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Ecological Sustainability within California's Improved Forest Management Carbon Offsets Program

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Ecological Sustainability within California’s Improved Forest Management Carbon Offsets Program

Cory Hertog

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A Master's Paper

Submitted to the faculty of Clark University, Worcester, Massachusetts, in partial fulfillment of the requirements for the degrees of Master of Science of Environmental Science and Policy in the department of International Development, Community, and Environment and a Master of Business Administration in the Graduate School of Management

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Abstract

Ecological Sustainability within California’s Improved Forest Management Carbon Offsets Program

Cory Hertog

Forest Carbon offsets are being used as a climate change mitigation strategy in multiple programs around the world. But, are programs setup in a way that are ecologically sustainable? This paper reviews concepts pertinent to ecologically sustainable forest management and then examines if Improved Forest Management Carbon offset policies and projects within the California emissions trading scheme are setup in an ecologically sustainable manner. After a review of the Improved Forest Management Protocol and 31 project documents, it is apparent that policies and projects promote aspects of ecologically sustainable management. However, there is room for improvement when managing for natural disturbance regimes and promoting connectivity of landscape. This review can be used to assist in the development of ecologically sustainable forest Carbon offset programs in the future.

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Introduction

Because of the increasing concern over climate change, and proposed solutions to mitigate it, environmental policy and programs have begun to use terrestrial carbon sinks that have the potential to sequester Greenhouse Gases (GHG) that would otherwise be remain in the earth’s atmosphere. In GHG reduction schemes, such as the cap-and-trade programs in Northeast United States, California, and Europe, a prominent mechanism for sequestering GHG emissions (and quantifying this sequestration) is through the use of terrestrial carbon sinks to generate Carbon offset credits (Bushnell, 2011; Wilman & Mahendrarajah, 2002). Carbon offset credits are defined as a “a reduction in GHG emissions (or an increase in carbon sequestration) by one individual or organization that can compensate for (or offset) emissions made by another individual or organization” (McKinley et al., 2011). A regulated entity within a cap-and-trade program that may not be able to reduce its emissions regulated quota it is allotted, as determined by the number of emissions allowances it is given, may purchase carbon offset credits from a non-regulated sector that will supplant the additional emission reductions necessary. Carbon offset credits can be created in many different forms, one of the most common being the biological sequestration of CO₂ in land use, land use change, and forest management (Ramseur, 2008).

However, there are potential concerns about the design of such biological sequestration offset policies and protocols. Carbon offsets are specifically designed to manage forests for climate change mitigation purposes, which is to sequester carbon to mitigate the effects of increased anthropogenic GHG emissions into the atmosphere. However, mitigation management objectives may be in conflict with adaptation management
objectives, such as the promotion of structural and compositional complexity, that would allow ecosystems to respond and adapt to uncertain future climate conditions. For example, managing to promote a fast-growing, monoculture forest structure may be the most effective management practice to increase Carbon sequestration, but may have adverse impacts on natural processes and ecological adaptation abilities. Understanding how mitigation and adaptation management strategies conflict will assist in the development of policies and protocols that balance both objectives, or at least minimize adverse impacts between objectives (D’Amato, Bradford, Fraver, & Palik, 2011). In another example, the incentive to maximize the number of trees in a given plot of land to sequester the largest amount of carbon may have adverse effects on potential landform and soil quality aspects of the area, as well as may affect natural disturbance regime processes (Galatowitsch, 2009; Madlener, Robledo, Muys, & Freja, 2006; Sims, Aadland, Finnoff, & Powell, 2013). Are offset programs designed in a way that will provide environmental co-benefits and ecological restorations that reflect the current state of scientific understanding? There is concern that public policy for carbon offsets has surpassed the scientific knowledge needed to support and ensure that not only these mechanisms create true carbon sequestration, but that they are also done in an environmentally sustainable way (Galatowitsch, 2009). Therefore, it is important to examine offset policies and protocols to understand if they promote ecologically sustainable practices. Defining ecologically sustainable forest management, and the concepts pertinent to it, is a first important step in understanding how offset policies relate to it. Then examining potential forest offset management strategies will further assist in understating how offset management practices are related to ecological sustainability.
Ecological Sustainability of Forest Ecosystems

Defining ecological sustainability, specifically within forest ecosystems, can be difficult. It should be noted that ecological sustainability in forest systems managed for economic purposes can be sharply distinguished from the concept of sustained yield, which focuses on the ability to maintain a certain level of resources to ensure continued economic viability of a forest. Ecological sustainability on the other hand can be used as a guiding principle to manage ecosystems that are economically exploited by minimizing the adverse impacts on a system's ecological integrity and not appreciably compromising the ecosystem's health (Callicott & Mumford, 1997). Ecological integrity refers to the historical species composition and structure of the biotic communities within that ecosystem (Angermeier & Karr, 1994). Ecosystem health on the other hand refers to the normal ecological processes and functions within an ecosystem, such as primary production, water purification, nutrient cycling, and soil stabilization (Callicott & Mumford, 1997). In order to achieve an ecologically sustainable future it will be necessary to use a combination of conserved, restored, and invented ecosystems using the breadth of scientific knowledge which may compromise aspects of ecological integrity, but not an ecosystem's health (Palmer et al., 2005). Sustainability of an ecosystem will generally mean placing a limit on its economic production potential and management practices, and should consider higher ecological system levels than the level of the area of interest (Fresco & Kroonenberg, 1992). Certain concepts are important to bear in mind when attempting to understand if a policy promotes ecologically sustainable management practices. Fonseca et al. (2009) outline six concepts for ecologically friendly management in Atlantic Forest ecosystems that can be applicable to many ecosystem types:
biogeographic suitability, landscape planning(connectivity), stand quality, stand-age, understory management, and species choice. Noss (1993) outlines sustainable forest management goals and concepts through the lens of impoverishment. Trajectories of impoverishment within a forest include young stand ages, simplified stands, smaller forest patches, and isolated patches. Management goals to reverse impoverishment, and thus be more sustainable, should include promotion of old-growth conditions, structurally complex stands, and larger and more connected forest patches (Noss, 1993).

**Resilience & Adaptation**

Due to uncertainty in future climate conditions, long-term ecological sustainability must consider the resilience and adaptive abilities of forest ecosystems. Resilience, as defined by Holling (1973) is the ability of an ecosystem to absorb pressures, such as disturbances, over a certain period of time and still return to its pre-disturbance state. Scheffer (2009) defined resilience in a similar fashion, however he emphasizes that it is the system’s ability to maintain similar functions and structures post-disturbance that makes it resilient. The concept of resilience must be examined in conjunction with the idea of a “tipping point” in which an ecosystem, because of a change or disturbance, leads to a large change in the state and functions of the system, thus having moved beyond the initial ecosystem characteristics (Brook, Ellis, Perring, Mackay, & Blomqvist, 2013; Reyer, Rammig, Brouwers, & Langerwisch, 2015). Promoting resilience is a primary way to manage forests to be adaptive in the face of uncertain future conditions (Millar, Stephenson, & Stephens, 2007).

The means for promoting adaptation are still in fluctuation and debated by forest managers. Forest conditions with higher levels of compositional, functional, and/or
structural complexity will better allow an ecosystem to adapt to changing conditions (D’Amato et al., 2011; Evans & Perschel, 2009; Malmsheimer et al., 2008; Puettmann, Coates, & Messier, 2012). However, this innately accepts the possible need for the management strategies to not adhere to the historic range of variability and previous ecosystem conditions. Therein lies a question as to what extent, and how should ecologically sustainable forest management strategies promote adaptability of forests? For example, if future climatic conditions are predicted to be more conducive to certain invasive or exotic species, should forest managers promote their presence? Another management option is to resist the influence of climate change on forest ecosystems. However, Millar et al. (2007) recommend that this management practice be applied only to forests with a high-value for a short term, as this is working against a natural, inevitable process. A more commonly suggested management strategy is to accommodate gradual change in a forest related to climate change, that still allows the forest to return to previous conditions after a disturbance. Managing forests to be more adaptive requires an emphasis on ecological processes (ecosystem health), and less so on structural and compositional aspects (ecological integrity) (Millar et al., 2007).

**Complexity and Diversity**

Since ecological sustainability is dependent on the perpetuation of ecosystem processes, it is still necessary to minimize the adverse effects on ecosystem integrity in any management practice. This means managing, at a landscape level, for a range and distribution of forest structures, species composition, and species diversity (Lindenmayer, Margules, & Botkin, 2000). When considering uncertain future climatic conditions, more diversity within a forest ecosystem can often be expected to increase its adaptability and
sustainability. The conservation of biological diversity is an important feature of ecologically sustainable forest management. However, depending on the scale, certain aspects of diversity may be more important. At a global scale, the end goal is to maximize species richness, but at a smaller scale, such as the landscape and stand levels of Carbon offset projects, quality of species may be more important (Noss, 1993). The concept of adaptability increasing with increasing levels of complexity and diversity also applies to a forest’s composition and forest processes and functions (D’Amato et al., 2011; Evans & Perschel, 2009; Malmsheimer et al., 2008; Puettmann et al., 2012). Structural complexity can be promoted by maintaining larger and older trees and logs, as well as a variety of over story and under story species within a forest stand (Lindenmayer et al., 2000). Regardless, when considering climate change mitigation goals for forest management in the face of future uncertainty, homogenous forest conditions should be avoided as this may make them more susceptible to unknown and large-scale disturbances such as insects, disease, and fire (Millar et al., 2007).

**Disturbance Regimes**

Natural disturbance regimes play a fundamental role in the structure and function of many forest ecosystems, and therefore, the ecological integrity of the ecosystem and ecosystem health (Moore et al., 2009; White & Jentsch, 2001). Disturbances also create spatial and structural heterogeneity, as well as support biotic diversity, which directly affects an ecosystem’s adaptive abilities (Christensen et al., 1989; White & Jentsch, 2001). Therefore, understanding the effects of natural disturbances on different ecosystems, and managing them based on current scientific understanding, is important for ecologically sustainable management (Nguon & Kulakowski, 2013). A general objective of forest
Carbon offset projects is to increase the amount of Carbon stored in either standing live wood, dead material, or both. However, increasing these attributes of a forest ecosystem may alter the severity, frequency, or extent of disturbance regimes. For example, it was noted that shifting management goals towards non-timber ecosystem services in Western North America had a direct effect on Mountain Pine Beetle (MPB)-induced mortality. A larger stock of homogenous susceptible host trees, many of which would have been removed in timber operations, are a requirement for an MPB outbreak, and may significantly amplify such an outbreak (J. D. Bailey & Tappeiner, 1998; Sims et al., 2013). Also, an increase in combustible fuel within a forest ecosystem that would coincide with Carbon offset project management goals would increase the ability for ground fires to transition into crown fires, thus affecting the behavior, outcome, and intensity of another natural disturbance regime (Sims et al., 2013; Van Wagner, 1977). Though natural disturbance regimes are a natural function within an ecosystem, differing management goals may alter these regimes, and thus alter aspects of ecosystem integrity and health. It is important to understand what the implications of certain management practices and objectives will have on these regimes.

**Fragmentation**

As noted previously, promoting connectivity of landscapes is an aspect of ecologically sustainable forest management (Fonseca et al., 2009; Noss, 1993). A more connected landscape allows the migration and exchange of seeds, pollen, and animals. This can promote migration of plants and animals, recolonization after timber harvests or disturbances, and increased retention of original vegetation in landscapes that are logged (Lindenmayer et al., 2000; Millar et al., 2007; Noss, 1991). Assessing whether a
management strategy promotes connectedness is an important aspect of assessing if the strategy promotes ecologically sustainable management practices.

**Environmental Co-Benefits**

It should also be emphasized that forests provide a plethora of other services that are not only linked to the sustainability of the forest itself, but affect external factors such as animal habitat, soil stabilization, and other ecosystem qualities. These aspects should be considered when assessing the ecological sustainability of certain forest offset practices (Englin & Callaway, 1995). It is obvious that the aforementioned themes of resilience, adaptation, diversity, disturbance regimes, and fragmentation directly affect habitat of other flora and fauna species, soil quality, and water quality. As mentioned previously, increased connectivity increases other species abilities to migrate and move (Lindenmayer et al., 2000; Millar et al., 2007). It has been shown that the offset practice of increasing forest growth to sequester more carbon may reduce stream flow and biodiversity (Ryan et al., 2010). The conservation of biodiversity of all types is considered a tenant of ecologically sustainable management (Fonseca et al., 2009; Lindenmayer et al., 2000). Many of these processes, specifically water quality and soil stabilization, directly affect ecosystem health, and are intertwined as external & internal factors that affect the ecological sustainability of certain management practices (Callicott & Mumford, 1997). Since ecosystems are not closed systems, and have resource inflows and outflows, it is important to consider how certain processes and populations are affected at differing hierarchical, and in different spatial regions of the same level, when assessing sustainability of a management practice (Burger et al., 2012; Fresco & Kroonenberg, 1992).
Management Options for Carbon Offsets

When discussing carbon offset management strategies for forest management projects, there are generally three strategies available for managers:

1. Decreasing carbon loss – This includes increasing the harvest rotation length, or decreasing harvest intensity
2. Increasing forest growth – This includes changing silvicultural practices and species composition to improve growth and regeneration rates
3. Thinning – This can be used to affect growth rate, as well as reduce the risk of Carbon loss from a fire disturbance (Ryan et al., 2010)

It should be noted that there are other forms of forest carbon offset practices, such as reforestation and afforestation, which this research did not focus on. The mentioned strategies apply to the GHG sequestration management options available to already established forests

Decreasing Carbon Loss

To decrease carbon loss on actively logged forest stands, forest managers can either lengthen periods between harvests, otherwise known as harvest rotations, or can decrease the intensity of the harvesting, i.e. harvest fewer trees. It is dependent on the type of ecosystem as to how this management approach may affect species diversity and structural composition. Decreasing harvests can increase diversity, but may also lead to simplification of composition, specifically in forests dominated by shade tolerant species,
where minimal canopy disturbance favors shade-tolerant species over others (D'Amato et al., 2011; Leak & Filip, 1977; Ryan et al., 2010). Regardless, forest ecology does suggest that the rotation length and harvest intensity will affect future growth and forest health, such as successional sequences, nutrient cycles, and other ecosystem functions (Erickson, Chapman, Fahey, & Christ, 1999). Increasing the length of rotation, or decreasing the harvest intensity, will effectively increase the stocking level of trees, as well as reduce the amount of dead biomass removed from a project area. This increased carbon sequestration may increase the intensity of natural disturbances such as fire or insect outbreaks, which may not only cause greater loss in Carbon stores, but may also increase ecosystem vulnerability to these disturbances. Therefore, there may be tradeoffs when managing forests for carbon sequestration objectives and ecological sustainability objectives (D'Amato et al., 2011; McKinley et al., 2011; Miller, Snyder, & Kilgore, 2012; Ryan et al., 2010).

**Increasing Forest Growth**

Increasing forest growth and regeneration rates can increase both carbon storage and wood production rates, which may be a viable management strategy for actively logged forests. However, this may incentivize managers to replace multispecies forests with monocultures, or to use faster growing exotic species rather than slower growing native species, which may be antithetical to ecologically sustainable forest management objectives. Increasing the growth rate of existing forests may have adverse impacts on stream flow and biodiversity within an area, and monocultures may make forests more vulnerable to rapid environmental change as well as large disease/insect disturbances. However, this may also provide an opportunity to promote the regeneration of more
adaptable species (McKinley et al., 2011; Ryan et al., 2010). This management strategy would coincide with a greater emphasis on ecosystem health and processes while possibly negatively impacting aspects of ecological integrity of certain ecosystems. An increase in forest growth may also create possible tradeoffs between carbon sequestration objectives and objectives to minimize vulnerability to disturbances that are also of concern when managing forests to decrease Carbon loss (D'Amato et al., 2011).

**Thinning**

Thinning is another forest management practice that may be used as a Carbon offset management practice but may create a tradeoff between adaptation and climate change mitigation goals (Bradford & D'Amato, 2012). Thinning involves the selective removal of certain trees to manipulate growth rate, tree size, form of trees, structure, and growth yield, and therefore will affect Carbon sequestration rates (Bradford & D'Amato, 2012; Churchill et al., 2013; Schaedel et al., 2017; Sjolte-Jørgensen, 1967; Tappeiner, Maguire, & Harrington, 2007). There are numerous different timings, methods, and procedures for forest thinnings, all of which have varying effects on adaptation and mitigation goals. Thinning from above, which is preferential for removal of the largest trees, has been shown to decrease Carbon storage in a forest stand in the short and long-term (Chatterjee, Vance, & Tinker, 2009; Harmon, Moreno, & Domingo, 2009; Hoover & Stout, 2007; Zhou, Zhao, Liu, & Oeding, 2013). Thinning from below, early in stand development, which is termed pre-commercial thinning (PCT), has shown inconsistent results in its effect on forest Carbon stores (Dwyer, Fensham, & Buckley, 2010; Hoover & Stout, 2007; Jiménez, Vega, Fernández, & Fonturbel, 2011; Schaedel et al., 2017; Skovsgaard, Stupak, & Vesterdal, 2006), though a recent study has indicated that it can
be used as an effective strategy to balance possibly conflicting climate change mitigation and adaptation management strategies for forest stands (Schaedel et al., 2017).

Performing thinning as a form of fuel reduction treatment can reduce the risk of a crown fire, and therefore reduce the intensity of such a disturbance and reduce the risk of loss of sequestered Carbon. However, there is debate about the Carbon benefit of such fuel treatments since trees are removed, and because these treatments can occur in areas with different fire regimes with varying risk of Carbon sequestration loss (McKinley et al., 2011). More traditional thinning techniques have been used to create structurally and compositionally uniform stands, which could possibly reduce its adaptive capacity. Generally, thinning methods that retain a large portion of mature trees are a more effective strategy for storing Carbon than methods associated with more intensive removals (D’Amato et al., 2011; Nyland, 2016).

Research Background & Methods

In 2013 California launched a cap-and-trade emissions reduction scheme. The cap-and-trade program, operated by the California Air Resources Board (CARB), mandated that companies within certain industries obtain emissions allowances, equal to one ton of carbon dioxide equivalent (CO₂e), equal to the GHG emissions emitted from their operations (Hsia-Kiung & Morehouse, 2015). Up to eight percent of each company’s emissions allowances can be substituted with Carbon offset credits regulated under the program. There are currently six different offset project types in the program, with US Forest project types having produced the most offset credits to date (CARB, 2017). US Forest Projects’ purpose are to “to quantify GHG emissions reductions & GHG removal enhancements associated with the sequestration of Carbon achieved by increasing and/or
conserving forest carbon stocks. There are three eligible project types in the US Forest Projects Offset Protocol (the Protocol): reforestation, avoided conversion, and improved forest management (IFM). IFM projects were the focus of this research and are defined by the CARB as “…Management activities that maintain or increase carbon stocks on forested land relative to baseline levels of carbon stocks…” (CARB, 2015).

This research examined if, how, and to what extent, climate change mitigation management goals (Carbon sequestration) and ecologically sustainable management goals were balanced within California IFM Carbon offset projects. The goal of the research was to answer the following questions:

1. Are protocols and policies in place that promote the ecologically sustainable management of IFM Carbon offset projects, and if so, what are they?
2. What management practices are IFM Carbon offset projects implementing, and are they ecologically sustainable?

There are approximately 35 IFM projects producing Carbon offsets credits, with more projects being developed that have not yet produced credits. California has just approved a continuation of its cap-and-trade program, of which these offsets are a part of, till 2030 (Mason & Megerian, July 17, 2017). Therefore, it is timely to examine this current offset program to determine if it is setup in an ecologically sustainable fashion, and how it could be set up to be more so. Also, with other cap-and-trade programs being considered nationally and globally, reviewing a current cap-and-trade scheme’s offset protocols and projects can serve as a guide of how to create an ecologically sustainable forest offset program.
A review of the Protocol, specifically pertaining to IFM policies within the document, was conducted to better understand what policies were in place, and if the program is setup in a way that promotes ecologically sustainable forest management practices. Then a review of 31 IFM project design and reporting documents (Appendix A) was performed to understand what management practices are being conducted within the projects that would affect the ecological sustainability of the ecosystem. These project documents were accessible at www.arb.ca.gov. The computer program NVivo was used to search for words and concepts within the project design documents that were deemed relevant to ecologically sustainable management from the literature review, as well as concepts that were mentioned in the Protocol itself (Appendix B). This word and concept search, a process inspired by research conducted by Nguon and Kulakowski (2013), pinpointed the areas in the project design documents that these management practices were mentioned, thus making the document review more efficient.

**IFM Protocol Analysis**

There are certain activities that are listed within the Protocol as eligible practices to increase Carbon stores within a forest:

1. Increasing overall age of the forest by increasing rotation ages;
2. Increasing the forest productivity by thinning diseased and suppressed trees;
3. Managing competing brush and short-lived forest species;
4. Increasing the stocking of trees on understocked areas;
5. Maintaining stocks at a high level
The activities are meant to be alternative management procedures conducted on the project site in contrast to what would be conducted in a baseline scenario. The baseline scenario describes the outcome of forest management practices if business were to continue as usual, and no altered practices occurred (CARB, 2015). Many of these eligible activities have been addressed within the scientific literature, as well their possible effects on climate change mitigation and adaptation goals.

Certain regulations within the Protocol attempt to address what D’Amato et al. (2011) refers to as the potential consequences of adhering to a single objective, such as managing forests for Carbon sequestration, which may ignore crucial ecosystem components that ensure long-term ecosystem functions.

**Natural Forest Management Criteria**

The Natural Forest Management (NFM) Criteria within the Protocol not only mandates that forest stands within the program must contain at least 95% native species, but also must maintain a certain level of compositional diversity within the project area. The appropriate native species are determined by what geographical Supersection the project is in, which is based on the ecological regions of the conterminous United States as defined by the US Forest Service (Appendix C). The Supersection also determines the Species Diversity Index (SDI) for the project site. No single tree species, as measured by percent of the total basal area within the project area, may exceed the percentage value defined by the SDI for that Supersection unless a government forestry agency can provide a written statement that the area does not naturally consist of a mixed species distribution.

Supersections and regions are defined by R. Bailey, Avers, King, and McNab (1994) and
McNab et al. (2007), while the SDI requirements are based on Forest Inventory Analysis Forest Types of the areas (CARB, 2015).

**Age Management/ Sustainable Management**

The NFM criteria within the Protocol also mandates that all projects be either certified under certain acceptable third-party certification programs (Sustainable Forestry Initiative, Forest Stewardship council, or the Tree Farm system), be managed under a renewable long-term contract that demonstrates sustainable forest harvesting levels, or that at least 40% of the project area be managed by uneven-age silviculture practices (CARB, 2015). The examination of third-party certification programs and long-term renewable contracts are outside the scope of this research, however, uneven-aged forest management was researched through the lens of sustainability. The Protocol (2015) defines uneven-age management as management that “leads to forest stand conditions where trees differ markedly in their ages, with trees of three or more distinct age classes either mixed or in small groups.” Forests under uneven-age management regimes also provide higher levels of habitat diversity for wildlife, resiliency to natural disturbance, watershed protection, and soil conservation (Schulte & Buongiorno, 1998).

**Dead Wood**

The NFM criteria also mandates that a certain amount of standing and lying dead wood per acre be present, or that the project must demonstrate progress towards this amount of dead wood. The amount is dependent upon if salvage harvesting has been conducted on the project area, but levels range from one to four metric tons of standing dead wood per acre. Areas that have conducted salvage logging need to work towards a higher amount or percentage of dead wood per acre to fulfill the Protocol requirements.
**Natural Disturbance Reversal Risk Rating**

Another economic incentive within the Protocol that may lead project operators to manage the project area in a manner that may affect disturbance regimes and ecological processes is the Natural Disturbance Reversal Risk Rating. Depending on the location of the project, a percentage is prescribed to the project based on how likely it is that a Carbon sequestration reversal will occur, which is an emittance of Carbon into the atmosphere after being sequestered in the forest stand. It is the percentage of offset credits generated by the project that must be placed in a CARB controlled reversal insurance fund. Project operators are not paid for the credits placed in this fund. Regarding forest fire risk mitigation, project operators can reduce the percentage of credits contributed to the fund by conducting certain fire risk mitigation procedures, such as thinning, that are approved by area fire agencies (CARB, 2015). If the project operator is incentivized to conduct these fire mitigation operations depends on Carbon credit prices, cost of mitigation operations, and the will of the project operator. However, if economic values line up, incentives to prevent fire regimes could occur, but the effects of such practices would be dependent upon the ecosystems they are conducted in.

**Project Documentation Analysis**

**Age-Management & Rotation**

16 of the project design documents mentioned that the project area was certified under one of the accepted third-party forest management certifications, or are in the process of attaining this certification, to fulfill the NFM criteria. Three project documents mentioned having a conservation easement that would prohibit, restrict, or guide harvesting of trees
on project lands to fulfill the requirements of the NFM criteria. Five project design
documents explicitly state that timber harvesting is not, and will not be allowed on the
property either because of an easement restriction, deed restriction, or due to a
management objective. Six project documents say that harvesting has not occurred since
the commencement of the project and that there is currently no immediate plan for
harvest. However, they do mention that even if they do not have plans, they may still
harvest in the future, but will do so under the NFM Criteria guidelines. 11 project design
documents state that harvesting is planned in the project area but will abide by the
harvesting, age-management, and rotation criteria set down by the Protocol.

**Biodiversity/Diversity**

Most of the diversity and biodiversity mentions within the project documentation pertained
to the SDI threshold requirements within the project area. 28 of the project design
documents state that their project areas met the SDI requirements set forth by the
Protocol at the commencement of the Carbon offset project. The SDI threshold
percentages, of which no single tree species (as measured by percent of the total basal
area within the project area) may exceed, ranged from 60-90% for the surveyed projects.
Therefore, the Protocol does not directly instigate change in the tree species diversity in
most of the surveyed projects, but it does hold the project area under a contractual
obligation to maintain such diversity standards. However, there were two projects that had
a single tree species above the SDI threshold, or within a stated statistical margin of error
of the threshold: Brosnan Forest Carbon Project (CAFR0087) and the Potlach Moro Big
Pine CE (CAFR0047). Interestingly, the single species that was above, or within the
statistical margin of error, was the Loblolly Pine, and these projects are located in the Southeast of the US.

Contiguity/Fragmentation

Within the Protocol itself there is no requirement that the land within the project area must be contiguous. There are restrictions dealing with contiguity of harvest areas that do limit fragmentation within that regard. However, because there are very few explicit requirements about contiguity within the Protocol, contiguity and fragmentation, and concepts related to them, are mentioned in a variety of ways if they are mentioned at all. In many of the project documents, maps were included of the project areas. 14 of the project design documents that have maps showed project areas that are made up of multiple non-contiguous land tracts (not considering roads and rivers that break up a continuous tract). Many of the tracts themselves seem to be fragmented in their own right because of natural elevation changes and shifting ecosystems that may be non-forest. Appendix D contains examples of different project area maps.

Most of the contiguity constraints for tracts within the projects tend to be based on legal requirements that were already in place prior to the offset project. For example, many of the projects located in California had contiguity constraints placed on them because they contain Northern Spotted Owl habitat, which is legally protected under certain habitat protection laws. There are similar constraints placed on project areas that contain Red Cockaded Woodpecker. For projects located in Maine, The Maine Forest Service Rule requires certain level of contiguous stocking land, and is a legal constraint placed on the project. However, all these requirements are in place prior to the offset project, and therefore the offset project does not change contiguity/fragmentation standards.
An interesting trend that was noted in multiple projects located in California was the increase of marijuana production as a pressure of increased fragmentation of forest stands in the project area, and therefore a possible baseline outcome of the project area if not for the IFM Carbon offset project.

One project’s document, the Downeast Lakes Land Trust, does explicitly mention the creation of wildlife corridors, and creating small stands of similar forest type, that are aggregated to facilitate the creation of larger, contiguous canopy layers. However, it does not mention if this action is a result of the offset project, or was a prior project area management objective.

**Disturbance**

The Protocol does state that “areas of significant disturbance may be excluded from sustainable management and age class distribution tests”, which does allow managers to let effects from disturbance regimes continue without Protocol regulations changing natural processes. Nearly every project design document mentions disturbance in the context of the Reversal Risk Ratings policy as described in the Protocol. 24 projects used the default percentage values for wildfire, disease/insect outbreak, and other catastrophic reversal risk ratings, which are 4%, 3%, and 3% respectively. Only three project documents’ explicitly mention performing any fire disturbance intensity mitigation practices, such as prescribed burns, or fuel treatments, which allow for a smaller reversal risk rating, and therefore, fewer credits submitted to the reversal buffer account. The Rips Redwood LLC project has a lower fire reversal risk rating because it was able to prove that the ecosystem of the project area was less vulnerable to reversal from fire than the average assumed risk. Salvage logging, the practice of logging after a disturbance is
permitted in multiple projects, which may have effects on post-disturbance processes. The project documents remain undescriptive about what these operations exactly entail.

**Environmental Services**

Other environmental services, such as water quality, soil quality, and animal habitat, are generally not explicitly addressed in the Protocol itself. However, it does mandate that all other legal constraints on the project area must be adhered to. Because of this, project documents mention abiding by certain environmental services constraints because of previous laws and regulations placed on the project area. Commonly mentioned regulations include the Clean Water Act, the Endangered Species Act, the California Porter-Cologne Water Quality Control Act, and other state specific forest practice rules depending on the state the project is located in. Habitat rules pertaining to regulations surrounding the Northern Spotted Owl in projects located in California and the Red Cockaded Woodpecker in the Southeast of the US are other legal constraints that were placed on project areas prior to the implementation of the offset project and must be followed if the projects are to continue.

Certain easements and sustainable forestry certifications, specifically the Forest Stewardship Council certification, require that silvicultural activities provide critical and diverse wildlife habitat. Certain easements placed on the land specifically require management objectives that improve water quality, soil quality, and wildlife habitat. Since some forest certification schemes and conservation easements were used to satisfy the NFM criteria, and were specifically placed upon the project area to satisfy this criterion, the Protocol does encourage other ecosystem services.
In a number of project documents, it is noted that state “Best Silviculture Management Practices” regarding water and soil quality are followed on the site. However, it is not a legal necessity for the project operator to follow these practices. Because of this, details of practices are generally not included within the project documents themselves, and no system of accountability for these practices is in place.

**Lying Dead Wood**

21 project documents explicitly state that the project areas meet the requirements of the dead wood per acre requirements within the NFM criteria of the Protocol. Eight projects explicitly state the project area does not meet the requirements for dead wood outlined in the Protocol. A common way to increase standing and lying dead wood within the project areas that do not meet the requirement is the passive management policy to not remove any of it during harvesting activities, and simply let it accumulate over time. It is also mentioned in multiple project documents that tree tops will be left after harvest to assist in increasing dead wood. However, besides this, there is very little mention of any active approaches to increasing or maintaining dead wood. Projects must demonstrate that they maintain the required amount of dead wood per acre for the life of the project.

**Native Species**

All documents for the 31 projects surveyed state that they met the Native Species requirement of the NCM criteria at the implementation date of the project. Percentage of Native Species are stated as composing between 97.7% to 100% of the tree species in the project area. Though this Protocol did not instigate immediate changes to forest species composition in the project area, it does hold these project areas under an obligation to ensure that it maintain the required number of native species.


**Thinning**

There was a wide variety of thinning treatments described within the project documents that may be used within the project areas. In six of the documents the term “Commercial Thinning” is mentioned as a possible thinning technique used. It is defined in the documents as “The removal of trees in a young-growth stand to maintain or increase average stand diameter of the residual crop trees, promote growth, and/or improve forest health.” These documents, as well as many others, discuss thinning techniques in how they will be used in conjunction with harvesting. Another common type of thinning mentioned in the documents in conjunction with harvesting is that of pre-commercial thinning. However, thinning was explicitly mentioned in only three of the project documents in the context of improving habitat or to assist the development of uneven-aged forest stands.

**Discussion and Policy Suggestions**

It is apparent that the Protocol, and consequently, the project documents, consider other management objectives in addition to climate change mitigation objectives. The aspects of the NCM criteria are the most explicit portion of the Protocol that addresses the possible tradeoffs that may occur between climate change mitigation and forest adaptation management objectives. It ensures that some form of species diversity, native species composition, and compositional complexity is created, or at least maintained, within the project area. The uneven-age management requirements within the NCM criteria are an especially pertinent management strategy to balance both objectives, as uneven-age forestry practices are a way to achieve a compromise of maintaining critical stand level
complexity elements while still achieving Carbon sequestration goals (D’Amato et al., 2011).

The Protocol explicitly states that areas of significant disturbance may be removed from sustainable management requirements, which does allow for natural disturbance processes to occur without interference from forest managers. However, the Protocol does not have strong guidelines for managing natural disturbance regimes in balance with mitigation objectives. The guidelines that do pertain to natural disturbance mostly relate to the Reversal Risk Rating portion of the Protocol, which deals with Carbon offset banking and mitigating the risk posed by reversal from a disturbance. Natural disturbances are so central to basic ecological functions and affect the existence of certain species or communities that it is important to explicitly consider regimes in management goals that promote restoration or conservation (Baker, 1992; Nguon & Kulakowski, 2013; Swetnam, Allen, & Betancourt, 1999). In this sense, the guidelines for managing for natural disturbance in the Protocol could be stronger to ensure that Carbon sequestration management strategies truly incorporate natural disturbance regimes (Galatowitsch, 2009). Also, a very small number of the reviewed projects (3) said they had implemented fire mitigation management strategies, which demonstrates that the Protocol’s Reversal Risk Rating does not generally incentivize forest managers to implement these strategies. Nevertheless, for the development of future projects, it would be important to include policies that incentivize fire mitigation practices that don’t interrupt natural disturbance processes or natural structures, which is not currently a part of the Protocol. It should also be noted that climate change may be shifting the intensity, timing, and frequency of natural disturbances. Of particular concern, models suggest the potential for an increase
in fire intensity and a 25% to 50% increase in area burned from wildfires in the US because of climate change (Dale et al., 2001). The program must consider the higher risk and uncertainty of natural disturbance events when incorporating policies related to natural disturbances within the program. Potential future research may involve examining these percentages used and if they are related to shifting disturbance regimes.

Other environmental considerations, such as water quality, soil quality, and fauna habitat and population concerns are generally not explicitly stated within the Protocol, though other aspects of the Protocol, such as the NCM criteria, will implicitly affect these sustainable management considerations. However, as demonstrated within the project documents, other policies and laws require certain management practices that explicitly consider these aspects of sustainable management. It therefore may not be necessary for the Protocol to outline requirements for these aspects. Regardless, the Protocol does require that projects meet all legal requirements within the project area. Therefore, the Protocol requirements add another level of motivation for project operators to manage these areas for these environmental considerations. This assumes the legal requirements are based on current ecological understanding and that they directly and comprehensively consider other environmental benefits such as biodiversity, nutrient cycling, and watershed protection, which is necessary for sustainable management (McKinley et al., 2011). Public Policy has generally outpaced ecological understanding, and the need for a toolset for better understanding environmental impact, such as the ability to better monitor soil carbon and what may affect this, is necessary for a more complete understanding of the outcomes of these policies (Galatowitsch, 2009).
Another area that may allow for improvement within the Protocol and the resulting projects is in the promotion of more connected landscapes which is an aspect of ecologically sustainable forest management noted by numerous authors (Fonseca et al., 2009; Noss, 1993). Currently, connected landscapes within the offset program are promoted through previous legal constraints that projects must abide by, as well as certain age management connectivity requirements (CARB, 2015). As noted in the research, nearly half of the project areas were made up of multiple, non-contiguous tracts, which leaves room for improvement within the Protocol in that regard.

As demonstrated within the project document review, though the Protocol does not create immediate changes in forest structure, it does require many project areas to be managed with sustainable management goals. Many of the project areas met the NCM requirements prior to their implementation. This suggests that forest areas that generally meet these requirements are the areas that are sought out to be developed as projects to ensure the lowest costs for the project as possible. However, one of the most immediate changes to management actions the Protocol creates is the amount of dead wood within project areas, as many of the projects did not satisfy these requirements, and because of this policy, dead wood within these areas will generally increase, which is one aspect of what Noss (1993) refers to as promoting old-growth conditions as an aspect of ecologically sustainable management.

A majority of the projects reviewed stated that a forest certification program or conservation easement would be used to ensure “sustainable” harvest practices. The examination of the policies and protocols of these programs was outside the scope of this project. This places management directives under the jurisdiction of third-party actors, and
the review and examination of these programs is a possible next step to further understand if, and how, these project areas are sustainably managed.

Millar et al. (2007) emphasizes the importance of basing decisions on sustaining ecological processes rather than structure and composition when managing forests for adaptability in an uncertain climatic future. Many of the policies within the Protocol strictly regulate structural and compositional aspects of project areas, and certain processes like nutrient and water cycles, are not explicitly addressed within the Protocol’s policies. Though many of the structural and compositional goals may implicitly affect these processes, the Protocol could be changed to focus more on maintaining ecological processes in order to create more ecologically sustainable forest systems.

**Conclusion**

It is apparent through this research that the Protocol and the associated reviewed IFM projects go beyond simply managing for the single objective of climate change mitigation that may lead to the exclusion of other forest management objectives, such as adaptation, resiliency, and sustainability (D’Amato et al., 2011). The Protocol and projects do support other environmental co-benefits, which is necessary for sustainable ecological restoration (Galatowitsch, 2009). However, there is still room for improvement within the Protocol to address other ecologically sustainable forest management objectives, including better alignment of objectives with natural disturbance regimes and the promotion of more connected landscapes. This research could be used to assist future development of other offset protocols, which may become more prevalent with the development of more GHG emissions cap-and-trade programs. The Protocol and IFM projects demonstrate how
Carbon offset programs can balance the possible conflicting objectives of climate change mitigation and ecologically sustainable management. Though there is room for improvement, the Protocol mandates that certain criteria that promote ecologically sustainable management are met for the project areas. Laying baseline policies in place ensures that managing forests for mitigation objectives does not completely eclipse the necessity to manage them sustainably. Other regions and countries of the world are discussing the development of Carbon offset programs and a review of California’s system can demonstrate how these mechanisms can be setup in a way that promote ecologically sustainable management, as well as how they can improve upon California’s program to incorporate ecologically sustainable management practices even more.
List of References


### Appendix A: Project Documents Reviewed

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Document Name</th>
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** OPDR – Offset Project Data Report  
** PDD – Project Design Document
### Appendix B: Words and Phrases NVivo Search

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<tr>
<th>Concepts</th>
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<tr>
<td><strong>Age-Management &amp; Rotation Length</strong></td>
<td>even-aged, uneven-aged, &quot;clear cut&quot;, &quot;seed tree&quot;, cutting, harvest, rotation, &quot;cutting cycle&quot;, shelterwood, harvesting, &quot;selection harvesting&quot;</td>
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<td><strong>Biodiversity/Diversity</strong></td>
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<td><strong>Contiguity</strong></td>
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<td><strong>Lying Dead Wood</strong></td>
<td>&quot;lying dead wood&quot;, &quot;coarse woody debris&quot;, LDW, CWD, logs, snags</td>
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<td>&quot;native species&quot;, &quot;natural species&quot;, &quot;exotic species&quot;, endogenous, &quot;invasive species&quot;</td>
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<td><strong>Thinning</strong></td>
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Appendix C: Map of U.S. Supersections
Appendix D: Example Project Maps

Figure 1. Hanes Ranch Project Area Map (CAFR5012), Created by NewForests: Forest Carbon Partners
Figure 2. Usal Redwood Forest Project Map (CAFR0123), Created by James D. Clark, North Coast Resource Management
Figure 3: MWF Brimstone Project Area Map (CAFR5130), Created by FintieCarbon