both described as theoretically allowed but "untested." Cap-and-trade market uncertainty post 2020, after which regulatory demand ceases without renewal of controversial legislation, adds perhaps the most conspicuous layer of risk and uncertainty to the offset production process. According to interviews, this factored prominently in landowner considerations of which lands to enroll, favoring higher stocked forests earning windfalls of upfront credits over lower stocked forests whose credit earnings were yet to come, and thus uncertain.

3. Discussion

The preceding section employed a commodity chain analytic framework to identify the actors and steps involved in quantification, sale, and permanent maintenance of forest offsets for California's cap-and-trade market. We now return to the research questions, particularly: who is participating, how are benefits accessed, and what does this reveal about ecosystem service commodification?

3.1. Forest offset production on working timberlands

Predecessor regulatory forest carbon programs emphasized GHG reduction via tree planting in the Global South, and resulted mostly in small projects targeting sustainable development (Bumpus and Liverman, 2008).[8] Advancements in REDD+ following the Paris (2015) climate conference may expand these projects, but thus far landowner market engagement has been low.[9] Using a different model, California's regulatory market sought to make carbon sequestration compatible with working forests, and to broaden program participation beyond 'boutique' carbon producers, through a performance standard baseline (Schmitz and Kelly, 2016). We demonstrate here that these policy choices are indeed creating a viable market with expanded utilization especially among conservation landowners, tribes, NIPFs (though limited to large properties in California), forest products industry (predominantly in California), and institutional investors such as TIMOs. Some of these participants are unsurprising: for example, previous researchers anticipated that carbon offsetting would fit naturally with the priorities, tools, and skill-sets of conservation landowners (Brown, 2014; Kay, 2015). However, participation of commercial timber interests—such as forest products industry and TIMOs, landowners possessing the acreage, technical capacity, and time horizons conducive to offset generation—demonstrates a new model for carbon sequestration based on intensive timber management and production of durable wood products, which may challenge public perception of the program. Future analyses will clarify implications for dual carbon and wood products production. The two markets are compatible to an extent, due to partial crediting for carbon stored in durable wood products, the ability of carbon revenue to complement timber production in specific situations (see Section 1.2), and because increasing stocking levels over time is consistent with some timber harvesters' broader management objectives. Yet they also compete, because timber is extractive while offsets are predominantly growth-based. Participation in both commodity chains thus may require balancing of management objectives. Future production decisions will likely be driven by economics: high carbon prices could decrease wood production over time, while more competitive timber markets may alter commercial landowners' willingness to maintain carbon stocking commitments or to enter lands into the market at all.

A comprehensive description of all landowner participants is beyond the scope of this paper. However, these examples highlight important early trends. Particularly we found participation largely limited to landowners with the highest preexisting compatibility with program rules, such as conservation landowners, and those with large land bases whose forests are at least marginally above common practice with intention to raise stocking levels, such as forest industry. Smaller-scale landowners such as most NIPFs are less likely to enter the market because of economies of scale—with few acres and therefore little revenue, the costs of market entry frequently outweigh the benefits. Thus it is unsurprising that early participants are those whose carbon revenue is unlikely to require management changes that reduce other revenue opportunities. The early carbon market may therefore act more as a subsidy by rewarding landowners for having managed above regional standards, and by providing revenue for conservation landowners and tribes to secure properties, but it is unlikely to change land management decisions per se. This is in part because uncertainty in market demand and duration privileges participation among highest-stocked properties, which can offset development costs with a windfall of credits in year-one. Lower-stocked lands that gradually earn revenue as forests grow may have significant climate benefit and profitability long-term; however, they have little incentive to enter a market with regulatory uncertainty and substantial ongoing expenses. Many forest types, management contexts, geographic regions, and landowner demographics are therefore absent from this market. Signs of market endurance and carbon price competitiveness are two factors likely to expand participation to currently non-viable projects, and those willing to forgo traditional revenue streams for forest offset production.

3.2. Access mechanisms

Though diverse, forest offset production is still an exclusive enterprise. Drawing on Ribot and Peluso's 'theory of access,' we find that relatively few landowners are benefiting from California's forest offset market, despite having rights to timber; yet others without timber rights are finding ways to benefit (2003). We now consider the mechanisms enabling and constraining access to benefits from forest offset production.

3.2.1. Access mechanisms: knowledge, capital, technical capacity

Ecosystem services are inherently difficult to commercialize, because they are intangible and do not physically travel along

[8] Only 58 CDM Afforestation/Reforestation projects have been registered since program inception in 2006 (https://cdm.unfccc.int/ accessed February, 2016).

[9] Fletcher et al. suggest that while hundreds of REDD projects have been implemented globally, only a 'handful' have been successfully incentivized though markets, while the rest depend on state subsidy (2016).

commodity chains. This is expressly true of forest offsets, because the actual commodities are locked-up in forests, while meticulously measured accounting claims are sold at market. Researchers elsewhere described the rigorous and costly accounting, reporting, and verification steps needed to render ecosystem goods 'real' for market consumers (Bumpus, 2011; Castree, 2003; Corbera and Brown, 2010). Our results repeat these findings by documenting participant experiences conforming with a technically complex protocol, conducting inventories of unprecedented intensity, and submitting to repeated third-party verifications. California's regulatory market may involve new producers and land management contexts; yet the need to legitimate intangible commodities is unchanged. This authentication process is arguably of greater importance in California's market, where offsets must stand-up as credible compliance instruments. This is explicit in the practice of triple verifying accounting claims in order to overcome invalidation risk, and in project developer distinctions between California's early voluntary forest offset market and the later compliance market, which increased the accounting rigor required for projects to 'pass regulatory muster' (see also Schmitz and Kelly, 2016).

Rigorous, costly, and technically complex steps in forest offset production raise the importance of knowledge, capital, and technical capacity as access mechanisms, creating participant dependency on third-party experts who offer market insight, development finance, and technology to bring offsets to market. This constrains participation among average landowners, while enabling it among specialized actors who have professionalized the development process (see Ribot and Peluso, 2003, p. 170). Service providers are numerous and involved at all points along the commodity chain, including carbon developers, consulting foresters, verifiers, registry staff, and brokers. Especially prominent are carbon developers, who have thus far developed over half of all projects and provided select services, such as marketing and sale of credits, for significantly more. Involvement of developers in some aspect of offset production is thus nearly universal. This phenomenon may owe to the emerging nature of the market, which reduces the likelihood that knowledge and technical capacity have been transmitted to landowners themselves. We note that while developers serve as key access facilitators, they also reduce benefit flows to resource holders and may introduce property complexities through equity-sharing contracts, with possible consequences for long-term offset project financial viability and land management flexibility.

The importance of specialized knowledge and upfront and ongoing capital means that some landowners will have greater access to market benefits. Industrial forest landowners and institutional investors have capital and in-house technical capacity and therefore access to the market. Non-industrial forest landowners are far less likely to have ready capital, and are unlikely to have the knowledge necessary to create complex inventories and feasibility analyses (Fletcher et al., 2009; Wade and Moseley, 2011; Charnley et al., 2010; Fischer and Charnley, 2011; Markowski-Lindsay et al., 2011; Thompson and Hansen, 2012; Miller et al., 2012). Conservation landowners may lack available capital but have extensive ability to secure grant funding to facilitate projects. Tribes, meanwhile, may have revenues from other businesses or settlement agreements, though because they are understudied forest landowners, their objectives and in-house capacities are less known and deserve further attention.

3.2.2. Access mechanism: identity

Unlike knowledge, capital, and technical capacity, which aid forest offset production, landowner identity functions as a marketing tool, by signaling value-added attributes, such as ecological or social co-benefits. Within voluntary markets and sustainable development programs, identity-based narratives are central to forest offset sales, because of the need to demonstrate project integrity in the face of large price and offset quality differentials. In contrast, California's cap-and-trade market suggests limited room for identity-based price distinctions, because meeting regulatory obligations is paramount. Yet landowners and project developers continue to construct identity narratives, particularly for NIPFs, tribes, and projects with apparent high conservation value (Section 2.5). This raises questions about why identity cachets persist amid rigorous state oversight, under a methodology designed to promote offset equality. One possibility is that because forest offsets compete with alternative offsets lacking the uncertain quantification, impermanence, and public environmental scrutiny of forest offsets, producers may highlight the charismatic attributes of forest conservation, such as habitat and open space protection, to bolster market appeal.[10] Alternatively, identity narratives could be less impactful on offset sales and more useful for the branding of producer organizations, such as land trusts and tribes. We see promise in future research to uncover why environmental and social contexts of production still matter, in the face of state efforts to deem offsets commensurate and tradable in markets. Analyses might explore the extent to which regulated emitters demonstrate higher demand or willingness-to-pay for projects with greater ecological or social credibility; how landowner identity affects access to the political process, and thus future influence over program design; and whether industrial and investor landowners, with their substantial financial resources, could capitalize on identity narratives through marketing, or alternatively diminish the value of these narratives through claims of project equivalency.

3.3. A policy-dependent commodity

California regulatory forest offsets depend on state policy to define, quantify, and assign value to them as market goods, creating what Knox-Hayes called "legislatively stimulated demand" (2013, p. 125). In this way, they contradict neoliberal assumptions about market functioning as the state has maintained power over project design and sale through control of protocols. We described elsewhere that nonstate actors with political capital originally had strong influence over program design (Schmitz and Kelly, 2016), however once ARB adopted the IFM protocol it moved into state jurisdiction. This research demonstrates that engagement with the commodity chain hinges on landowner ability to comply with now state-controlled protocol requirements and is sensitive to design adjustments which may decrease project viability. We have already seen protocol amendments alter commodity chain participation, signified by the flood of IFM projects (n = 70) in October 2015, just prior to controversial protocol revisions, suggesting project developers anticipated and sought to avoid reductions in project profitability. We see ARB management of the protocol, invalidation as a state tool to overturn offsets even once third-party verified, and the state's role as sole grantor of compliance-grade offsets, as indicators that the state functions as the ultimate access mediator, repeating Ribot and Peluso (2003). This contrasts starkly with traditional wood products, which are certainly affected by forest management regulations, but which nonetheless possess use and exchange-value independent of state policy and may be transacted in markets without direct state intercession. This signals an important aspect of policy-dependent commodity chains, such as markets for carbon offsets: they are neither producer nor consumer-driven, but ultimately driven by the state, confirming the perspective of Raikes et al. (2000)

[10] The primary alternative offsets in California's cap-and-trade program are those produced by destruction of ozone depleting gases and destruction of methane.

about governance external to the commodity chain. The state both creates demand through the creation of the market—in this case through legislation for a cap-and-trade market—and regulates production dynamics and offset supply through program implementation authority.

4. Conclusion

We have employed CCA to systematically and critically analyze the relationships among market actors and processes, as a framework for understanding *how* and *by whom* benefits are accessed in California's regulatory forest offset market. This setting was unusual, with offsets created in the US on predominantly timber producing forests, in contrast to CDM and REDD, which link Global South producers to Global North polluters (Bumpus, 2011). We found that despite differing geographic contexts, California's regulatory market exhibits unequal benefit flows similar to offset markets globally, chiefly because production cost and complexity limit participation of economically marginal landowners and encourage dependence on third-party experts, who share both the risk and reward of market entry. This demonstrates the utility of CCA even within the Global North, where tenure rights are presumed secure and market relationships, well-defined. CCA also allowed us to trace the otherwise obscure forest offset production process, documenting the feats of technical sophistication needed to produce and legitimize abstract ES goods, and revealing the pervasive role of the state: establishing demand, regulating production supply and terms, and participating directly in the supply chain through issuance and invalidation of commodities. These insights present a lucid picture of state governance used to create, sustain, and manipulate an ES marketplace, rendering it anything but natural. We submit this translates across policy-dependent ES markets globally, where state agents are/will be similarly empowered to shape market access and functioning through program administration.

Future analyses should study evolving questions of production and governance as the California carbon market matures. For instance, current participation is shaped largely by threat of market discontinuance post 2020; subsequent analyses might test how policy-related risks, such as market impermanence, shape ES production dynamics, e.g. by circumscribing which lands are viable for market entry. More fundamentally, research should clarify whether land-use offsets actually facilitate their ultimate goal of mitigating climate change, or whether they simply provide new forums for land management commodification, while offering carbon emitters low cost compliance. Such investigations might also consider the California regulatory market in a global context. Emissions trading systems are proliferating worldwide and may try to link to California. Already California has developed Memoranda of Understanding (MOUs) with states in China, Brazil, Mexico, and Canada to link emissions trading systems and potentially trade offsets (see Hsia-Kung et al., 2014). Our analysis points-out some of the difficulties of linking as the steps of the commodity chain for the California market are highly regulated and exceedingly specific. Without similar obligations such as standardized baselines, rigorous third-party verification, and 100-year permanence commitments, other forest carbon schemes will have difficulty linking to California. Thus the problematic nature of carbon commodification is that while offsets are all theoretically the same good (a ton of CO_2), in practice they are differently quantified, with diverse social, economic, and environmental implications. Future research should consider emerging governance questions raised by linkages to methodologically distinct ecosystem service markets, while monitoring the outcomes of globally dispersed environmental commodities.

Acknowledgements

We gratefully acknowledge the critical input of Dylan Jenkins of Finite Carbon, and two anonymous reviewers. This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture McIntire-Stennis program, accession number 231837.

References

Angelsen, A., Gierløff, C.W., Beltrán, A.M., den Elzen, M., 2014. REDD Credits in a Global Carbon Market: Options and Impacts. Nordic Council of Ministers.
Boyd, E., Corbera, E., Estrada, M., 2008. UNFCCC negotiations (pre-Kyoto to COP-9): what the process says about the politics of CDM-sinks. Int. Environ. Agreem.: Polit. Law Econ. 8, 95–112. http://dx.doi.org/10.1007/s10784-008-9070-x.
Brown, K., Corbera, E., 2003. Exploring equity and sustainable development in the new carbon economy. Clim. Policy 3, S41–S56. http://dx.doi.org/10.1016/j.clipol.2003.10.004.
Brown, K., 2014. Forest Carbon Markets and Conservation Easements: Implications for Land Trusts in Northern New England and New York M.S. Thesis. Natural Resources, The University of Vermont, Burlington, Vermont.
Bumpus, A., Liverman, D., 2008. Accumulation by decarbonization and the governance of carbon offsets. Econ. Geogr. 84 (2), 127–155. http://dx.doi.org/10.1111/j.1944-8287.2008.tb00401.x.
Bumpus, A., 2011. Realizing Local Development in the Carbon Commodity Chain: Political Economy, Value and Connecting Carbon Commodities at Multiple Scales. United Nations Research Institute for Social Development.
Cabello, J., Gilbertson, T., 2012. A colonial mechanism to enclose lands: a critical review of two REDD+-focused special issues. Ephemera 12 (1/2), 162.
Caldwell, B., Holland, K., Barbane, Z., Jonas, M., 2014. AB 32—a compliance carbon market for US forests, an opportunity for foresters. J. For. 112 (1), 60–61.
Castree, N., 2003. Commodifying what nature? Prog. Hum. Geogr. 27 (3), 273–297. http://dx.doi.org/10.1191/0309132503ph428oa.
Cavanagh, C., Benjaminsen, T., 2014. Virtual nature, violent accumulation: the 'spectacular failure' of carbon offsetting at a Ugandan National Park. Geoforum 56, 55–65. http://dx.doi.org/10.1016/j.geoforum.2014.06.013.
Charnley, S., Diaz, D., Gosnell, H., 2010. Mitigating climate change through small-scale forestry in the USA: opportunities and challenges. Small-Scale For. 9 (4), 445–462. http://dx.doi.org/10.1007/s11842-010-9135-x.
Corbera, E., Brown, K., 2010. Offsetting benefits? Analyzing access to forest carbon. Environ. Plan. A 42 (7), 1739–1761. http://dx.doi.org/10.1068/a42437.
Corbin, J., Strauss, A., 2014. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Sage Publications, New York.
Cowlishaw, G., Mendelson, S., Rowcliffe, J., 2005. Structure and operation of a bushmeat commodity chain in southwestern Ghana. Conserv. Biol. 19 (1), 139–149. http://dx.doi.org/10.1111/j.1523-1739.2005.00170.x.
Dressler, W., McDermott, M., Smith, W., Pulhin, J., 2012. REDD policy impacts on indigenous property rights regimes on Palawan Island, the Philippines. Hum. Ecol. 40 (5), 679–691. http://dx.doi.org/10.1007/s10745-012-9527-y.
Fischer, P., Charnley, S., 2011. Social and cultural influences on management for carbon sequestration on US family forestlands: a literature synthesis. Int. J. For. Res. 2010. http://dx.doi.org/10.1155/2010/960912.
Fletcher, L., Kittredge, D., Stevens, T., 2009. Forest landowners' willingness to sell carbon credits: a pilot study. N. J. Appl. For. 26 (1), 35–37.
Fletcher, R., Dressler, W., Büscher, B., Anderson, Z., 2016. Questioning REDD+ and the future of market-based conservation. Conserv. Biol. http://dx.doi.org/10.1111/cobi.12680.
Galik, C., Cooley, D., Baker, J., 2012. Analysis of the production and transaction costs of forest carbon offset projects in the USA. J. Environ. Manage. 112, 128–136. http://dx.doi.org/10.1016/j.jenvman.2012.06.045.
Galik, C., Mobley, M., 2009. A virtual 'field test' of forest management carbon offset protocols: the influence of accounting. Mitig. Adapt. Strat. Glob. Change 14 (7), 677–690. http://dx.doi.org/10.1007/s11027-009-9190-9.
Gereffi, G., Korzeniewicz, M., 1994. Commodity Chains and Global Capitalism. No. 149. ABC-CLIO.
Gunn, J., Saah, D., Fernholz, K., Ganz, D., 2011. Carbon credit eligibility under area regulation of harvest levels in northern Minnesota. For. Sci. 57 (6), 470–478.
Hopkins, T., Wallerstein, I., 1986. Commodity chains in the world-economy prior to 1800. Review (Fernand Braudel Center) 10 (1), 157–170 <http://www.jstor.org/stable/40241052>.
He, J., 2010. Globalised forest-products: commodification of the matsutake mushroom in Tibetan villages, Yunnan, Southwest China. Int. For. Rev. 12 (1), 27–37. http://dx.doi.org/10.1505/ifor.12.1.27.
Hsia-Kung, K., Reyna, E., O'Connor, T., 2014. California Carbon Market Watch: A Comprehensive Analysis of the Golden State's Cap and Trade Program. Environmental Defense.
Ituarte-Lima, C., McDermott, C., Mulyani, M., 2014. Assessing equity in national legal frameworks for REDD+: the case of Indonesia. Environ. Sci. Policy 44, 291–300. http://dx.doi.org/10.1016/j.envsci.2014.04.003.
Jackson, P., Ward, N., Russell, P., 2006. Mobilising the commodity chain concept in the politics of food and farming. J. Rural Stud. 22 (2), 129–141. http://dx.doi.org/10.1016/j.jrurstud.2005.08.008.

Jenkins, D., 2013. The Business Case for California Forest Carbon Offsets. Forestry Source. Society of American Foresters, January.
Kay, K., 2015. Breaking the bundle of rights: conservation easements and the legal geographies of individuating nature. Environ. Plan. A, 1–19. http://dx.doi.org/10.1177/0308518X15609318.
Kerchner, C.D., Keeton, W.S., 2015. California's regulatory forest carbon market: viability for northeast landowners. For. Policy Econ. 50, 70–81. http://dx.doi.org/10.1016/j.forpol.2014.09.005.
Klooster, D., 2005. Environmental certification of forests: the evolution of environmental governance in a commodity network. J. Rural Stud. 21 (4), 403–417. http://dx.doi.org/10.1016/j.jrurstud.2005.08.005.
Knox-Hayes, J., 2013. The spatial and temporal dynamics of value in financialization: analysis of the infrastructure of carbon markets. Geoforum 50, 117–128. http://dx.doi.org/10.1016/j.geoforum.2013.08.012.
Lecocq, F., Ambrosi, P., 2007. The clean development mechanism: history, status, prospects. In: Cooper, Maureen (Ed.), The Policy Monitor. http://dx.doi.org/10.1093/reep/rem004.
Markowski-Lindsay, M., Stevens, T., Kittredge, D.B., Butler, B.J., Catanzaro, P., Dickinson, B.J., 2011. Barriers to Massachusetts forest landowner participation in carbon markets. Ecol. Econ. 71, 180–190. http://dx.doi.org/10.1016/j.ecolecon.2011.08.027.
Miller, K.A., Snyder, S.A., Kilgore, M.A., 2012. An assessment of forest landowner interest in selling forest carbon credits in the Lake States, USA. For. Policy Econ. 25, 113–122. http://dx.doi.org/10.1016/j.forpol.2012.09.009.
Naughton-Treves, L., Day, C., 2012. Lessons about Land Tenure, Forest Governance and REDD+. UW-Madison Land Tenure Center, USAID, Madison, Wisconsin.
Raikes, P., Friis Jensen, M., Ponte, S., 2000. Global commodity chain analysis and the French filière approach: comparison and critique. Econ. Soc. 29 (3), 390–417. http://dx.doi.org/10.1080/03085140050084589.
Remucal, J.M., McGee, J., Fehrenbacher, M., Best, C., Mitchell, R., 2013. Application of the climate action reserve's forest project protocol to a longleaf pine forest under restoration management. J. For. 111 (1), 59–66. http://dx.doi.org/10.5849/jof.11-094.
Ribot, J.C., Peluso, N.L., 2003. A theory of access. Rural Sociol. 68 (2), 153–181. http://dx.doi.org/10.1111/j.1549-0831.2003.tb00133.x.
Ribot, J.C., 1998. Theorizing access: forest profits along Senegal's charcoal commodity chain. Develop. Change 29 (2), 307–341. http://dx.doi.org/10.1111/1467-7660.00080.
Russell-Roy, E.T., Keeton, W.S., Pontius, J.A., Kerchner, C.A., 2014. Rehabilitation forestry and carbon market access on high-graded northern hardwood forests. Can. J. For. Res. 44 (6), 614–627. http://dx.doi.org/10.1139/cjfr-2013-0437.
Schmitz, M., Kelly, E., 2016. Ecosystem service commodification: lessons from california. Global Environ. Polit. (in press), http://dxdoi.org/10.1162/GLEP_x_00356GLEP_a_00374.
Suykens, B., 2010. Diffuse authority in the Beedi commodity chain: Naxalite and state governance in tribal Telangana, India. Develop. Change 41 (1), 153–178. http://dx.doi.org/10.1111/j.1467-7660.2009.01622.x.
Thompson, D.W., Hansen, E.N., 2012. Factors affecting the attitudes of nonindustrial private forest landowners regarding carbon sequestration and trading. J. For. 110 (3), 129–137. http://dx.doi.org/10.5849/jof.11-010.
Thomas, S., Dargusch, P., Harrison, S., Herbohn, J., 2010. Why are there so few afforestation and reforestation Clean Development Mechanism projects? Land Use Policy 27 (3), 880–887. http://dx.doi.org/10.1016/j.landusepol.2009.12.002.
Wade, D., Moseley, C., 2011. Foresters' perceptions of family forest owner willingness to participate in forest carbon markets. N. J. Appl. For. 28 (4), 199–203.