



Synergies and trade-offs among integrated conservation approaches in Mexico

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Abstract: Integrated conservation approaches (ICAs) are employed by governments, communities, and non-governmental organizations worldwide seeking to achieve outcomes with dual benefits for biodiversity conservation and poverty alleviation. Although ICAs are frequently implemented concurrently, interactions among ICAs and the synergies or trade-offs that result are rarely considered during program design, implementation, and evaluation. In support of more deliberate and effective use of ICAs, we examined interactions among four well-known strategies: biosphere reserves (BRs), voluntary protected areas (VPAs), payments for ecosystem services (PES), and community forest management (CFM). Through a comparative case study, we analyzed interactions among spatially or temporally clustered ICAs implemented on communally held and managed lands in three ecologically and socioeconomically distinct regions of Mexico. Our research methods combined policy analysis with data gathered through participant observation and semistructured interviews ($n = 78$) and focus groups ($n = 5$) with government officials, implementers, and participants involved in ICAs in 28 communities. Despite the significant differences among the regions in which they were implemented, we found that key actors at each level of involvement generally perceived interactions among ICAs as synergistic. The PES programs were perceived to strengthen protected areas by reducing forest cover loss in and around BRs, fostering proconservation attitudes, and incentivizing the establishment of VPAs. Communities that invested PES income in CFM were motivated to conserve forests beyond the duration of PES programs, and CFM in buffer zones was perceived to strengthen BRs by maintaining forest cover and generating income for communities. We also identified key social and environmental factors that can influence these interaction effects among ICAs. Based on these findings, we recommend further study of ICA interactions and intentionally complementary policy design to maximize positive environmental and social outcomes.

Keywords: biosphere reserves, carbon offsets, community forest management, integrated conservation approaches, Latin America, Mexico, payments for ecosystem services, voluntary protected areas, América Latina, áreas protegidas voluntarias, compensaciones por carbono, estrategias de conservación integrada, manejo comunitario de bosques, México, pagos por servicios ambientales

Resumen: Las estrategias de conservación integrada (ECI) son empleadas en todo el mundo por los gobiernos, comunidades y organizaciones no gubernamentales que buscan alcanzar resultados con beneficios tanto para la conservación como para la mitigación de la pobreza. A pesar de que múltiples ECI suelen implementarse simultáneamente, es raro que se tomen en cuenta las posibles interacciones positivas (sinergías) o negativas (trade-offs) durante el diseño, la implementación y la evaluación de estos programas. En búsqueda de un uso más deliberado y efectivo de las ECI, examinamos las interacciones entre cuatro estrategias conocidas: reservas de la biósfera (RB), áreas protegidas voluntarias (APV), pagos por servicios ambientales (PSA) y el manejo comunitario de los bosques (MCB). Mediante un estudio de caso comparativo analizamos las interacciones entre las ECI agrupadas espacial o temporalmente implementadas en tierras con administración y propiedad comunal en tres regiones con diferencias ecológicas y socioeconómicas en México. Nuestros métodos de investigación combinaron el análisis

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de políticas con datos recopilados mediante la observación participativa, entrevistas semiestructuradas ($n = 78$) y grupos focales ($n = 5$) con funcionarios del gobierno, implementadores y participantes involucrados en las ECI de 28 comunidades. A pesar de las diferencias significativas entre las regiones en las que se implementaron estas ECI, descubrimos que los actores clave en cada nivel de participación percibieron de manera generalizada las interacciones entre las ECI como sinérgicas. Los programas de PSA fueron percibidos como algo que fortalece a las áreas protegidas mediante la reducción de la pérdida de la cobertura forestal dentro y fuera de las RB, el fomento de las actitudes a favor de la conservación y el estímulo al establecimiento de las APV. Las comunidades que invirtieron los ingresos por PSA en el MCB expresaron su motivación para conservar los bosques más allá de la duración de los programas de PSA y el MCB en zonas de amortiguamiento fue percibido como un factor de fortalecimiento de las RB mediante el mantenimiento de la cobertura forestal y la generación de ingresos para las comunidades. También identificamos los factores sociales y ambientales importantes que pueden influir sobre estos efectos de interacción entre las ECI. Con base en estos hallazgos, recomendamos un estudio más profundo de las interacciones entre las ECI y un diseño de políticas intencionalmente complementario para maximizar los resultados sociales y ambientales positivos.

Introduction

Priority areas for biodiversity conservation in the tropics are frequently located in regions with high poverty levels (Fisher & Christopher, 2007). To address intertwined needs for conservation and poverty alleviation, conservation practitioners often turn to integrated conservation approaches (ICAs) that aim to protect ecosystems and simultaneously generate economic and social benefits for local populations (Alpert, 1996). Since their introduction in the 1980s, ICAs have been incorporated into a wide variety of initiatives for sustainable development, integrated conservation and development, and community-based natural resource management around the world (Turner et al., 2012). Adoption of ICAs has also been motivated by a growing recognition of local peoples' natural resource rights (Cronkleton et al., 2012; Rights and Resources Initiative, 2014) and the greater political viability of these approaches relative to more exclusionary conservation strategies (Ruíz-Mallén et al., 2015). Today ICAs include approaches across the spectrum of regulatory to market-based incentives (e.g., biosphere reserves [BRs] versus payments for ecosystem services (PES), ecotourism, and product certification) and from strict land protection to productive management (e.g., protected areas with limited extractive use versus community forest management [CFM]) (Lambin et al., 2014).

Although ICAs' dual goals are increasingly important as humans intensify use of biodiversity-rich areas, these approaches have also been extensively critiqued as "conservation by distraction" (Ferraro & Simpson, 2002:349) that often fail to foster either conservation or economic development (Brown, 2004). However, critical assessments of ICAs generally overlook potential synergistic interactions between complementary approaches. While ICAs are typically designed, implemented, and evaluated in isolation (Méndez-López et al., 2014; Sims & Alix-García, 2017), multiple approaches frequently are or could be implemented at the same site. Research on interactions among ICAs, thus, far has been limited

and has largely reported trade-offs, such as reductions in biodiversity and ecosystem services in protected areas due to productive management (Hutton & Leader-Williams, 2003) and negative effects of financial conservation incentives in protected areas (Lambin et al., 2014; Rode et al., 2015). Realizing the full potential of ICAs necessitates a better understanding of interactions among approaches, both when implemented in the same area at the same time (spatially) or in close succession (temporally), to allow for explicit consideration of both trade-offs and synergies in program design and implementation.

We addressed this knowledge gap surrounding ICA interactions by examining the design and implementation of four common approaches: BRs, VPAs, PES, and CFM (Table 1). Applying a comparative case study approach, we analyzed the interactions among spatially or temporally clustered ICAs implemented in communally held and managed lands in three ecologically and socioeconomically distinct regions of Mexico. We gathered data through interviews and focus groups with government officials, implementers, and participants combined with participant observation and policy analysis. Our analysis of these data focused on the design and implementation of individual ICA policies, interactions among the ICAs, and the influence of contextual factors such as local social, environmental, and economic conditions. Based on these results, we characterized a variety of synergistic and antagonistic interactions among these ICAs and devised generalizable recommendations for improving synergy and reducing trade-offs among BRs, VPAs, PES, and CFM.

Methods

Study Area

Mexico provides an ideal context for comparative case study research on ICA interactions due to widespread implementation of standardized policy design across highly

Table 1. Descriptions of integrated conservation approaches (ICAs) included in our analysis of interactions between ICAs in Mexico.

ICA	Description	References
Biosphere reserves	Protected areas established through a participatory approach, made up of core zones dedicated strictly to conservation and buffer zones dedicated to sustainable use of natural resources	Halfpeter (2011)
Voluntary protected areas	Areas set aside on communal lands by community members, who may or may not seek recognition under national law	Bezaury-Creel et al. (2009); Martin et al. (2011)
Payments for ecosystem services	Voluntary program in which conditional payments are made directly to landowners in recognition of the ecosystem services (e.g., hydrological cycling, biodiversity conservation, carbon sequestration) provided by their lands	Wunder (2006)
Community forest management	Community-based management of forests, often on communal lands, for timber, nontimber forest or both products; generally small scale and often incorporate practices for ensuring sustainable yield and conserving biodiversity	Gilmour (2016)

socially and ecologically diverse regions. Mexico is home to 12% of the world's biodiversity (Valdez et al., 2006), and forests cover about 30% of the country, mostly in highly economically marginalized regions (Madrid et al., 2009). Approximately 60% of forested lands are owned by *ejidos* and *comunidades indígenas* (Madrid et al., 2009). The common-property land tenure and social organization of these two categories of agrarian communities, founded by peasant farmers and Indigenous peoples with historic land rights respectively, creates a strong foundation for community-based natural resource management (Bezaury-Creel et al., 2009). We use the term *indigenous territories* where appropriate to describe areas where *comunidades indígenas* have a particularly strong degree of autonomy.

Mexico's multitiered protected area network covers 10% of its terrestrial territory (Bezaury-Creel et al., 2009). Some protected areas, such as BRs and VPAs, integrate local participation and use in their establishment, design, and management. BRs are designated by the federal government, often on land owned by communities, as part of the United Nations Educational, Scientific and Cultural Organization's (UNESCO) global network of protected areas (Halfpeter, 2011). Though core areas are under strict conservation, BRs are considered ICAs because sustainable productive activities, including forest management, are permitted in the buffer zones (Bezaury-Creel et al., 2009).

In contrast to BRs, VPAs are established by communities or other landowners. As with many VPAs globally, some VPAs in Mexico are internally recognized, protected, and managed solely on a community level, whereas other VPAs are externally recognized by government agencies such as Mexico's National Protect Areas Commission (CONANP) (Kothari, 2006; Martin et al., 2011). This agency awards an official certification for voluntarily conserved areas upon submission and review of management plans, which can facilitate access to PES programs and green markets (Bezaury-Creel et al., 2009).

Mexico's protected areas network is complemented by a large-scale government-financed PES program, one of the largest and longest standing of over 550 PES programs active around the globe (Salzman et al., 2018). Founded in 2003, by 2018 the program had enrolled 6.32 million ha belonging to over 9,300 private landowners and communities (CONAFOR, 2018a). The PES program is managed by the National Forestry Commission (CONAFOR), and enrollment is granted based on a range of social and environmental criteria including proximity to protected areas. Federal PES contracts issued for hydrological or biodiversity services last five years with a one-time renewal option and are conditional on maintenance of forest cover and specific conservation activities such as monitoring against forest fires, illegal logging, and poaching (DOF, 2016). Other government PES programs include state-level programs and another federal program that allows companies, organizations, or local governments to pay landowners with matching payments from CONAFOR. One prominent example of this matching-funds program is the Fondo Monarca, a permanent trust fund established by international donors that provides compensation for communities in the core area of the Monarch Butterfly BR (Vidal et al., 2014). Finally, the sale of forest-based carbon offset credits on national and international voluntary markets constitutes another form of independent, nongovernmental PES for some Mexican communities.

CFM also known as community-based forestry, promotes the integrated aims of sustainable forest management and improvement of local livelihoods (Gilmour, 2016). CFM is widespread in Mexico. Approximately 52% of *ejidos* and *comunidades* with commercially viable forests sell timber to some degree (Hodgdon et al., 2013). Mexican forestry law requires submission of management plans with locally appropriate harvesting volumes and encourages biodiversity conservation through restricted harvesting areas, wildlife corridors, reforestation, and monitoring (Barrón Sevilla, 2016; Ellis, 2016; Torres-Rojo et al., 2016). Communities manage

Table 2. Integrated conservation approaches (ICAs) currently implemented at each study site in Mexico.

<i>ICA category</i>	<i>Monarch Butterfly Biosphere Reserve</i>	<i>Calakmul Biosphere Reserve</i>	<i>Indigenous territories of Oaxaca</i>
Biosphere reserves	x	x	
Voluntary protected areas (VPAs)		x	X
Federal payments for ecosystem services (PES)	X	x	X
Federal matching funds PES	x		X
State-level PES	x		
Carbon offsets*			X
Community forest management	x	x	X

*Certified by the UN's International Organization for Standardization (ISO) and US-based Carbon Action Reserve Protocol (CARP).

forests with the help of certified intermediaries, usually foresters (Bray & Wexler, 1996), who often also facilitate PES participation.

Research Design

Comparative case study research is the analysis of outcomes across cases that share key variables but differ significantly in others (Yin, 2017). Analyzing cases from distinct settings enables researchers to more confidently assess the influence of context and clarify relationships among complex sets of variables (Yin, 2017). Accordingly, we selected three sites with distinct socioecological conditions and combinations of ICAs (Table 2), but with similar ICA policies and community-based implementation: the Monarch Butterfly BR (Monarch Reserve) in Michoacán and Estado de México, the Calakmul BR (Calakmul Reserve) in Campeche, and a sample of four Indigenous territories in Oaxaca (Figure 1). The Monarch Reserve was established on land owned by long-standing ejidos and comunidades in the mountainous temperate fir and pine forests in central Mexico; the more recently established ejidos overlapping the Calakmul Reserve are embedded in the tropical forests of the Yucatán Peninsula; and the Indigenous territories of Oaxaca we studied have temperate or temperate-tropical forests.

Based on spatial data and program enrollment information from host organizations and government agencies, we applied a maximum variation purposive sampling strategy to select communities with the broadest range of ICA combinations in each site (Etikan et al., 2016). Similarly, we used a purposive sampling strategy to select research participants whose experiences with ICAs positioned them to provide key insights for expert interviews and focus groups (Etikan et al., 2016).

To gain a nuanced understanding of ICA interactions across our three cases, we collected primarily qualitative data through semistructured interviews, focus groups, and participant observation (Table 3) (Supporting information Appendix S1 describes characteristics of communities and intermediaries). This facilitated comparison among cases but also allowed for the emergence

of novel themes. We conducted 33 semistructured interviews with representatives from 28 communities and 25 interviews with ICA designers and implementers from 15 different organizations. We also conducted five majority-female focus groups in communities to counterbalance the largely male point of view presented in interviews. Our participant observation in 16 communities included seven guided forest tours, two community assemblies, and two PES contract renewal meetings.

Our research protocol was approved by the Institutional Review Board of Duke University prior to our fieldwork conducted from May through July 2018. All participants gave informed consent to participation and audio recording. Interview guides are in Supporting information Appendices S2 and S3, and interviews were often arranged or attended by staff from host organizations.

Data Analyses

We thematically coded and analyzed interview and focus group transcripts and participant observation notes with the qualitative analysis software NVivo12 (thematic hierarchy in Supporting information Appendix S4). We corroborated PES enrollment and PES and protected area boundaries with geospatial data from relevant government agencies. We reviewed government policies for the ICAs to assess how design elements influenced observed interactions.

Based on analysis of interview and focus group transcripts, we classified interactions among BRs, VPAs, PES, and CFM as synergies or trade-offs. We further categorized interactions as spatial, meaning the ICAs were implemented simultaneously, or temporal, meaning they were implemented in sequence (Table 4).

Results

Protected Areas and Payments for Ecosystem Services

We identified a variety of spatial and temporal interactions, many of them synergistic, between PES and the two categories of protected areas represented in our

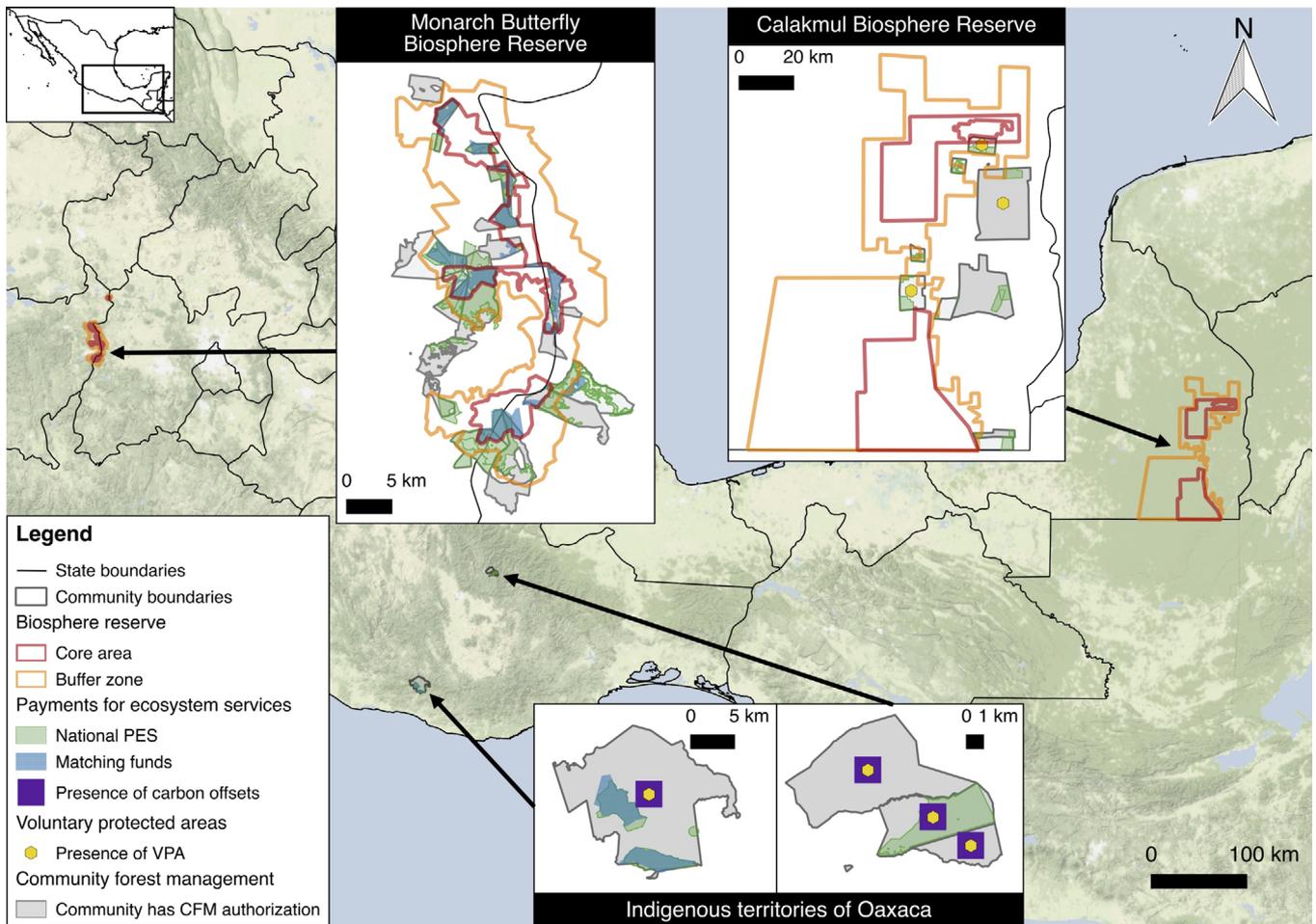


Figure 1. Study sites and characteristics of communities participating in different combinations of integrated conservation approaches. Presence of community forest management permits, voluntary protected areas, and carbon offset contracts was determined through interviews. Sources: CONANP (2017), INEGI (2010), CONAFOR (2018a)

sample. We observed that PES had multiple synergistic interactions with BRs and VPAs by providing financial incentives and technical support to protect surrounding forests, offering partial compensation and support for alternative economic activities, and fostering proconservation attitudes. We also observed trade-offs in some situations, with PES potentially exacerbating inequality and crowding out other conservation motives.

Communities associated with protected areas demonstrated numerous spatial synergies with PES that were facilitated by existing policy design. Communities with certified VPAs or located in or near BRs were preferentially enrolled in federal PES programs. Internally recognized VPAs in Oaxaca, which are commonly located around springs, were prime sites for federal hydrological PES. Enrollment in PES also directly and indirectly conserved forests in and around protected areas. In Oaxaca land-use zoning required by federal PES programs generated discussions that prompted some communities to internally recognize and delineate VPAs. Though VPAs

and PES areas sometimes overlapped, communities recognized VPAs as distinct entities that should endure beyond the end of PES contracts. According to officials in the Monarch and Calakmul BRs, PES provided an additional buffer against deforestation by conserving adjacent forests. Several interviewees also indicated that PES indirectly benefited protected areas by improving forest functioning through policy requirements and financial support for improved management of pests, diseases, fire, and illegal logging. Likewise, Indigenous communities in Oaxaca often reinvested funds from PES into managing these types of threats in their VPAs.

We found that PES provided at least partial compensation for land-use restrictions in BRs, which, along with funding complementary conservation and economic activities, reduced resentment in several communities. In the Monarch Reserve, managers and community members alike expressed that perpetual PES through the Fondo Monarca trust made the reserve socially and economically tolerable, if not necessarily beneficial, for

Table 3. Primary methods of data collection and sample sizes in examination of interactions between integrated conservation approaches in Mexico.

<i>Method</i>	<i>Target population</i>	<i>Topics</i>	<i>Sample size</i>	<i>Total number of participants</i>
Intermediary interviews	Forestry consultants, protected area staff, NGO employees, government officials	Regional threats, local conservation and degradation motives, design and effectiveness of payments for ecosystem services (PES), biosphere reserves, and voluntary protected areas (VPAs)	25	30
Community representative interviews	Past and present community leaders	Community-level demographics, history of participation in integrated conservation approaches (ICAs), perceived effects of PES, biosphere reserves, VPAs, and their interactions	33	48
Focus groups	Women from communities	Forest goods and services, changes in supply of those goods over time, resource governance, program participation including ICAs	5	38

Table 4. Classification of the types of interactions between integrated conservation approaches.

	<i>Spatial</i>	<i>Temporal</i>
Synergies	two strategies implemented on a community's land at the same time, although perhaps in different sites (coexisting strategies that may or may not overlap), resulting in beneficial social or environmental outcomes	two approaches implemented on a community's land in the same area, but at different times (one strategy followed by another), resulting in beneficial social or environmental outcomes
Trade-off	two strategies are implemented on a community's land at the same time, although perhaps in different sites, resulting in detrimental social or environmental outcomes	two approaches are implemented on a community's land in the same area, but at different times, resulting in detrimental social or environmental outcomes

communities in the core zone, where forest management was severely restricted. As a leader commented on the decisive role of the Fondo Monarca: "If they hadn't given us those funds, perhaps the forest wouldn't exist anymore, perhaps there would be only avocado plantations and this spring wouldn't exist either." In accordance with recent federal program requirements, PES funds were often reinvested in sustainable community-based development projects, such as ecotourism or honey production, which lead to further income generation (CONAFOR, 2018b). The BRs' name recognition and visiting tourists contributed to branding and creating demand for these community businesses.

We observed that participation in PES led to increased awareness of the value of forests and their ecosystem services, positively influencing community members' attitudes toward BRs and biodiversity conservation. One community leader said PES helped his community connect with the Calakmul Reserve because participation created shared goals of environmental conservation. Several communities in the Calakmul Reserve buffer zone

used federal PES funds to establish and certify VPAs in hopes of selling carbon offsets in the future, although these protected areas are ineligible for carbon offset certification by some organizations due to lack of additionality. Community members in all three regions also said PES participation increased awareness of and willingness to protect wildlife.

We did observe some trade-offs in interactions between PES and protected areas. Differences in PES eligibility and amounts may have exacerbated resentment and real or perceived inequality. Eligibility of Monarch Reserve communities in the Estado de México for a state-level PES program called PROBOSQUE led neighboring communities in Michoacán to protest lack of a similar program in their state. Communities in the Monarch Reserve's core zone also received much higher PES payments through Fondo Monarca than buffer zone communities enrolled in federal PES, which resulted in complaints about "first, second, and third class ejidos" in the reserve. Fondo Monarca payments only partially compensated for the loss of timber income due to the ban on

CFM in the core area, however, and while buffer zone communities did not receive Fondo Monarca payments they were still permitted to harvest a limited volume of timber. Five community interviewees in BR regions stated they would deforest if the payments stopped. This could be interpreted positively as justifying the importance of financial support for conservation or negatively as an example of motivation crowding out, in which financial incentives replace intrinsic conservation motives or respect for the law (Kerr et al., 2012; Lambin et al., 2014; Rode et al., 2015).

Payments for Ecosystem Services and Community Forest Management

Federal PES in Mexico prohibits timber harvesting on enrolled lands, creating a policy-based antagonistic relationship between PES and CFM (DOF, 2016). Nonetheless, communities across all three regions legally and creatively demonstrated spatial and temporal synergisms between the two ICAs. Rules for carbon offsets differ from federal and state-level PES, creating opportunities for unique interactions with CFM.

Many communities participated in federal or state-level PES and conducted CFM simultaneously by enrolling areas with low viability for timber harvesting in PES. In some cases, PES funds were used to certify timber or other CFM products, a practice promoted by federal program guidelines. Interviewees in Oaxaca also reported that PES-funded forest monitoring benefited CFM through reductions in pest and disease outbreaks, thereby improving forest health.

Positive temporal interactions were also common between PES and CFM. Several communities, particularly in Campeche, enrolled former CFM areas in PES programs, and while not discussed by our interviewees, timber from those plots could potentially be harvested once short-term federal PES contracts expire. In contrast, carbon offset contracts with communities in Mexico can last up to 30 years, but may allow some timber harvesting. Because timber is commonly harvested in 25- to 40-year cycles, however, even contracts that place more restrictions on timber harvesting may not create a significant burden for communities.

Interactions between carbon offset PES and CFM were complex and varied according to the standards of the offset-certifying organization. While some offset certification standards prohibited management for timber due to perceived lack of additionality, others promoted or required thinning, pruning, and other silvicultural treatments to maximize carbon sequestration. Thinning stands is also integral to producing high-value timber, potentially creating synergistic, spatially overlapping interactions among these ICAs should communities decide to harvest plots once the offset contracts expire (Nyland, 2002). Additionally, unlike other ecosystem ser-

vices whose production typically increases with forest age, carbon sequestration rates are generally higher in younger forests than mature forests, although the latter store more total carbon (Carey et al., 2001). These dynamics enabled another temporally synergistic interaction: some communities in Oaxaca harvested timber, planted native tree species, and then certified reforested clearings for carbon offset production. One Oaxacan community intermediary shared his belief in the synergistic relationships among carbon offset PES, federal PES, and CFM: “I believe that there should be an affinity between the goods and services such as carbon, water, biodiversity, the payments for all of those, and forest management, [...] they’re not rivals, not at all ...”

Protected Areas and Community Forest Management

Protected areas and CFM had obvious trade-offs and subtler synergies. Timber harvesting was prohibited in the core zones of BRs, but CFM and BRs still provided some mutual benefits. Interactions between VPAs and CFM varied by type.

As in most BRs, establishment of the Monarch Reserve resulted in the prohibition of CFM within core areas and significant harvest restrictions (30% of previous timber volume) for buffer-zone communities. Community representatives from core zones clearly stated they would continue CFM were it not for the reserve. Expanding CFM was also viewed favorably by most local intermediaries. A local consultant who advises communities on natural resource management harshly critiqued tightly controlled protected areas and expressed a strong preference for CFM as a more sustainable conservation mechanism: “If you asked me which of the two strategies is viable, one that is conservation by decree and using the armed forces [...], or one that is related to the valuation of the resource, income generation, the opportunity for landowners to carry out a management activity in the medium and long term, I’ll keep the second one.”

Despite trade-offs, synergies existed between CFM and protected areas. CFM in all regions incentivized forest conservation, complementing the goals of protected areas. In the Monarch Reserve, respondents credited the BR with reducing illegal logging through monitoring and enforcement, which may benefit CFM communities by reducing theft of their natural resources and competition from cheaper timber.

Recently established and certified VPAs near the Calakmul Reserve permitted CFM and other productive uses of the forest. In Oaxaca, forest management plans required for CFM authorization often delineated conservation areas with restricted harvesting, frequently because of springs or high biodiversity value, leading some communities to designate these areas as internally recognized VPAs (Barrón Sevilla, 2016). CFM motivated communities to manage VPAs to reduce fire and pest risk to

adjacent harvestable stands. Community members also perceived VPAs as benefiting CFM by serving as temporary wildlife refuges during and after timber harvesting and as undisturbed reference plots for biodiversity monitoring and restoration. Some community interviewees also considered VPAs potential emergency timber reserves. Other respondents mentioned, however, that the general public perceived CFM as a conservation threat, and that visitors had made negative comments about timber trucks in BRs or CFM communities.

Enabling Conditions

As with all ICAs, program effectiveness and the interactions among BRs, VPAs, PES, and CFM were determined by social and environmental conditions at the site of implementation. Ecosystem type, internal governance, intermediary organizations, land tenure, ratio of land area to officially recognized communal landowners, and previous experience of environmental degradation or conservation were emphasized across all three regions as critical factors influencing ICA dynamics and outcomes.

Ecosystem type determined the location of protected areas, costs and benefits of PES to communities, and the feasibility of CFM. Protected areas, particularly BRs, were generally established in highly biodiverse ecosystems. Payment amounts and eligibility for PES programs in Mexico also differed by ecosystem type. Ecosystem characteristics, particularly density and value of merchantable trees, also determined whether CFM was economically feasible. For example, clearcutting in temperate forests, even in the small tracts normal for CFM, is more cost-effective than the selective harvesting required in tropical forests where high species richness results in low density for most species (Merino-Perez, 2013).

The functionality of internal governance through collective decision-making, internal statutes, and territorial zoning determined the ability of communities to effectively manage PES, VPAs, and CFM on communally owned and managed lands. Interview participants in Campeche and Oaxaca noted that community organization was facilitated by smaller populations, ethnic and linguistic homogeneity, and strong kinship relationships, while respondents in Indigenous territories in Oaxaca also strongly emphasized traditional leadership hierarchies and community service.

The NGOs and other intermediaries played crucial roles in all three cases, supporting communities by interfacing with government agencies and providing access to technical support, personnel, and funding. Intermediaries provided technical consulting for both PES and CFM, as well as advising the certification of VPAs. We saw multiple examples of successful government-NGO-community collaborations, particularly around BRs. In the Monarch Reserve, NGOs partnered with government agencies to monitor changes in forest cover and enforce

environmental regulations. In both BRs, NGOs and intermediaries' associations provided staff and resources for programs when reserve budgets were constrained.

Strong land tenure rights were crucial for incentivizing investment in sustainable management practices, particularly when returns were delayed, as with CFM. Although ejidos and Indigenous communities in Mexico have relatively strong land tenure, land area to officially recognized communal landowner ratio affected the relative benefit from income-generating projects such as PES or CFM. Communities with a large land base and small population also earned relatively more per capita from PES. For example, one ejido in Campeche received the equivalent of MXN \$47,469 per community member over a 5-year contract, while another in Michoacán received only the equivalent of MXN \$401 (Supporting information Appendix S1). Communities used funds in a variety of ways, ranging from equal division among officially recognized members to investing in community projects or business ventures. We conjectured that collective uses of funds may lessen negative effects of low land area to officially recognized communal landowner ratios, as a more substantial investment into something with lasting, though shared, benefit may be preferred to meagre individual payments. For CFM communities also need a minimum land area, which varies by forest type, for sustainable timber harvests and to recoup the costs of timber authorization and extraction (Klooster & Masera, 2000; Merino Pérez, 1996).

Previous, direct experience with either forest conservation or degradation appeared to serve as strong motivator for adoption and acceptance of ICAs. Direct experience of forest degradation, such as by outside timber companies in Oaxaca or illegal logging in the Monarch Reserve, was a strong motivation for communities' decisions to conserve through VPAs, PES, or CFM. Community members frequently described the negative effects of deforestation in terms of increased temperatures and reduced water availability, which they linked with a decline in well-being and quality of life. Similarly, observing the positive effects of conservation through ICAs, such as during facilitated intercommunity visits, was mentioned as strong motivation for participation in PES and CFM.

Discussion

Our results revealed a greater number of synergies than trade-offs among interacting ICAs across the highly disparate social and environmental conditions of our three case studies (Table 5). Here, we compare our findings with previous research on ICAs.

While some authors conclude that PES in protected areas is not cost-effective due to perceived lack of additionality (Robalino et al., 2015) and may crowd out intrinsic conservation motives (Kerr et al., 2012;

Table 5. Potential synergistic and trade-off interactions among biosphere reserves (BRs), payments for ecosystem services (PES), voluntary protected areas (VPAs), and community forest management (CFM) based on three case studies in Mexico.

<i>Pair of approaches</i>	<i>Synergies</i>	<i>Trade-offs</i>
BRs & PES	<p>Overlaps in targeting criteria may make protected areas eligible for PES^a</p> <p>PES-enrolled lands may serve as ecological buffers around reserves.^a</p> <p>PES incentivizes conservation activities within and around reserves.^a</p> <p>Simultaneously allocating PES to affected communities can make the establishment of biosphere reserves acceptable.^a</p> <p>If reserves have name recognition, their ability to attract funds or tourists may benefit PES-funded products or services.^a</p> <p>Receiving PES can improve attitudes toward conservation within and around reserves.^a</p>	<p>Receiving PES may crowd out other motivations to conserve biosphere reserves.^a</p> <p>Unequal allocation of PES within and around reserves may exacerbate perceived inequalities among communities.^b</p>
VPAs & PES	<p>Communities can enroll their own protected areas into PES.^a</p> <p>If protected area certification incurs a cost, as in the case of Mexico's areas voluntarily destined for conservation (AVDCs), PES funds can cover these costs.^b</p> <p>If protected area certification provides access to PES markets, this may motivate communities to enact protected areas, as in the case of Mexico's AVDCs.^b</p> <p>Territorial zoning studies carried out as part of PES enrollment process can be used to decide if and where to establish VPAs.^a</p> <p>PES funds may be used to monitor or care for voluntary protected areas.^a</p>	<p>Some carbon offset PES may exclude voluntary protected areas due to lack of additionality.^b</p>
PES & CFM	<p>PES and CFM may be implemented simultaneously in different parts of communities' land.^a</p> <p>Communities may use PES to apply for certifications of their CFM products.^a</p> <p>PES activities may improve overall forest health, benefitting CFM.^a</p> <p>Former CFM areas can be enrolled in PES.^b</p> <p>PES rules may permit CFM activities such as small clear cuts and thinning.^a</p>	<p>PES rules may prohibit timber harvesting and other CFM activities.^b</p>
BRs & CFM	<p>CFM may be allowed in biosphere reserve buffer zones.^a</p> <p>If a well-protected reserve reduces illegal logging, CFM enterprises may benefit from reduced competition.^a</p> <p>CFM may provide an economic incentive for good forest management and conservation around reserves.^a</p>	<p>CFM is often prohibited in core zones and may be restricted in buffer zones.^b</p>
VPAs & CFM	<p>Protected areas may be designed to allow CFM in certain zones, as in the case of Mexico's AVDCs.^a</p> <p>Having a voluntary protected area may make communities eligible for certain forest product certifications, as in Mexico's AVDCs.^a</p> <p>Former CFM areas can be designated as voluntary protected areas.^b</p> <p>CFM and voluntary protected areas may occur simultaneously in different parts of communities' land.^a</p> <p>VPAs perceived as a refuge for wildlife temporarily displaced by CFM activities, as a baseline or control for monitoring^a CFM effects, and as a model for reforestation.^a</p> <p>Forestry rules may require an area to be set aside, which can be designated as a protected area.^b</p> <p>Voluntary protected areas may be perceived as reserves for potential future CFM.^b</p>	<p>Communities may prohibit CFM within their voluntary protected areas.^b</p>

^a Spatial interactions.^b Temporal interactions.

Lambin et al., 2014; Rode et al., 2015), we found that PES interactions with BRs and VPAs were largely positive. In the Monarch Reserve and the Calakmul Reserve, PES was credited with improving attitudes toward BRs and conservation, which supports the argument that wider PES implementation in protected areas would increase acceptance of land-use restrictions among their residents (Halffter, 2011) and suggests that interaction among these ICAs has the potential to benefit people and biodiversity. Statements by five participants that they would deforest if payments stopped may be evidence of motivation crowding out, but they could also be interpreted as demonstrating the critical value of PES in making protected areas socially and economically palatable. Because most protected areas in Mexico and many other countries are surrounded by degraded land (Fuller et al., 2006) and continue to be deforested (Balvanera & Cotler, 2009; CONABIO et al., 2007), avoiding further deforestation creates additional justification for PES within protected areas.

Mirroring the conclusions of reviews of CFM and PES in the tropics (Klooster & Masera, 2000; Wunder, 2006), we identified numerous opportunities for synergistic interactions. Our research indicated that although federal PES prohibited timber management in enrolled plots, PES-funded management activities (i.e., control of pests and diseases, fire, illegal logging, etc.) can benefit CFM by increasing overall forest functioning and reducing risk to harvestable stands. In some cases, funds from PES were also used to finance certification of forest products. We also found that CFM was uniquely compatible with PES for carbon offsets, particularly when certifying organizations permit management practices that also improve timber quality. These findings are consistent with previous studies that identified potential for CFM to lead to PES enrollment (Rasolofoson et al., 2015) and for carbon offsets to lead to CFM (Karky & Banskota, 2006).

Protected areas have traditionally excluded or limited timber harvesting, so studies of protected areas and CFM generally compare their effectiveness in preserving forest cover (Bray et al., 2008; Ellis & Porter-Bolland, 2008) rather than exploring current or potential interactions. Nonetheless, our results indicated multiple current and potential synergies between CFM and protected areas. Respondents in our study emphasized the potential for CFM to complement the conservation objectives of protected areas by providing income tied to the sustainable harvest of forest products. We also found that the intensive management of forest threats in CFM can reduce risk of wildfires and pest and disease outbreaks in adjacent protected areas. Communities and managers also viewed VPAs as refuges for biodiversity during timber harvesting.

As found previously (Nieratka et al., 2015; Pagdee et al., 2006), several social and environmental conditions at the site of ICA implementation seemed key to determining dynamics and enabling outcomes, in-

cluding ecosystem type, functionality of internal governance, presence and effectiveness of intermediary organizations, land tenure and the ratio of land area to officially recognized communal land owners, and previous experience with environmental degradation or conservation. It is vital to take these factors into account when determining the optimal combination of ICAs for any given location.

Based on our findings, and recognizing the value of CFM for long-term, landscape-scale biodiversity conservation, carbon sequestration and economic development (Klooster & Masera, 2000; Wunder, 2006), we see particular promise in more intentional integration of CFM with protected areas, such as BRs and VPAs, and some types of PES. Mexico's federal PES program had already taken steps toward increasing complementarity with CFM and other ICAs through revisions in program guidelines (DOF, 2017; CONAFOR, 2018b) that strongly encourage communities to invest PES funds in sustainable, productive activities. Community members and intermediaries perceived this as a very positive development, although intermediaries in the Calakmul Reserve raised concerns that they lacked training to support communities in projects such as ecotourism or value-added forest products. Still, potential for financial independence and long-term forest conservation makes interactions between PES and CFM particularly promising if intermediaries and communities can receive the training and support necessary for success (Cronkleton et al., 2012).

Our study brought to light novel perspectives on interactions among BRs, VPAs, PES, and CFM in three socially and ecologically distinct regions of Mexico. We found that community-level interactions among these ICAs were common in Mexico and were generally perceived as synergistic by government officials, intermediaries, and community members. Trade-offs also existed, but could be further minimized through careful policy design and implementation. Communities and conservation intermediaries already strategically implement spatial and temporal combinations of ICAs, but the involvement of policy makers is urgently required to maximize positive social and environmental outcomes at broader scales. We recommend more research on these interactions and a renewed attention to complementary policy design for ICAs to leverage synergistic interactions and maximize benefits for biodiversity conservation and local communities.

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Supporting Information

Appendix S1. Characteristics of sampled communities and intermediaries.

Table S1. Demographic and PES data for interviewed communities, as well as participation in integrated conservation approaches.

Table S2. Intermediary affiliations and experience.

Table S3. Names and hierarchy of the themes we identified and used to code our qualitative data, as well as the coding frequency for each theme. Data includes interviews, focus groups, and notes from presentations and other participant observations.

Appendix S2. Interview guide for implementers, intermediaries or promoters

Appendix S3. Interview guide for community representatives

Appendix S4. Hierarchy of themes used for coding interview data

Table S3. Names and hierarchy of the themes we identified and used to code our qualitative data, as well as the coding frequency for each theme.

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