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KEY TERMS

Aggregated Land: this refers to land that is owned or operated by different people or organizations but has been pooled together for business or logistical reasons
Afforestation: planting, growing, and developing forest cover in an area that was not previously a forest
Avoided Conversion: protecting forests with a high likelihood of tree loss (usually from land-use change to agriculture, industry or other development) by dedicating the land to continuous forest cover
Biomass: organic matter that comes from plants or animals and is a renewable resource
Cap: in regards to carbon markets, a cap is the regulated threshold below which an industry or market must emit
Carbon Dioxide Equivalent: these term is used to measure and quantify all the greenhouse gases into one metric, each greenhouse gas is given a different weight (global warming potential) and an amount to find the final number of carbon dioxide equivalent
Carbon Inventory: a quantitative analysis and report on the amount of carbon in a specific parcel of land, forest, or area
Carbon Offset: a reduction in greenhouse gas emission through a number of different project types. These projects are typically to reduce the emissions into the atmosphere without reducing production or consumption
Carbon Stock: the amount of carbon that is currently stored in a forest, ecosystem, soil, or other biomass
Conservation Easement: a voluntary legal agreement between a landowner and a land trust (in this case, VLT) that permanently limits the uses of the land for conservation reasons (the terms of the easement will vary and can disallow different activities)
Credit: carbon offset projects produce a specific number of credits which are associated with the amount of reduction in GHG emissions. These are buyable and tradable
Emissions Allowance/Permits: in a carbon market, emitters are given allowances or permits to emit a specific amount of GHGs. These allowances or permits are tradable and buyable across the market
Forest Inventory: quantifying the data and information about a forest land including: how many trees, age, type, health, etc.
Forest Stock: this refers specifically to the carbon stock within the forest as a whole
Greenhouse Gases: these are the different gas that contribute to the greenhouse effect and to global warming. They include: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride
Improved Forest Management: a forestry management strategy which betters the health and quality of the land and forest. This is usually done for carbon reduction and conservation reasons

Leakage: unanticipated change in GHG benefits outside of the projects accounting boundary as a result of project activities
Reforestation: the reestablishment or regrowing forests cover in a parcel that used to be forest
Sequester: the long-term storage of carbon in effort to mitigate global warming and climate change
Strata: the grouping of forest segments or layers based on specific attributes or characteristics, in order to streamline inventory processes

ABBREVIATIONS

AB 32: Assembly Bill 32 (Global Warming Solutions Act of 2006)
ACR: American Carbon Registry
BAU: business as usual
CA: California
CAR: Climate Action Reserve
CARB: California Air Resources Board
CDM: Clean Development Mechanism
CH_4: Methane
CO_2: Carbon Dioxide
CORSIA: Carbon Offset and Reduction Scheme for International Aviation
EPRI: Electric Power Research Institute
EU ETS: European Union Emissions Trading System
FSC: Forest Stewardship Council
FTE: full time equivalent
GHG: Greenhouse Gases
GISL: Geographic Information Systems
GMBM: Global Market Based Measure
Gt: Gigaton
HFCs: Hydrofluorocarbons
ICAO: International Civil Aviation Organization
IFM: Improved Forest Management
JI: Joint Implementation
LDCs: Least Developed Countries
N_2O: Nitrous Oxide
NF_3: Nitrogen Trifluoride
ODS: Ozone Depleting Substances
OPR: offset project registries
PDD: project design document
PFCs: Perfluorocarbons
REDD+: Reducing Emissions from Deforestation and Forest Degradation
RGGI: Regional Greenhouse Gas Initiative
SET: Small Emitters Tool
SF_6: Sulfur hexafluoride
SIDS: Small Island Developing States
SIG: Spatial Informatics Group
tCO_2e: 1 metric ton of CO_2-equivalent
USDA: United States Department of Agriculture
UVM: University of Vermont
VCR: Verified Carbon Standard
VCS: Verified Carbon Standard
VLT: Vermont Land Trust

ABSTRACT

The following study analyzes the potential for Vermont projects in the forestry carbon offset division through California's AB 32 program. This focus was determined by the Vermont Land Trust and Lyme Timber to address their shared interest in achieving permanent conservation of working forests and examining the viability of forest carbon offsets. Included in the study is an analysis of financial information regarding the AB 32 market, an analysis existing approved projects, and a financial model to determine the threshold for a viable project. A business plan is provided to suggest ways to make aggregated projects in Vermont potentially viable. The type of forest carbon offset projects would be improved forest management. Due to parcelization in Vermont, an aggregation scheme is necessary where parcels of land are listed under one owner to enhance financial viability. The capstone team developed this study through existing literature research and interviews with industry professionals.

BACKGROUND

VERMONT FOREST INDUSTRY: ACREAGE, STAKEHOLDERS, FOREST LAND USE, FINANCIAL VALUE

LAND USE & FOREST

The Vermont forest serves as a source of natural beauty, a natural resource, and adds financial value to the state economy. For Vermont residents, the forest provides enjoyment through recreational activities, employment, and a successful tourism industry. Recreational activities include outdoor sports, such as fishing or skiing, as well as hiking and camping.

Approximately 78% of the state of Vermont has forest cover, totaling over 4.46 million acres. Since 2010 there has been a gradual decline in forest land in Vermont, with a 1.5% decrease in forested land (United States Department of Agriculture 2015). The majority of land in Vermont is owned by private entities such as families, individuals, or corporations; 80% to private owners, 19% to state, local, and federal government, and 1% owned by the timber industry (Vermont Woodlands Association).

Prominent tree species include maples, beech, and birch trees which cover 71% of the forest land and softwood forest trees comprised of pine, spruce and fir trees. Softwood forests of white pine and oak/pine are primarily owned by private entities (Vermont Woodlands Association).

Forests are important ecological resources in their provision of habitat for a diverse range of species as well as the vast array of ecosystem services for which they are responsible, including clean air and water quality improvement. Forests reduce the impacts of climate change by offering protection from extreme weather events, such as floods and strong wind, stabilizing outbreaks of pests and diseases , as well as offsetting greenhouse gas emissions through carbon sequestration. The ecosystem services that Vermont's forests provide are: provisioning services, regulating services, supporting services, and cultural services (Vermont Agency of Natural Resources).

Although there is currently little development pressure on Vermont's forests, it is important to consider various ways to ensure that they do not get developed in the future - in particular, if global warming causes an influx of 'climate refugees' leaving warmer climates to settle in Vermont. Other than conservation easements, carbon offsets are another way to provide this assurance.

FINANCIAL VALUE OF VERMONT FOREST

The Vermont forests are also economically valuable. Overall, the forest-based economy contributes approximately $33 billion in Maine, New Hampshire, New York, and Vermont annually (NEFA 2013). In 2012, Vermont's forest industry contributed $3.4 billion to the state's economy through commercial activities including sugaring and timber harvesting, as well as sustaining about 20,000 jobs. In addition to these figures, ecosystem services provided by the Vermont forests are less easily quantified, but are very valuable in mitigating the impacts of climate change.

STAKEHOLDERS

Stakeholders that are relevant to implementing carbon offset projects can be broken down into four categories: government, community, organizations, and forest industries. A successful carbon offset project requires the input of many groups ranging from legislation, landowners, and organizations whose focus is conservation, such as the Vermont Land Trust. A key element of the social organizations are the Regional Partnerships in Vermont. Partnerships allow the combination of resources such as funding and data from large organizations with the community outreach and comprehensive forest management knowledge of grassroots organizations.

The interaction of various stakeholders in Vermont to bring about forest carbon offset projects was analyzed in White's thesis paper which surveyed 233 private forest landowners and estimated how different features of a carbon credit program would affect their willingness to be part of it (White 2017). White found that depending on the features of a program, 14.5%-60% of landowners would be willing to accept it (2017). In particular, having a non-profit organization instead of a for-profit company implement the program would increase the likelihood of it being taken up by landowners by 45%-

points, and would also make the landowners willing to accept less carbon revenue in compensation (2017). This suggests that social and grassroots organizations, including the Vermont Land Trust, would be well-placed to bring about such projects.

FOREST CARBON OFFSETS

THE SCIENCE OF FOREST CARBON

Carbon dioxide contributes significantly towards the Greenhouse Gas Effect, whereby CO_2 molecules prevent solar radiation from escaping the earth's atmosphere, resulting in a cumulative warming effect (Ryan *et al.,* 2010). Anthropogenic carbon emissions have been rising continually since the Industrial Revolution, 30% of which is attributed to land-use change including deforestation and forest degradation activities. Carbon stocks, or pools, refer to the amount of carbon stored in a particular place, whilst carbon fluxes, or flows, refer to the transfer of carbon between these stocks. The atmosphere is one of the smallest carbon stocks when compared to oceanic and geological carbon. Thus this increase in carbon emissions has led to a net addition of carbon to the atmosphere - the main driver of climate change (USDA Forest Service, 2017).

Forests sequester carbon in live trees and dead wood, forest litter, and soil. Forests account for 92% of global terrestrial biomass, with a combined carbon stock of over 400 Gt of carbon, and play an active role in regulating atmospheric CO_2 through their role in the carbon cycle (USDA Forest Service, 2017). Similarly, it is estimated that forests are responsible for offsetting 12-19% of fossil fuel emissions in the United States (Ryan *et al.,* 2010). Stored carbon, as well as gains and losses, change throughout the life cycle of the forest. These will vary based on region, climatic conditions, forest age and forest type, and result in varying ratios of carbon stored above- and below-ground (USDA Forest Service, 2017).

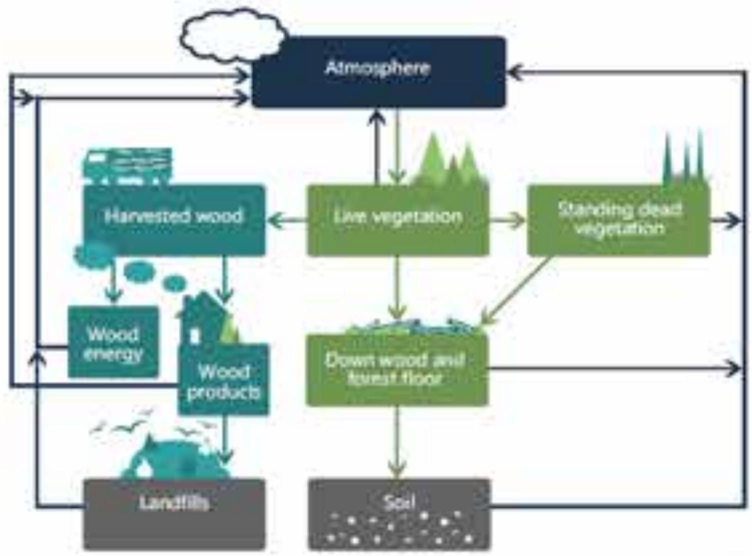


Figure 7: The forest sector carbon cycle includes forest carbon stocks and carbon transfer between stocks. Adapted from Heath et al. (2003) and USDA (2011).

Graphic Link: [*https://www.fs.usda.gov/ccrc/topics/forest-mgmt-carbon-benefits*](https://www.fs.usda.gov/ccrc/topics/forest-mgmt-carbon-benefits)

The primary flux of CO_2 from atmospheric to terrestrial carbon stocks is through photosynthesis. In photosynthesis, plants' leaves capture incoming solar energy, which is used to convert CO_2 and H_2O into carbohydrates (sugars) and O_2, to provide the plant with energy to grow. Reciprocally, carbon can be released from forests back to the atmosphere through plant respiration, combustion of biomass, and litter decomposition (USDA Forest Service, 2017). These processes result in a net removal of CO_2 from the atmosphere. Disturbances such as insects and big storms can lead to tree loss, and consequently microbes will decompose the dead matter and release CO_2 back into the atmosphere, although some CO_2 remains trapped in the decomposing biomass. Forest fires or burning wood for fuel release a large amount of CO_2, but similarly leave some stored in dead trees and soil. Harvesting trees also removes carbon from the forest, although some will remain stored in wood products (Ryan *et al.,* 2010).

Disturbances also vary regionally and seasonally, and only some are within human control. After any disturbance, a forest will naturally return to a neutral carbon cycle, or equilibrium, over a long enough recovery period. However, more frequent disturbances result in a net decrease in stored forest carbon (Ryan *et al.,* 2010). The regional and characteristic differences between forests mean that all of the processes occur at different rates, and different opportunities exist to manage each forest to either decrease carbon loss or increase carbon sequestration.

THE BENEFITS OF FOREST CARBON OFFSETS

Carbon offsets offer the opportunity for landowners to earn financial compensation for their efforts in increasing carbon sequestration and reducing emissions. Offsets, as such, are an intangible carbon sequestration asset class, and rely on the principle that emitters can reduce GHG levels in the atmosphere beyond the reduction of their fossil fuel based emissions.

The private forestlands of the Northeastern United States provide numerous benefits beyond the primary economic revenue of the timber and sugaring industries, through recreational value, open space, clean water, flood control and habitat for wildlife (Brooke, 2009). However, these co-benefits are increasingly under threat, and thus carbon offset projects have the potential to preserve and create additional benefits in the form of employment, biodiversity protection, water security, climate change resilience, and land tenure clarification, among other positive outcomes (Goldstein & Franziska 2016). Keeping the "forests as forests" is beneficial to increasing ecosystem health and productivity. It is estimated that 88% of current carbon projects cover prioritized vulnerable habitats in the United States, providing additional benefits over and above the carbon sequestration and storage (Jenkins *et al.* 2014).

Through carbon offset projects, urban forests and ecosystems can also be used and improved and create a better community environment for the urban communities, who need it most for recreation, and other ecosystem services leading to increased public health. Universities such as Duke have been instrumental in getting these urban offset projects started (Duke University). Forests maintain higher water quality through decreasing water pollution and degradation, whilst also stabilizing sediment and soil structures to prevent soil erosion and siltation of rivers and lakes. Sustainable forest management can also help to reduce the threat of forest fires which are damaging to ecosystems and are a threat to public safety and property. Communicating these co-benefits effectively can enhance public support and awareness for forest conservation.

MARKET ANALYSIS FOR CALIFORNIA

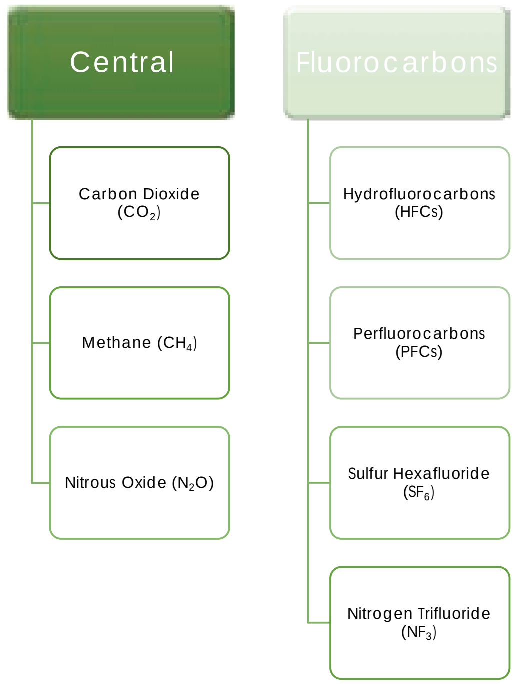
AB 32: HISTORY AND RELEVANCE TO FOREST CARBON

CALIFORNIA CARBON MARKET - HOW DOES THE CAP AND TRADE WORK

The state of California implemented the cap and trade program in 2006 as a market-based mechanism to lower greenhouse gas emissions. The cap-and-trade program sets an amount of greenhouse gas emissions for emitters and creates tradeable allowances so the reduction target can be achieved. Emissions allowances are based on a compliance period which will decrease over time (California Air Resources Board, 2014).

Assembly Bill 32 is a California State Law, also known as the Global Warming Solutions Act of 2006, which establishes a comprehensive set of programs to reduce climate change-causing greenhouse gases. AB 32 is managed by the California Air Resources Board (CARB) who has created market mechanisms to reduce greenhouse gas emissions to 1990 levels by 2020 (a 15% reduction from the BAU emissions projection), and ultimately an 80% reduction by 2050. The cap and trade program was launched in 2012 is one of the main mechanisms of the legislation. This carbon trading scheme allows emitters to purchase or sell carbon credits depending on their emission levels and the comparative abatement costs. Approximately 85% of California's total GHG emissions are now covered under the cap and trade system, and a fine system (set at a much higher price than the cost of purchasing offsets) is used to incentivize this method of compliance to the emissions "Cap". Auctions are held quarterly for emitters to buy and sell credits and since the auctions began, they have raised more than $4 billion for California to fund environmental projects and other climate change reduction strategies. There is a strong enforcement mechanism in place which requires an emitter to submit four times their obligation if they are late in buying or submitting allowances for their level of emissions. Additionally, they could be fined $25,000 (California Air Resources Board, 2014).

The greenhouse gases covered by AB 32 are:



Currently, entities covered by the cap and trade program are allowed to offset 8% of their total emissions using compliance carbon offsets. The first offsets were issued in 2013 and this is a relatively new program under AB 32. Offsets currently come in a variety of forms, including:

- Ozone Depleting Substances (ODS)
- Livestock
- Forests
- Mine Methane Capture

Forest-based projects currently comprise the majority of issued compliance carbon offsets, with approximately 43 million offsets credits issued. Offsets are generated based on the difference between the baseline scenario (i.e. the potential management practice without an offset project) and the project scenario (i.e. with offset project implementation) (Kerchner & Keeton, 2015). There are three main types of forest carbon offset projects under AB 32, based on the method through which increased carbon sequestration will be achieved:

1. Reforestation/Afforestation- This protocol applies to forest offset projects that either create new forest cover or re-establish forest cover on previously forested land.
2. Improved Forest Management (IFM) - The most common project type, and the chosen method of carbon offset development for this study. This protocol applies to forest offset projects which involve management activities that maintain or increase carbon stocks on forested land relative to baseline levels of carbon stocks. Improved Forest Management can be achieved through a number of strategies, described later.
3. Avoided Conversion- This protocol applies to forest offset projects that involve protecting forests with a demonstrably high likelihood of tree loss (usually from land-use change to agriculture, industry or other development) by dedicating the land to continuous forest cover through a qualified conservation easement or transfer to public ownership, excluding transfer to federal ownership.

There are a number of different requirements for each forest project type:

- Real - the offset is real and the project will physically sequester the amount specified, which is proven through transparent processes and documentation
- Permanent - the project will sequester the allotted amount of carbon in perpetuity, under AB 32, this is for at least for a 100-year time frame. This is done to ensure the longevity of the carbon storage and to reduce any stressors or impacts on the forest health. Carbon is only *stored* in the forest, the carbon is not gone. If a tree was to be cut down and removed or die and decompose, the carbon will be released and the result will be a loss of stored carbon. Consequently, each project is required to have a buffer pool of forest carbon which can be used in the case of this loss in carbon.
- Quantifiable - the amount of carbon sequestered can be counted and has metrics that can be attributed to it
- Verifiable - the offset project can be verified and validated by a third party and considered a project under the guidance of ARB
- Enforceable - a carbon offset project must be enforced by an independent third party who sets the rules, regulations, and requirements that each projects must abide by. AB 32 allows the CARB to be that institution who oversees this all.
- Additional - each project is verified by a third party and then registered for carbon credits. This will allow the project to receive money for the credits, but only to receive money from one party for each credit. The credits cannot be cross-sold. The projects has to be additional or a surplus to the baseline of carbon sequestration. The question to ponder is: would this reduction have occurred under a BAU-case? The project has to be sequestering additional carbon above what is normally sequestered, through one of the three methods described above: reforestation/afforestation, improved forest management, or avoided conversion.

- Baseline - For Improved Forest Management projects, this is defined as 'Common Practice'. There are specific requirements for measuring the baseline for both public lands and private lands. It is important for projects to have a create baseline measurement as this is used to quantify the total credits issued from year 0 to year 1.
- Buffer Pool - each project is required to submit a portion of the project credits to an ARB-managed forest buffer account which acts as insurance against any damage to a forest which would reduce its carbon levels such as a forest fire or pest infestations. The amount of credits each project must submit is calculated using a risk rating which takes into account the owner's finances, the forest's risk of forest fire, disease, illegal harvesting and other catastrophic events.

CALIFORNIA OVERALL MARKET SIZE - DEMAND & SUPPLY

The California Cap and Trade system requires businesses that emit more than 25,000 tons of GHGs each year to submit a permit, allowance, or offsets for every ton of GHG pollution they emit. In order to create an effective market system, the government of California issues a limited amount of allowances yearly, creating a cap on emissions. This system enables the creation of demand for credits.

This compliance market enforces the reduction in GHG pollution playing a major role in the carbon pricing creating demand with enforcing caps and carbon floor pricing. In regulating the demand and supply California is ensuring the longevity of the cap and trade compliance market in the state. The price floor can be adjusted to the supply and demand as well as any policy changes passed during the regulation's lifetime.

PROJECTIONS FOR CARBON PRICING

As mentioned previously, carbon prices in the AB 32 offset market have experienced fluctuation. Although it is difficult to predict the exact future pricing of offsets, there are mechanisms in place to limit extreme price differences. The price floor and holding limit ensure that prices do not drop too low. In addition, an allowance price containment reserve is an auction of credits that are kept at stable prices. The reserve addresses the possibility that low supply of credits will drive up the prices and controls the price ceiling. Additional regulation declares that if credits are not sold for two consecutive auctions, that only 25% of total credit allowance will be permitted back into the market. If the unsold amount is greater than 25%, the credits are put into the Reserve and no longer available for purchase through the voluntary market (CARB, 2016).

Trends to date show that a very small proportion of the credits were actually purchased in the past few auctions. In February 2016, about 95% of allowances sold while only 11% sold in May, and 35% in August. It is not expected to create long term issues in the market because the compliance period is not annual. The aforementioned trends can be attributed to political uncertainty and last minute purchasing before the end of the compliance period. Other reasons the emissions fell under the cap are economic impacts of the recession, other legislation reducing more emissions than anticipated, and unanticipated technology advances (Busch, 2017).

We have identified three anticipated drivers of price volatility:

- Major climate event occurrences may create a shortage of credits resulting in an increase in prices.
- As renewables become price competitive with fossil fuels, the cost of reducing emissions, and the demand for offsets declines.
- Introduction of an industry specific aviation market may drive the demand higher due to need for more carbon offsets.

The carbon prices have fluctuated since their release, but the fluctuations have been directed downward and the price has dropped over the years. This creates challenges for the financial viability of a proposal and the variability creates risk for a long term contract. Carbon prices, however, have a price floor in the California market and are also expected to rise as a result of the market being aligned with the timber pricing.

RECENT POLICY CHANGES

In 2016, California enacted SB 32, a continuation of AB 32 which the mandates that the state reduce GHG emissions to 40% below 1990 levels. A recent piece of legislation, SB 775, which was passed by the California legislature on July 17, 2017 extends California's Cap-and-Trade program to 2030. It was signed into law by California Governor Jerry Brown. The newly passed extension includes new rules pertinent to carbon offsets, including a reduction in the overall number of offsets allowed in the program. Currently, each emitter can use carbon offsets to meet up to 8% of their emissions and under the new legislation carbon offsets may only cover 4% of an emitters emissions, and half of these offsets must be from projects in the state. This has considerable implications for VLT, as it could limit the extent to which private Vermont forest owners are able to access the program (United States of America, California State, State Assembly).

From our interviews, it seems that only 2-3% of the original 8% of offsets allotted was used (telephone interview with Bloomgarden & Agrawal). The assumption is that the demand for out-of-state offsets will shrink, but the reality could be that there was never a enough out-of-state offset demand or supply to reach the original 8%. Lowering the supply may actually raise prices for offsets as they become more valuable to industries which rely on them to meet their carbon goals, however, California is also enacting a price ceiling in the carbon allowance market in addition to the price floor to prevent this.

The State of California also recently had a significant victory in a long-awaited court decision about the legality of the cap and trade program. The California Chamber of Commerce had sued the state of California regarding the AB 32 program, claiming that the program was an illegal form of tax on businesses. The state supreme court decided in favor of the state, deeming that it was in fact legal and can continue to operate (Fehrenbacher, 2017).

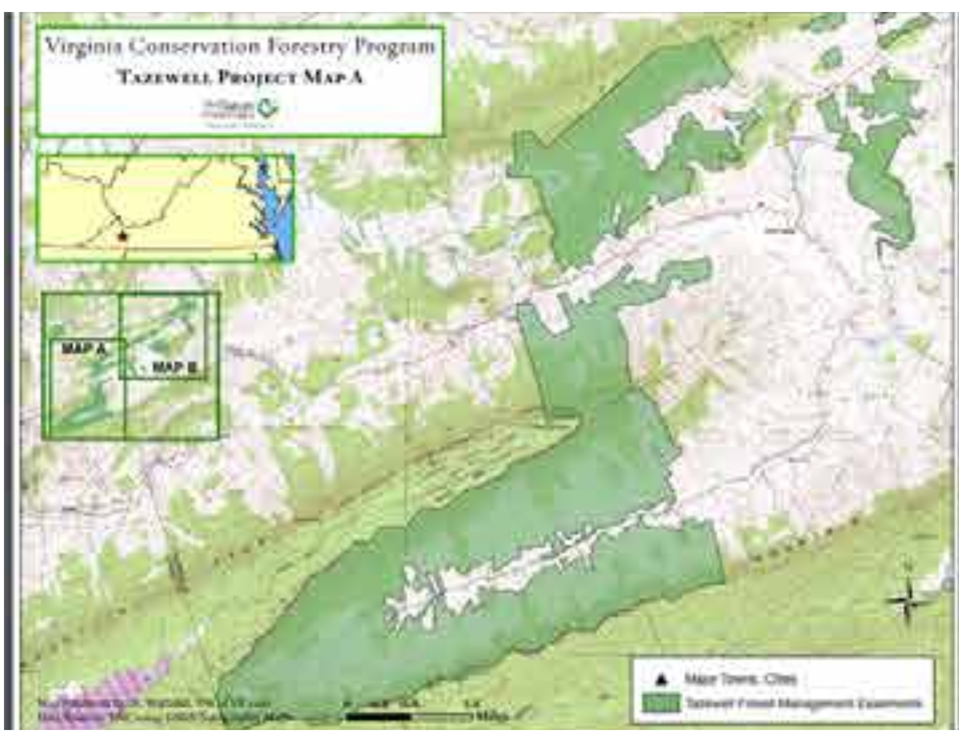
THE POTENTIAL AND FEASIBILITY OF CARBON OFFSET PROJECTS

APPROVED FOREST CARBON OFFSET PROJECT ANALYSIS

In order to analyze the feasibility of the forest carbon offset projects in Vermont, criteria were selected to choose comparable approved projects. Those criteria were the following: the northeast of the U.S., aggregated parcels, and parcel sizes that fit the model created in this report. Projects that fit the aforementioned criteria are summarized below.

1.) The Nature Conservancy

Virginia Conservation Forestry Program: This is a 11,672 acre improved forest management aggregated project located in Virginia. The forest land is considered central Appalachian hardwood stands with a richness of many different species in the area. There is a good amount of recreational activities in these forests including hiking, fishing, and birding. During the 2013 vintage year,



the project was able to be issued 33,036 offset credits with 6,356 credits in the buffer pool. The project considers risk in financial failure, over-harvesting, wildfire, and disease outbreak. The Nature Conservancy is the aggregator in this situation and holds the easements on the different lands. Because of the separation of land parcels, harvesting/natural disturbances were monitored using medium resolution leaf-off imagery and Landsat OLI sensor imagery. And, during the initial verification, a risk rating of 16.713% was applied to the project.

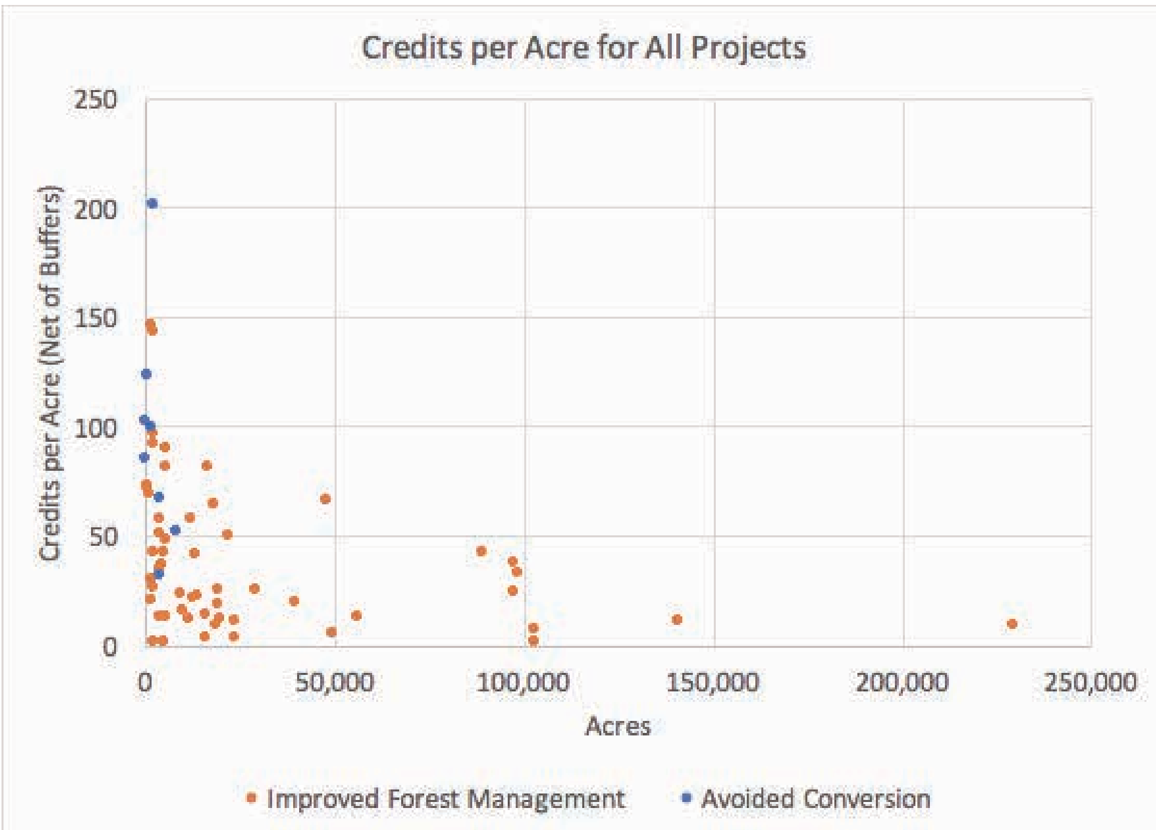
2.) GLS Woodlands, LLC

Lyme Grand Lake Stream Project: Using the improved forest management method, this project covers 19,552 acres in Maine. This forest is mostly spruce-fir and some northern hardwoods species and more than 90% of the forest is 20+ years old. In the 2015 vintage year, the project was verified for 599,217 offset credits with 155,050 credits in the buffer pool.

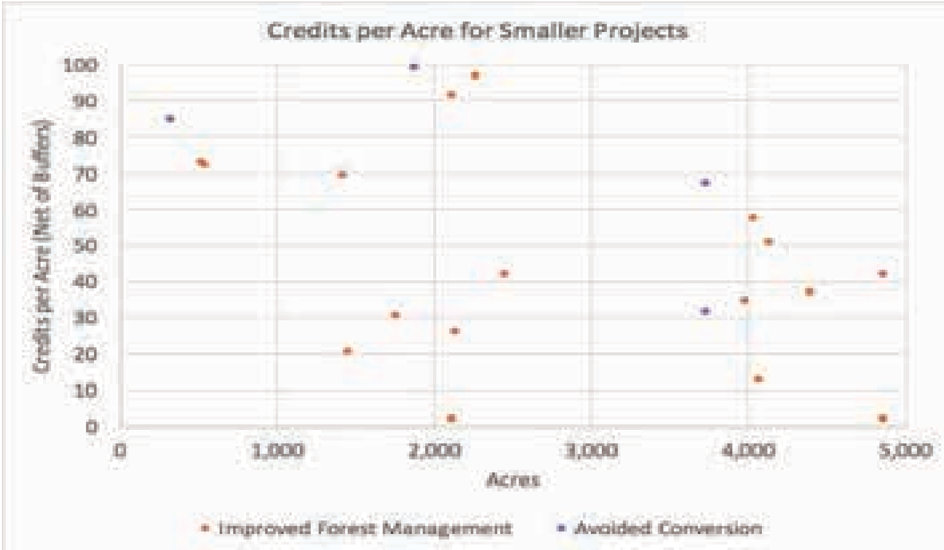
3.) Downeast Lakes Land Trust

Finite Carbon - Farm Cove Community Forest Project: This 19,118 acre project is located in Maine and is using improved forest management to receive carbon credits. This forest land has 62 miles of shoreline on six lakes and varying elevation levels and most of the forest cover being hemlock and spruce. In the 2010 vintage year, the project received 178,014 offset credits and kept 39,077 credits in the buffer pool.

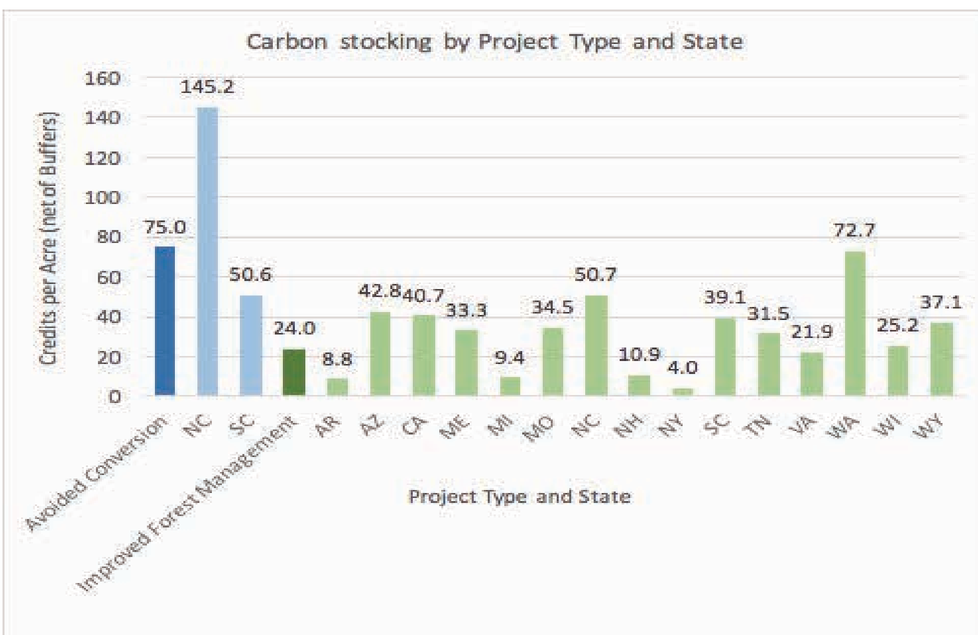
In addition to the relevant project summary, the capstone team conducted an analysis of all approved forestry carbon offset projects. Below, we have highlighted relevant trends such as credits awarded per acre for all projects, credits for small projects, and the carbon stocking by project type and state. In Appendix E, there is an additional table with a summary of approved compliance market projects that considers state, number of acres, and number of offsets issued.



Graph 1- Credits per Acre for All Projects: The projects across the United States vary widely in terms of acreage and credits per acre. While smaller projects vary widely in terms of metric tons of CO_2e stocked, it is clear that they have had higher stocking per acre than the larger projects.



Graph 2- Credits per Acre for Smaller Projects: In this graphic, smaller carbon projects are those with less than 5,000 acres. From the data, it is clear that smaller projects require higher carbon stocking to be viable. Among projects of less than 4,000 acres in size, only one project has had sequestered carbon stocks to date of less than 20 t CO_2e/acre. Of those less than 1,000 acres in size, all have had sequestered carbon stocks of more than 70 t CO_2e/acre. There is clearly a section at the lower left of the graph below where projects have not been done due to low stocking or lack of financial viability.



Graph 3- Carbon Stocking by Project Type and State: A breakdown by state and project type shows that Avoided Conversion projects have higher carbon stocking, of 75.0 t CO_2e/acre, as compared to Improved Forest Management projects which had stocks of 24.0 t CO_2e/acre. In the northeastern part of the United States, projects in Maine had stocks of 33.1 t CO_2e/acre, and projects in New Hampshire had stocks of 10.9 t CO_2e/acre.

DEVELOPMENT OF A FOREST CARBON OFFSET PROJECT

The examined type of forest carbon project is the Improved Forest Management protocol under AB 32, which is based on the principle that sustainable and holistic forest management can increase carbon in the forest and in harvested wood products. This is done through practices which may include:

- Increasing overall age of forest by increasing rotation ages, and maintaining stocks at higher levels
- Increasing the forest productivity by thinning diseased or suppressed trees, regenerating harvested or damaged forests, managing brush to reduce fire risk and other competing vegetation, fertilizer use, and the use of different species or genetically modified varieties
- Improving harvest practices, such as decreasing carbon loss through extending harvest intervals or reducing the amount of timber removed in a harvest This type of project will include various different practices in the forest management that will include the carbon stock and health of the forest.

Harvesting timber is allowed under the AB 32 IFM protocol, provided one of the following strategies are employed on each parcel of land within the project portfolio:

- Forest certification: this may include Forest Stewardship Council (FSC) Certification on timber products or verification as a registered carbon offset project
- Implementation and adherence to a Long-Term Management Plan, monitored by state or federal government
- Employment of uneven age management practices: selective harvesting within the forest as opposed to heavy cutting of entire plots of timber land in one cut (i.e. clear cutting)

These requirements are explained under the CARB Eligibility Protocol 3.1.3. (CARB, 2013).

The development of an Improved Forest Management project, as well as forest carbon projects in general, would start with the initial design and planning of the project. This would include activities such as site selection, community engagement, as well as proposals on financing and the management structure of the project (Olander & Ebeling, 2011). This would be followed by a project listing, which Jenkins characterizes as “akin to obtaining a building permit” (2015). Thereafter, a forest inventory is taken. The inventory is then used to model growth and yield of the forest. A project design document is then written, akin to the complete proposal for the project.

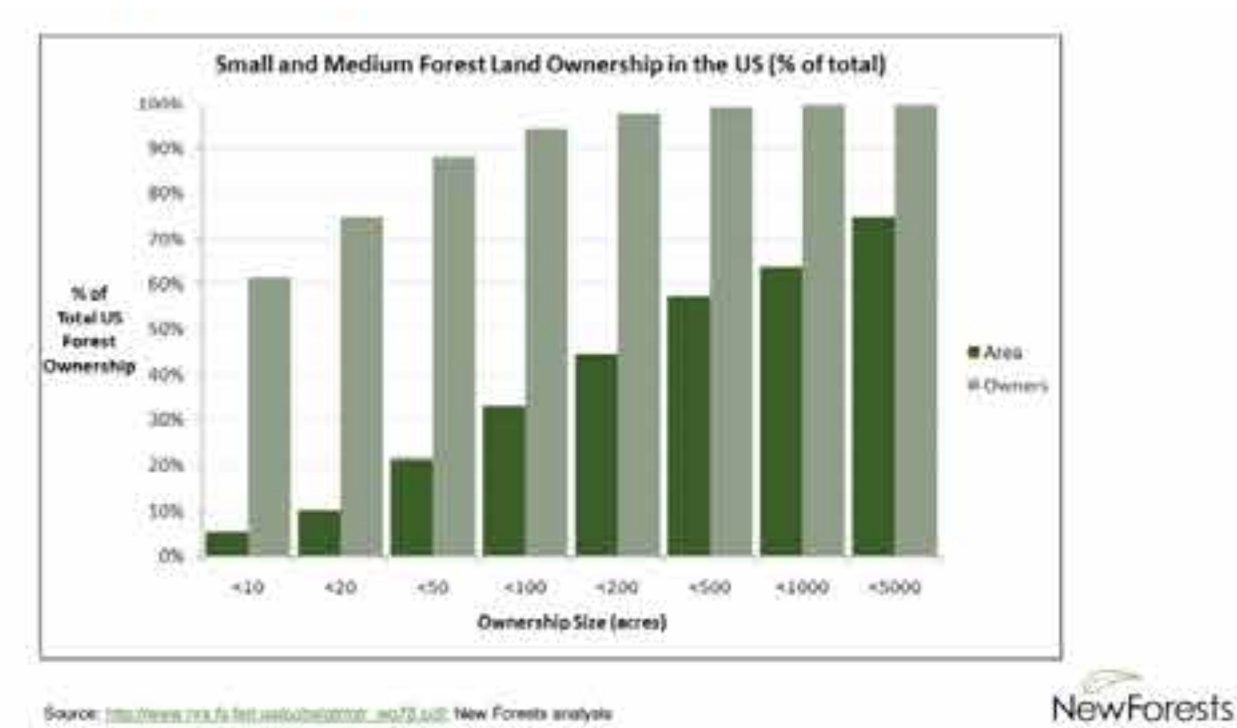
Following this, the project proceeds to the implementation stage. Third-party verification is required to certify the initial carbon stocks in the forest. The project is then registered with an Offset Project Registry, either as a voluntary project or as one for the CARB compliance market. This project development cycle takes about 12 months (Jenkins, 2015).

Over the project’s lifetime, periodic reporting must be done. Every time carbon credits are issued, another round of verification is required - either a desk review of the reports, or a less frequent but more rigorous on-site verification of carbon stocks.

A table of these steps can be found in Appendix A.

AGGREGATION OF FOREST OFFSETS

Carbon offsets are usually traded in 100 t CO_2e, and small forests are unable to generate this amount of offsets alone. Northeastern forests in the U.S. are estimated to sequester 0.6 to 6 tons of CO_2 per acre, which puts a lower limit on the size of the plots that can reach the magnitude of carbon sequestration required. The high costs of measuring, monitoring and certifying carbon offset projects has left the market concentrated around large-scale landowners who own several thousand acres, or those with mature, high-stocking forests. Aggregation allows multiple smaller-scale landowners to group the amount of carbon sequestered into one common pool for the purpose of market interaction. As 75% of privately-owned forestland in the U.S. are in



smallholdings less than 5000 acres, aggregating small forest owners would open the carbon market to a large potential group of participants (Shillinglaw, 2012). There is an added intangible value to offset buyers in being able to support smaller forest owners locally, rather than purchasing credits from projects in other regions. More specifically, 55% of forest owners in the Northeast own blocks of less than 1,000 acres, and are consequently faced with a vast array of challenges in maintaining the economic viability of these plots and preserving the forest as forest, for the sake of the range of benefits previously described (Brooke, 2009). The majority of Vermont's forest is privately owned, and these land parcels fragment the areas of forest such that is it rare to find large contiguous tracts under single ownership. Thus it would be necessary to link these parcels to reach the scale required for an offset project.

Additional benefits of aggregation include the reduced offset delivery risk due to diversifying the offset portfolio, the opportunity to establish a reliable domestic supply of offsets and potentially establishing a scalable offset supply model.

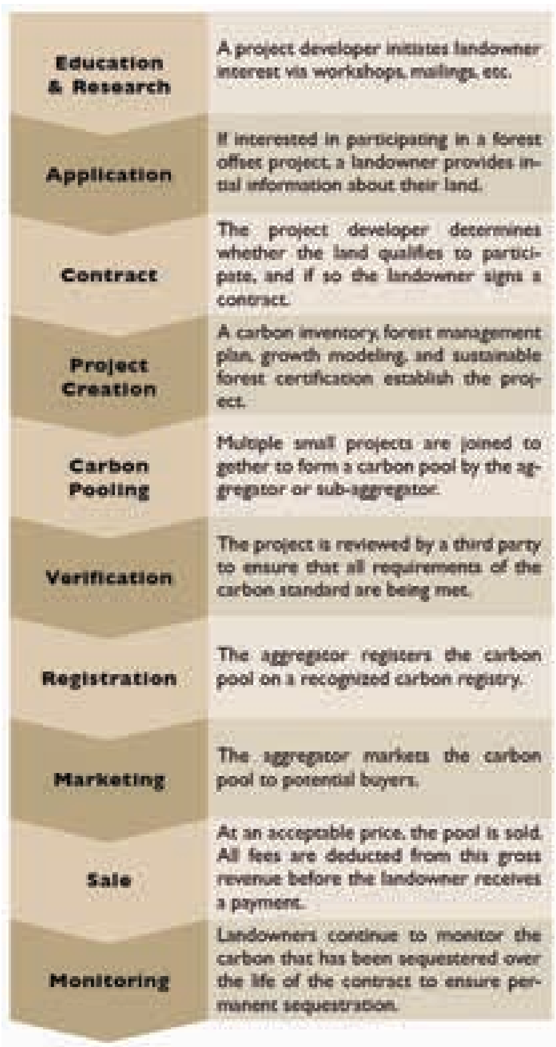
There are also significant challenges which may result from establishing working relationships with numerous entities, including managing landowner skepticism, increased inventory requirements, verification requirements and consistency among verified plots, and revenue distribution with respect to differing IFM costs between smallholdings.

THE ROLE OF AN AGGREGATOR

Aggregating small areas of forest land requires an entity acting as an aggregator, which can be a corporation, city, county, land trust or an individual land owner. The aggregator is responsible for coordinating the relevant entities and activities between the group of landowners, including carbon inventory, verification, registration of the project, brokerage and distribution of revenues generated from the sale of offsets. In many cases, the aggregator takes on many of these roles in their service offering, charging varying fees depending on the package of services offered. Organizations currently acting as aggregators use both for-profit and nonprofit models, with little standardization of the business models they follow.

Aggregated projects depend on stable relationships between the aggregating body and the small landowners taking part in the project. Outreach in the form of presentations, interviews, websites, workshops, direct mailings and radio advertisements have been used by aggregators as initial means through which to gather interested parties and convey information on the projects. Once a project group is assembled, the Project Design Document will be drafted, including the carbon inventory for the forest plots, the future land management plan, other sustainable forest certifications and growth or yield modelling. Once these steps are completed for each plot, the aggregator will be responsible for consolidating this information and using their chosen data management system to project the offset potential for the entire pool. The PDD will then be verified and registered, after which time the aggregator usually takes responsibility for marketing and selling the registered offsets.

Most aggregators charge a trading fee, on a dollar per ton basis (usually around $0.20 per t CO_2e traded) as well as a 10% fee for their services. Existing aggregators employ 2-4 people to focus solely on the forest carbon aggregation projects and landowner relationship management.



"The steps in Aggregated Carbon Offset Project Development" (Brooke, 2009).

Aggregators often provide financing options to cover the upfront expenses of implementing the project (i.e. for IFM practice implementation etc). This can take the form of a low-interest loan, or revolving loan fund (whereby interest payments are deducted from carbon offset sales, once a sale takes place).

Aggregated projects often also rely on additional funding sources for direct subsidization, which can come from foundations, endowments or other funds willing to backstop the project. Examples of those involved in these types of projects: U.S. Endowment for Forestry and Communities, the Ford Foundation, and college endowments. This additional funding can also come directly from offset buyers searching for specific offset attributes, such as location or forest co-benefits, who may be willing to provide pre-project financing.

AGGREGATION AND FOREST MANAGEMENT

Larger areas of contiguous forest are essential for a multitude of reasons, including the preservation of high quality wildlife habitat, preserving the aesthetic and scenic beauty for which Vermont is well-known, best practice forest management and economic productivity of the forest industry. Although this trend of parcelization and subdivision of the land is ongoing in Vermont, there is an opportunity for owners of contiguous sections of forest to implement management practices across an aggregation of properties, allowing the health, function and value of larger forest tracts to be preserved, and capitalized upon. Silvicultural treatments focused on increased carbon sequestration have a multitude of co-benefits to biodiversity and habitat provision, which are amplified when structural complexity can be increased across a wider forest area through rotational management plans for the various plots in the aggregation (Ford & Keeton, 2017).

This consideration of aggregation for the purpose of conservation management was listed in the Intergenerational Transfer of Forestland Working Group Recommendations for 2017, stating that "*Carbon offsets may be generated when a working forest parcel is managed above existing requirements to maximize carbon sequestration and retention. Given the size of most Vermont parcels and the relatively slow growth of our forests, revenue derived from a single woodlot may not be sufficient to fund additional conservation, but aggregating carbon credits across a portfolio of land, such as land conserved through one of the state's conservation partners, may result in sufficient funds to leverage the conservation of additional forestland.*"

OFFSET PROTOCOLS & AGGREGATION

In considering the development of a carbon offset project for the compliance or voluntary markets, it is important to account for the increased capacity that will be required in completing a carbon inventory for multiple parcels of land. This section explores the relationship between increased capacity, project verification, and long-term monitoring requirements.

CALIFORNIA AIR RESOURCES BOARD

Multiple landowners may participate in an aggregated project under CARB, provided that there is only one baseline and one cumulative inventory submitted for the entire project, which would be submitted as a single entity for registration (ARB, 2015). Although the total registered Project Area may be comprised of contiguous or separated land areas, the project is subject to geographical limitations whereby the project area cannot extend beyond two adjacent Ecosections or Supersection, which is explained under Section 4 and Appendix F of the CARB protocol (2015). In the case of Vermont, this stipulation is <u>not inhibitory</u> in considering aggregated offset projects as the Vermont forests belong to one Supersection, but is a consideration for projects that include land in neighboring states.

A high-quality carbon inventory is essential on every parcel aggregated in the project, as verification will take place on a random sample set and could thus include any plot on any property. The inventory requirements are stringent under CARB and require a much greater level of detail and accuracy than regular timber inventory or voluntary market carbon inventory. This requires the expertise of a skilled and well-prepared forester team, as an inaccurate or low-quality inventory can result in the project failing the verification process (Interview with Robert Turner, July 2017). As verification under CARB makes use of random sampling in plot selection, the inventory must be sufficient across all land parcels such that a plot selected from any parcel will be sufficiently accurate to pass the verification (ARB, 2013). Consequently, as the total land area of the project increases across numerous locations, as would occur under an aggregation scenario, the inventory costs will increase proportional to the amount of land included in the project.

The number of plots required to be verified are based on the total land area listed under the project, and will not increase based on the number of individual parcels or land owners involved. Depending on whether or not the inventory is stratified[1], which is usually recommended due to greater statistical accuracy.

The minimum number of plots increases with decreasing number of strata and increasing total project land area (see table below). Minimum number of sample plots for verification in sequence, as a function of project size (ARB, 2013):

Number of Strata Verified	Project Acres				
	<100	100-500	501-5,000	>5,000	>10,000
3	2	3	4	5	6
2	4	6	8	10	12
1	8	12	16	20	24

By this description, increasing verification costs will only occur through larger total project verification, and aggregation will not increase the cost of the verification process. However, economies of scale play an important role as less than 500 acres requires a 12-plot sample, whereas up to 5,000 acres (a ten-fold area increase) only

[1] Stratification is the process through which forest vegetation sub-populations which share similar characteristics (and consequently carbon stocks) are grouped, reducing the sampling effort required whilst maintaining the same level of confidence in the carbon inventory precision (Pearson *et al.*, 2013).

requires 16 sample plots, resulting in a much lower verification cost if divided among numerous participating landowners owners in an aggregated project.

Under CARB, a forest carbon offset project requires monitoring and reporting for 100 years after the last year of credits sold, i.e. if a project's starts in 2017 and has a 25-year crediting period, credits will be sold until 2042, but monitoring must continue through 2142 (Kerchner & Keeton, 2015). This requirement imposes further costs in considering aggregating multiple land parcels, but is contingent on the development of the AB 32 policy post-2020, explained above.

OTHER EXISTING AGGREGATION PROTOCOLS

VERIFIED CARBON STANDARD

Under the Verified Carbon Standard (VCS), aggregation is allowed and individual projects can even be added to a project group over time. The individual projects are then treated as a single, unified project. However, the VCS requires that the various smaller projects have the following characteristics:

I) They are in the same geographic area, which has to be defined and approved at the start of the project group.
II) They have the same crediting period, which again is defined at the start of the project group. Projects that are added later can only be credited for the duration of the project group's crediting period.
III) They share the same baseline scenario. This means that the sub-projects have to have the same regulatory frameworks, common practices and quantification criteria.

These requirements do not seem prohibitive for projects that are aggregated across the same geographic area, especially if it is in the same area (e.g. Adirondacks and Green Mountains). However, they might be prohibitive for projects that start at different times as such projects might have different baseline scenarios. As for monitoring and verification, VCS requires that this be done for projects individually, even as part of a larger project group (EPRI, 2012).

CLIMATE ACTION RESERVE

The Climate Action Reserve (CAR) allows projects that are smaller than 5,000 acres in size to join other such projects in an "aggregated pool". In doing so, each individual project can reduce its costs in three ways:

1. Inventory costs by enjoying economies of scale in statistical sampling once it is sampled together with other projects.

2. On-site verification needs only to be done every 12 years instead of every 6 years.
3. Desk verification for the purpose of issuing offsets can be done for just a subset of the projects (equal to the square root of the number of projects in the disaggregated pool), following which credits can be issued for the entire pool of aggregated projects.

In a study of a 2,000-acre landowner's costs, the EPRI found that the cost of a forest carbon offset project could be reduced from $417,000 to $161,500 under the CAR's aggregation guidelines if the landowner enters into an aggregated pool with eight other 2,000-acre landowners (EPRI, 2012):

Required activities	Landowner costs (disaggregated)	Landowner costs (aggregated)	Rationale	Assumptions
Preparing forest inventory	$27,000	$3,500	Reduction from 358 to 45 plots when aggregated	Each inventory plot costs $75
Updating forest inventory	$100,000	$30,000	Aggregated inventory has fewer inventory plots and is cheaper	Disaggregated update costs $10,000, while aggregated update costs $3,000.
On-site verifications (2016-70 or 55 years)	$150,000	$75,000	Disaggregated: 10 verifications; aggregated: 5 verifications	On-site verification costs $15,000
Desk reviews (2016-70 or 55 years)	$140,000	$53,000	Disaggregated: 55 reviews; aggregated: 21 reviews	A desk review costs $2,500 per project per year.
Total Cost	$417,000	$161,500		

Source: EPRI, 2012

However, each individual project is still required to maintain a separate account and sign a project implementation agreement with the CAR, albeit at a lower cost (i.e. a registration fee per project owner of $200 instead of $500). This requirement is intended to maintain individual accountability for each project owner, in particular holding forest owners liable for any intentional reversals of sequestered carbon for 100 years after the last credit is issued. In this way, permanence can be managed. This reflects that the CAR system still views each project as an individual project, instead of as part of a unified project group. This limits the extent to which costs can be reduced, especially for small projects (such as those less than 500 acres) where even a lower frequency of on-site verification can be expensive (EPRI, 2012).

AMERICAN CARBON REGISTRY

The American Carbon Registry (ACR) takes an approach different from the VCS and the CAR in that it treats all the individual projects in an aggregate as an individual project. This lets statistical sampling for the inventory and verification be done for aggregates instead of for individual projects. With this treatment, there must be a common baseline and an aggregate inventory for the whole project (as is the case with the VCS) (EPRI, 2012).

With this methodology, the aggregator gets more flexibility in managing the individual project owners but has to find a way to manage reversal risk. For example, the aggregator could use insurance to manage financial risks. In these cases, the aggregator would have to take on residual risk (EPRI, 2012).

BARRIERS

The following section highlights identified barriers in developing a forest carbon offset project in the state of Vermont. Key barriers are broken down into the following five categories: small parcel size, forest carbon requirements, social challenges, market challenges, and barriers to project enrollment. Recommendations for potential options to overcome these barriers are provided in the Business Model section.

BARRIERS TO PROJECT ENROLLMENT

The process of drafting and submitting a proposal project to CARB under the Compliance Offset Protocols is incredibly laborious and complicated. This creates a barrier to entry when coordinating with multiple forest landowners. As part of this report, a general guide to aggregating forest land for the purposes of submission to the CARB has been included in the appendix. This will clarify the process and outline the steps necessary to determine a project's viability and develop a proposal. These steps include necessary paperwork as well as inventory and verification that must be completed prior to enrollment.

SMALL PARCEL SIZE

As previously stated, the majority of land parcels in Vermont are privately owned. As a result of private ownership, the average parcel size is 1,131 acres [2](Vermont Natural Resources Council, 2013). Carbon offset projects this size would not be financially viable, which prompts the need for parcel aggregation and verification.

AGGREGATION

Parcel aggregation is necessary in Vermont to create viable forest carbon offset projects under the current CARB regulations, adding complexity to already elaborate requirements for project development. Aggregation methods and create social and legal obstacles when negotiating with many landowners. Potential strategies to address aggregation methods will be addressed in the Business Model.

VERIFICATION

Verification is a barrier in the process of project enrollment due to parcelization in Vermont. The cost of this step in project development becomes expensive and difficult. Best practice for verification currently involves manual measuring and sampling of plots within the desired project area. Parcelized land raises the cost and feasibility of manual verification.

FOREST CARBON REQUIREMENTS

Requirements for forest carbon projects vary by carbon registry. This poses a barrier for streamlining project development, in hopes that one project could be considered for multiple carbon registries. As new markets develop, qualifications for "additionality" and "permanence" of the forest should be considered. In the United States RGGI and AB 32, have different requirements for additionality and permanence.

ADDITIONALITY (SPECIFIC)

- *Regional Greenhouse Gas Initiative*: For a project to be considered "additional" under RGGI; projects may not involve activities required by any law or judicial order, may not receive incentives from programs funded through RGGI auction or proceed programs funded by electricity or natural gas ratepayers, and must meet category specific benchmarks, including using methods that exceed standard market practice (RGGI Model Rule, 2013).

[2] This is from the Vermont Natural Resources Council where the average size is based on 4,031 parcels in Vermont.

- *California AB 32*: Projects that generate eligible offsets must be considered additional from business as usual practices, must exceed any greenhouse gas emission requirements by law or regulation.

PERMANENCE

- *Regional Greenhouse Gas Initiative:* Permanence in RGGI approved projects is for a 100 year period and must consider the listed verification requirements for project permanence. Onsite carbon stocks must monitored annually and undergo third-party verification, with site visits every six years in duration of project life. In addition, the project owner must comply with intentional and unintentional reversal protocols. An intentional reversal is any disruption in the carbon stock of the forest caused by a forest owner's negligence or willful intent, including harvesting, development, or harm to the area. An unintentional reversal is any disruption in the carbon stock due to wildfire, disease, and not a result of negligence. Each type of reversal has a detailed protocol that must be followed to either be compensated for credits or for credits to be retired[3] (Regional Greenhouse Gas Initiative Offset Protocol U.S. Forest Projects, 2013).
- *California AB 32*: The term of permanence in an approved AB 32 project is 100 years. Projects must undergo third-party verification with on-site monitoring every six years. All intentional reversals will be addressed through retiring of project credits. In addition, projects must have a forest buffer account to provide insurance against reversals due to unintentional causes.

SOCIAL CHALLENGES

Aggregation of multiple small properties could require the cooperation of multiple landowners entering into a 100-year contract for improved management of their forests. This requires careful selection of like-minded landowners that would agree to participate and remain in an aggregation scheme. There is a level of uncertainty for these landowners as the AB 32 program is very politically dependent and evolving with time.

MARKET CHALLENGES

Since its creation, the AB 32 market in California has experienced a range of changes and outcomes regarding demand and pricing. We anticipate that these two market challenges will continue to evolve in time as legislation changes.

[3] Retirement of carbon credits mean they are taken out of circulation on the market and unable to be purchased or sold.

DEMAND

With the newly passed legislation, there is a decrease in the allowed out-of-state offset carbon credit (from 4% of total emissions to 2% of total emissions). It is unclear how the change in legislation will impact demand for carbon offset projects. Demand is an existing concern in the AB 32 market. The usage of carbon offsets hasn't been robust, with 2% to 3% usage of enrolled projects since 2013 (Interview Eron Bloomgarden, 2017).

PRICING

Prices for carbon offset credits have fluctuated since their release to the market. This creates challenges for the financial viability of a proposal and the variability creates risk for a long term contract. Carbon prices have a price floor in the California market and are also expected to rise as a result of the market being aligned with the timber pricing. Most carbon offsets have been selling at or near the price floor.

FINANCIAL PROJECTION

This section outlines the theory behind a financial model for a forest carbon offset project as well as the assumptions used. This model is proposed as a template which could be easily adapted by the Vermont Land Trust for future project assessments. At the point when it is used, the assumptions should also be screened and replaced with any more up-to-date assumptions.

A site in Bakersfield, VT (1831 acres) is used as an example of a potential project. The assumptions for baseline project development costs were obtained from the project team's correspondence with SCS Global Services, which provided a range of costs for a 2,000-acre project. These costs are then assumed to be applicable for a land area between 800 and 2400 acres. Other assumptions, such as on carbon prices and costs of aggregating landowners, are explained in the section.

FINANCIAL MODELING

In developing a financial model for a forest carbon offset program, the net revenue of a forest under a carbon offset program should be compared to the net revenue without a carbon offset program. This is because the latter represents the opportunity cost of an Improved Forest Management (IFM) or an Avoided Conversion project.

Without revenue from carbon sequestration or other non-timber benefits, a working forest would typically be managed based on an optimal rotation where trees in a plot of land are cut after a certain period (e.g. 15 or 30 years) in order to maximize discounted net revenue. In theory, this would occur in the year when the rate of increase in revenue from growth in timber volumes, net of maintenance costs and harvesting costs, falls below the interest rate. This theoretical result occurs because as the percentage increase of volume in trees generally declines with age, the 'interest' on the increasing capital represented by the timber stock decreases. In practice, forest owners and managers practice 'adaptive management' and consider actual market conditions. For example, stumpage prices fluctuate considerably, and selling at high prices and holding off selling during low price periods is an important way to maximize revenue in practice. (Klemperer, 2003).

If there is added revenue outside timber income, this provides additional revenue in the following year if the forest owner now chooses to delay harvesting for another year. (Klemperer, 2003.) Such added revenue could take the form of payments for recreational value such as hiking or hunting, or a conservation easement which reduces tax costs and thus adds to net revenue in the additional year. (Assuming that the forest owner has already enjoyed such revenue in the current year and is making a decision on harvesting at the end of the year, such additional revenues for the current year are considered 'sunk' and do not enter into decision-making.) As this additional non-timber revenue is now added to the increase in net revenue from growth in timber volumes, the percentage increase in total net revenue is now higher – and as long as this higher rate of increase is above the interest rate, there is financial value for the forest owner to defer harvesting.

Carbon offset credits are another such form of additional revenue, and are earned net of any transaction costs. Again, as a forest owner would have already earned offset credit revenue from carbon sequestered in the current year if he chooses to have it verified, it is a 'sunk' form of revenue.

With these broad principles in mind, the carbon offset scenario needs to be compared to the business-as-usual scenario for a full financial analysis. The components of a financial model for an IFM or Avoided Conversion project are as follows:

CARBON OFFSET SCENARIO: NET REVENUE INCLUDING CARBON CREDITS

REVENUE FROM CARBON OFFSETS

The main revenue stream from forestry carbon offsets would be credits, either from voluntary markets or the California compliance market. Interviews (with Turner, R.W.) and the literature (Kelly & Schmitz, 2016) concur that the initial offset generation in year 1 is the most important as this is when the majority of offsets are accounted for. As subsequent offset revenue is often insufficient to cover monitoring and verification costs, revenue from the first year is typically invested in order to pay for these line items (Kelly & Schmitz, 2016).

NET REVENUE FROM CO-BENEFITS

As trees are allowed to grow older and bigger (i.e. in height, diameter, overall volume and biomass) under carbon offset projects, forests can become more attractive to some types of wildlife and also may be more scenic. There may thus also be some revenue such as from recreational purposes (e.g. hunting, hiking). There may also be other sources of forestry income, such as from the tapping of maple sap which is financially much more attractive than sugar maple logging. Maple trees can be tapped after 40 years of age, while maple hardwood would require a tree of 115 years of age. The forest's existence value could also be considered a co-benefit.

There are other types of co-benefits which do not currently have a market value but should still be considered, at least qualitatively. For example, older forests may also be more beneficial for water management and flood control as they intercept precipitation and also promote infiltration of water into the ground to replenish groundwater (Vermont Flood Ready). While it may be challenging to quantify the co-benefits of a specific forest site, the overall benefits are potentially large - as evidenced by how 2011's Hurricane Irene resulted in as much as 11 inches of rain in Vermont, and damages of $733 million (Pierre-Louis, 2016).

The co-benefits of ecosystem services are a key reason why forest carbon offsets are more attractive than other types of carbon offsets (Interview with Sarah Wescott).

NET REVENUE FROM TIMBER OPERATIONS

In the case of a forest carbon offset IFM project, a forest owner in theory defers harvesting to later years due to the presence of carbon offsets and other non-timber revenue streams. As the timber revenue is postponed, the present value of timber revenue over the lifetime of the forest would be lowered as part of an IFM project. This might be partially offset by lower harvesting costs as each harvest would gather more timber and might therefore allow fixed costs to be spread over a larger volume of timber harvested. Alternatively, a forest owner might choose to forego harvesting of timber in all of the forest or part of the forest. In all cases, the timber revenue and costs under a carbon offset scenario would be gathered for the purpose of comparing it to the BAU scenario. Costs of forestry operations such as maintenance costs (e.g. inventory costs or monitoring), harvesting costs (e.g. logging, replanting of trees), and taxes could be assessed.

For example, using a plot of 500 acres as a case study for harvesting, an improved forest management program could result in only half the acreage being harvested over the 25 year crediting period for improved management where half would be harvested. This 250 acres would be divided into five entries, totaling 50 acres each. Each acre yields about 15 cords totaling 750 cords for each entry. This would bring in a revenue of $4,000 per entry or $20,000 total (Robert Turner, 23 July, 2017).

CONSERVATION EASEMENTS

Conservation easements should also be included in the model. Depending on the perspective taken, this could be a cost or benefit. For landowners, conservation easements would provide a lump-sum payment and would thus be a benefit. From the perspective of a local government or a land trust, this could be a cost which needs to be covered from other sources (e.g. investors).

CARBON OFFSET PROJECT DEVELOPMENT AND MANAGEMENT COSTS

There would thus be upfront costs for ***project development*** itself. This would comprise the upfront cost of additional FTE man-hours if a project is developed in-house by the Vermont Land Trust, or if the Vermont Land Trust chooses to outsource this to a project developer instead. There would also be similar labor or outsourcing costs for regular running of the project, such as to manage contracts for regular inventory-taking or verification.

There would also be *inventory cost*, which is typically the largest cost. The inventory must collect items like total tree height, merchantable tree height, standing dead trees and saplings above 1 inch diameter at breast height (DBH) (Bloomgarden & Agrawal). Even for IFM projects, this is a cost as the requirements for taking inventory for a sustainable forest are more stringent than that typically undertaken by timber management companies. There is an upfront cost of taking the initial inventory, and subsequent smaller costs of taking periodic inventories.

Reporting costs must also be incurred regularly (e.g. annually) under various forest carbon offset protocols.

Verification costs are also usually the second highest item. In particular, verification costs may have risen for California compliance market projects as staff there have been scrutinizing projects very closely (Sarah Wescott, 29 June 2017).

There are also *additional costs incurred for the purpose of aggregation* when multiple small landowners are involved in an aggregated project. For example, there might be additional legal cost for developing and negotiating contracts which a single aggregator organization might sign with each landowner, and additional manpower or outsourcing costs for managing these contracts. There would also additional offset registration costs. If the Climate Action Reserve's offset protocol is being used, there are additional account fees for each individual landowner.

CARBON OFFSET REGISTRATION COSTS

A carbon offset project must be registered with an offset registry which provides requirements to ensure the additionality and permanence of the offset project and also has verification requirements. Currently, there are three offset project registries (OPR) for the California Air Resources Board – the Climate Action Reserve (CAR), the American Carbon Registry (ACR), and the Verified Carbon Standard (VCS). The costs usually comprise (i) upfront account setup fees; and (ii) regular account maintenance fees for offset project operators. There are also (iii) project submittal fees when a project is submitted for consideration; and (iv) credit issuance fees when credits are actually issued.

BUSINESS-AS-USUAL SCENARIO: NET REVENUE FROM FOREST HARVESTING UNDER OPTIMAL ROTATION

The carbon offset scenario needs to be compared to the business-as-usual scenario. For example, if the optimal rotation policy is the BAU scenario, net revenues under an optimal rotation policy represent the opportunity cost which a forest owner foregoes when he chooses to undertake a carbon offset project. [The same principle applies to carbon sequestered, as forest offset protocols only provide credits for carbon sequestered in addition to the baseline level.]

NET REVENUE FROM TIMBER OPERATIONS

This baseline could include timber revenue under the optimal rotation policy. There are also costs of forestry operations such as maintenance costs (e.g. inventory or monitoring costs), harvesting costs (e.g. logging, replanting of trees), and taxes.

Alternatively, if the baseline would be land development, then there should only be a quantification of net revenue from one-off clear cutting of the forest.

NET REVENUE FROM CO-BENEFITS

If non-timber revenue (e.g. from recreation, tapping of maple sap) is applicable in the baseline case, it should also be included as a cost foregone. If this revenue is the same in both BAU and carbon offset project scenarios, it just means that the latter does not have any additional co-benefits.

TIMEFRAME

Revenues and costs for forest offset projects should be ideally quantified for both the crediting period, currently 25 years under the California offset protocol, as well as the subsequent 100 years after the crediting period which are required to ensure permanence - the post-project monitoring period.

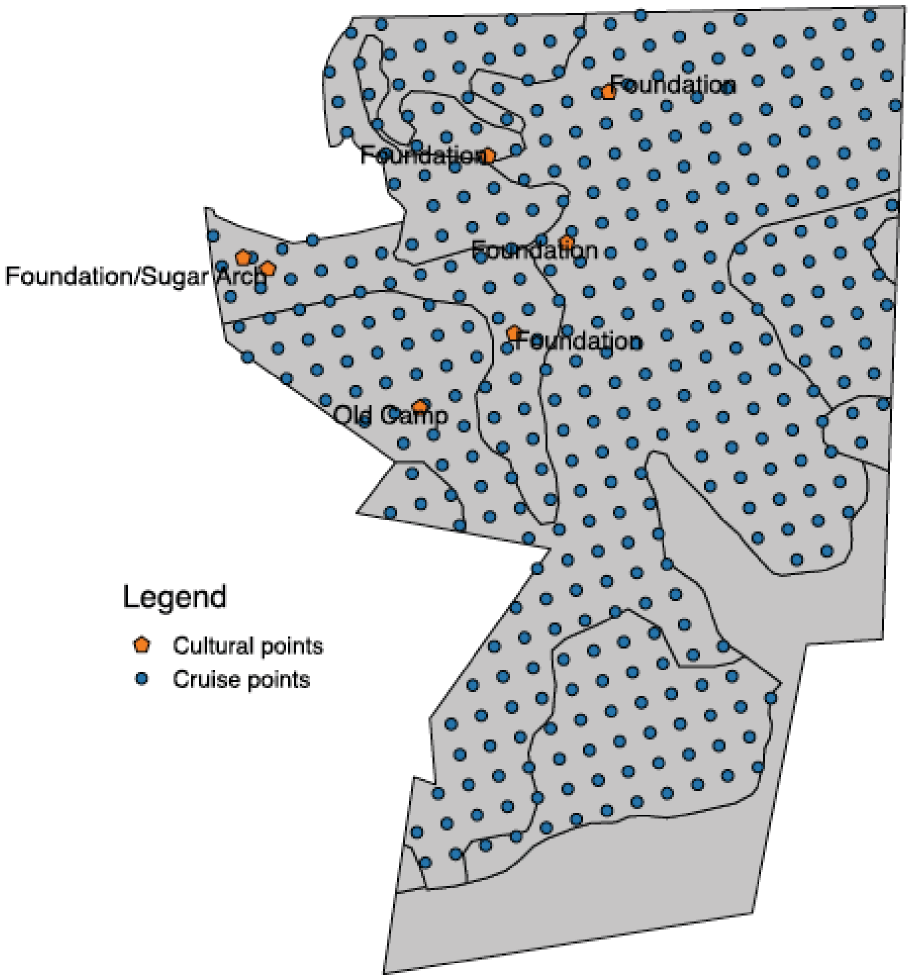
ASSUMPTIONS

PROJECT CHARACTERISTICS

The client, the Vermont Land Trust, has provided a site at Bakersfield for a sample project. This site contains 2,151 acres total and 1,831 acres of commercially operable forested land. Before 2000, the property's forests were harvested based on a diameter-limit cutting regime where trees beyond a certain diameter were cut. The most valuable species (e.g. yellow birch) were targeted. (MD Forestland Consulting & RJ Turner Company, 2015). A recent timber inventory estimated that the majority of the sawlog volume comprises sugar maple (47%), yellow birch (20%) and beech (8%) (MD Forestland Consulting & RJ Turner Company, 2015).

As for co-benefits, a key forest co-benefit is that of maple sugar production which is a lucrative revenue stream. Other co-benefits include recreational hunting as the area is known for large deer and bear. There are also aesthetics such as mountain vistas and streams. There is also existence value of the wildlife as well as cultural value - the land has a history of farming and logging, with cultural points such as old barn foundations, sugaring arches, and an old camp (MD Forestland Consulting & RJ Turner Company, 2015).

A map of the area is below.



DATA ON COSTS

Project management cost assumptions are primarily based on suggestions from SCS Global Services (email correspondence with Letty R Brown). (Project development and management fees provided by SCS Global Services are at Appendix A) Two cost estimates are used for various sizes.

For a normal-sized project (in this project assumed to be 2,000 acres), costs are assumed to be applicable for a project of size 800 acres to 2400 acres. Development costs are assumed to be the midpoint of $35,000-$80,000 and initial verification costs the midpoint of $40,000-$50,000 (SCS Global Services, 2017). On-site verification costs are assumed to be the mid-point of $11,000-$12,000 (SCS Global Services), and verification is assumed to be done at the minimum frequency required by the CARB - every 6 years. Ongoing monitoring costs are assumed to be $5,000 incurred every year as suggested by Kerchner & Keeton (2015). As SCS Global Services quoted $0-25,000 per year for ongoing monitoring costs, it is assumed that the balance (i.e. of $20,000) is the cost incurred for an update to the inventory and forest modelling, done every 12 years as required by the ARB.

As for small projects (200-400 acres), development costs are assumed to be the mid-point of $25,000-$60,000 and initial verification costs are assumed to be the midpoint of $35,000-$40,000. As SCS Global Services quoted $0-$15,000 per year for ongoing monitoring costs, the cost for an inventory and forest modelling update is assumed to be the balance (i.e. $10,000). Other project costs are assumed to be the same.

As for post-project monitoring costs, these are assumed to be zero as there is no current information on what CARB requirements would be for post-project monitoring.

With these cost assumptions and a 6% discount rate, life-cycle costs have a present value of about $209,000 for normal-sized projects and $184,000 for small-sized projects. Although unpredictable, changes in legislation and protocols can add costs of $15,000 plus to a project depending on the changes. These variables should be built into the project budget as a variable cost. If this contingency cost is included, life-cycle costs would be $224,000 for normal-sized projects and $199,000 for small-sized projects.

This estimate for normal-sized projects is comparable to estimates by Finite Carbon - of at least $100,000 to develop "modest projects" and $150,000 for long-term maintenance and operations costs (i.e. total of at least $250,000) (Jenkins, 2015). The lower $224,000 estimate could be attribute to the cost-cutting measure of choosing to have carbon credits accrue every 6 years with on-site verification (i.e. at years 1, 7, 13, 19 and 25) and doing away with more frequent desk review verification. Desk review verification could cost about $3,000 per audit (Kerchner & Keeton, 2015)[4].

The modeling costs between $20,000 to $25,000 with verification adding an additional $15,000-$20,000. The project documentation cost can vary from $10,000-$15,000 (Finite Carbon). Moreover, legal fees can range between $1,500-$2,000 (Bloomgarden), and aggregation would likely add to this legal cost due to additional time required for legal negotiations. The minimum cost per aggregated project is likely to exceed $60,000. These are the initial expenses to be accrued with registering and proving eligibility for the AB 32 program, although they are conservative estimates to provide a 'best case scenario' for project viability.

[4] If desk audits are done every year, this would raise costs to a present value of about $254,000.

The costs for aggregation will consist of the salary for a dedicated aggregation program manager at a salary of $75,000 per year and additional legal expenses. Assuming a single project manager can manage 20 different landowners, this works out to a cost of $3,750 per landowner per year. We assume that each landowner will require 4 hours of legal work per project and 0.5 hours per year on an ongoing basis at a cost of $875 per hour (McHenry). This works out to a one time legal fee of $3,500 per landowner per project and an ongoing cost of $437.50 per landowner per year. These additional legal costs are to account for the added complexity in the project contracts and agreements when creating an aggregated project. The present value of all aggregation costs is estimated to be about $304,000 for 5 landowners and $608,000 for 10 landowners. This is higher than life-cycle project costs and clearly a significant problem.

It should however be noted changes in legislation could potentially make aggregation cheaper. If an aggregated project is brought together under the Climate Action Reserve's model, aggregation costs are potentially much lower as the Climate Action Reserve signs a standardized Project Implementation Agreement (PIA) with each individual landowner (Email interview with Sarah Wescott, 26 July 2017). The costs of doing so are only of initial costs of $200/landowner and annual account fees of $200/landowner. Bringing an aggregation project to fruition under the Climate Action Reserve is thus a financially much more attractive option, although it is not used in this project proposal as current CARB policy on aggregation is more similar to that of the American Carbon Registry. If the CARB changes this policy to one more similar to the Climate Action Reserve's, aggregation costs could potentially be cut significantly.

DATA ON TIMBER AND CARBON SEQUESTRATION

Based on reviews with various foresters we have compiled a set of assumptions that were used to calculate any potential timber and carbon credit revenues. Firstly, traditional timber harvesting revenues have been calculated using the Use Value Appraisal (Current Use Program) 2017 values of $135/acre (Vermont State Department of Taxes, n.d.; Robert Turner, 23 July 2017). . This would be the discounted sum of a perpetuity of timber harvesting profits. This program provides a tax break to forest owners as it lets them value their property based on the timber harvest value of the land rather than the potential development value. This generally provides a tax break of 80-90% for owners enrolled in the program and necessitates that they maintain their property as forest. The use value also provides a useful proxy as it averages discounted value of forests per acre across the state of Vermont which is why we used it to calculate the BAU discounted timber revenues.

Secondly, IFM practices typically result in the harvesting of 40-50% of the forest growth per year, although an organization can cut all of the growth and maintain a carbon project as long as they do not allow their carbon stocks to fall below the baseline.

Growth in the Northeast is typically only 1-2 t CO_2e per acre per year (Finite Carbon, 2012)[5] so IFM means that they harvest 0.4-1 t CO_2e of the total sequestered carbon per acre per year. Initial carbon storage for projects in the Northeast is also estimated to be around 10-25 t CO_2e per acre above baseline. As for carbon prices, these are assumed to start at $11.50, which is reasonable as offset prices in July 2017 for California's Carbon Credit Offsets with 8 year invalidation periods (CCO-8), which are what most forest offsets would start out at, were $11.40-$11.70 (California Carbon Info). This is higher than in previous months but is still considered to be a useful starting point. Prices are then assumed to increase at 5% per year plus inflation which is the current California policy.

As for the proportion of timber revenue which is foregone due to an improved forest management project, this is assumed to be zero as in practice, many participants in the California compliance market have not had to make management changes that reduce other revenue opportunities; as such Kelly & Schmitz (2016) note that the market acts more as a reward for landowners to manage stocking above regional practices.

STUMPAGE PRICES

Vermont's Department of Forest, Parks and Recreation releases quarterly reports on stumpage prices dating back to 1981. The report from Q4 of 2016 listed sugar maple at a price of $223/thousand board feet (MBF) in the North to $255/MBF in the South and yellow birch between $100/MBF in the North and $193/MBF in the South with beech at a standard $50/MBF (Vermont Stumpage Report, March 2017). Although this data is not used in this report's model, this serves as a good basis for the current market pricing for stumpage for specific species to value potential revenue.

DATA ON CONSERVATION EASEMENTS

In practice, landowners often gift easements to the Vermont Land Trust instead of being paid for them. In practice, in Vermont, these easements are often gifted prior to a forest carbon project. Many California compliance market carbon offset projects are often reliant on agreements tailored for the project, rather than conservation easements, to bring about permanence. The landowners then benefit from gift tax deduction and this would be considered potential revenue. If conservation easements come about as a result of a forestry carbon project, they should be part of the financial model. However, as it is unclear if the lands being analyzed are already under some sort of easement, the model used here assigns a cost of zero to conservation easements.

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[5] This figure is lower than the previously-cited 0.6-6 t CO_2e/acre-year. It is used as it is more conservative.

DATA ON CO-BENEFITS

Sugaring is a very lucrative business in Vermont that can add additional revenue from a property without extensive alterations to the management plan. The maple trees that are 10-12 inches in diameter and around 40 years old would be considered for tapping. The season starts in February and goes through the sugaring season in the spring and finish processing in the summer. It takes about 40 gallons of sap to make each gallon of syrup, but this can vary based on the sugar content of the syrup while on average each tree can produce 10-20 gallons of sap per tap (NYS Maple Weekend). Bakersfield has the stock to yield 13,125 gallons of maple syrup each season. If the landowners decided to run the sugaring business themselves, there is the potential of $238,525 in profits. This can be broken down into 35,000 taps each yielding on average 15 gallons of sap totaling 13,125 gallons of syrup. At current market price of $35.00 per gallon this would yield $459, 375 (US Maple Syrup Price). Each tap has an initial cost of $6.31, totaling $220,850 (Cost of Maple Sap Production). Alternatively, landowners could lease out the sugaring operation generating $1.50 per tap totaling $52,500 in revenue.

The forests that contain sugaring operations can still be included under Vermont's Current Use program and the landowners would receive a tax break for continuing to not develop the land. These co-benefits can incentivize landowners by allowing the sugaring business to still operate well generating additional income in offset credits.

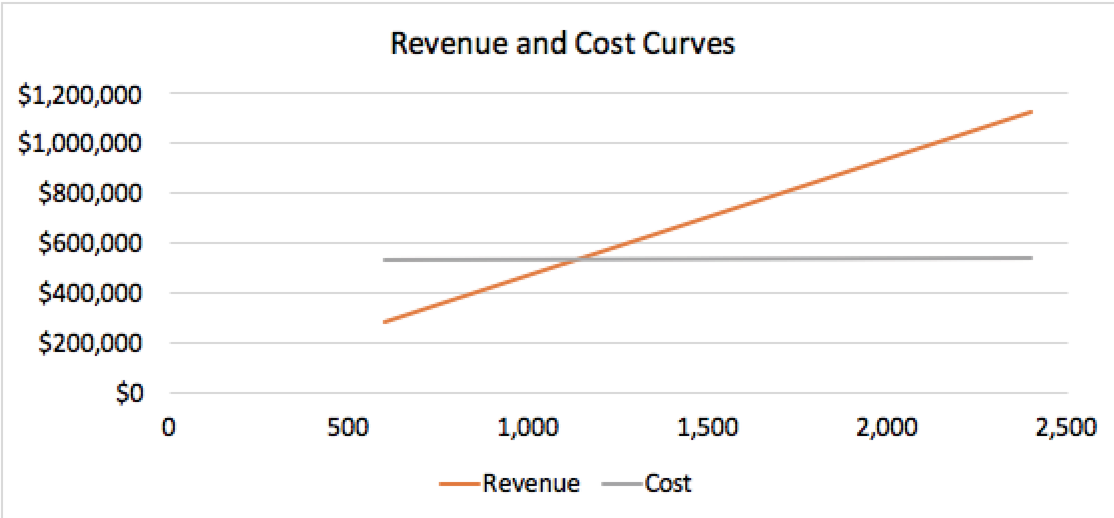
Sugaring revenues for the Bakersfield site are therefore assumed to be $52,500 in revenue under both a forest carbon offset and the BAU cases.

As for other co-benefits such as hiking or hunting, these are assumed to contribute zero revenue under both the forest carbon offset and BAU cases. This would be consistent with the project team's visit to Cold Hollow to Canada projects in Vermont, where recreational activities are undertaken on forest lands for free.

MODEL RESULTS

A financial model was developed on an Excel spreadsheet to incorporate the assumptions as above. In addition to the assumptions outlined above, it should be noted that this model uses the American Carbon Registry's fees as the American Carbon Registry's procedure for aggregation is most similar to the California Air Resources Board. Both systems require a single entity to be designated the representative for the project. The discount rate is assumed to be 6%, which is the ACR's assumption for non-Federal US forestlands. The number of landowners is assumed to be 5.

A graph of how revenues and costs under the model change with acreage is shown in the diagram below. With the assumptions used, costs for a project would stay relatively fixed despite increasing acreage; costs per acre then decline significantly. However, as revenue per acre stays the same, total carbon sequestered and total revenues would increase with acreage. With an assumption on credits of 20 t CO_2e/acre, the break-even point is at 1,135 acres[6].



Two types of analyses are then carried out.

SCENARIO ANALYSIS

First, analysis could be carried out under various scenarios to determine the financial viability of the Bakersfield project. At this point, it should be noted the model which this project proposes is one where cost estimates are conservative and revenue estimates are aggressive. For example, verification and monitoring costs are assumed to stay constant over time. In reality, they might increase over time due to inflation, albeit dampened somewhat with technological progress. On the other hand, carbon credit revenues are assumed to increase at a rate of 5% plus inflation which is the current CARB policy.

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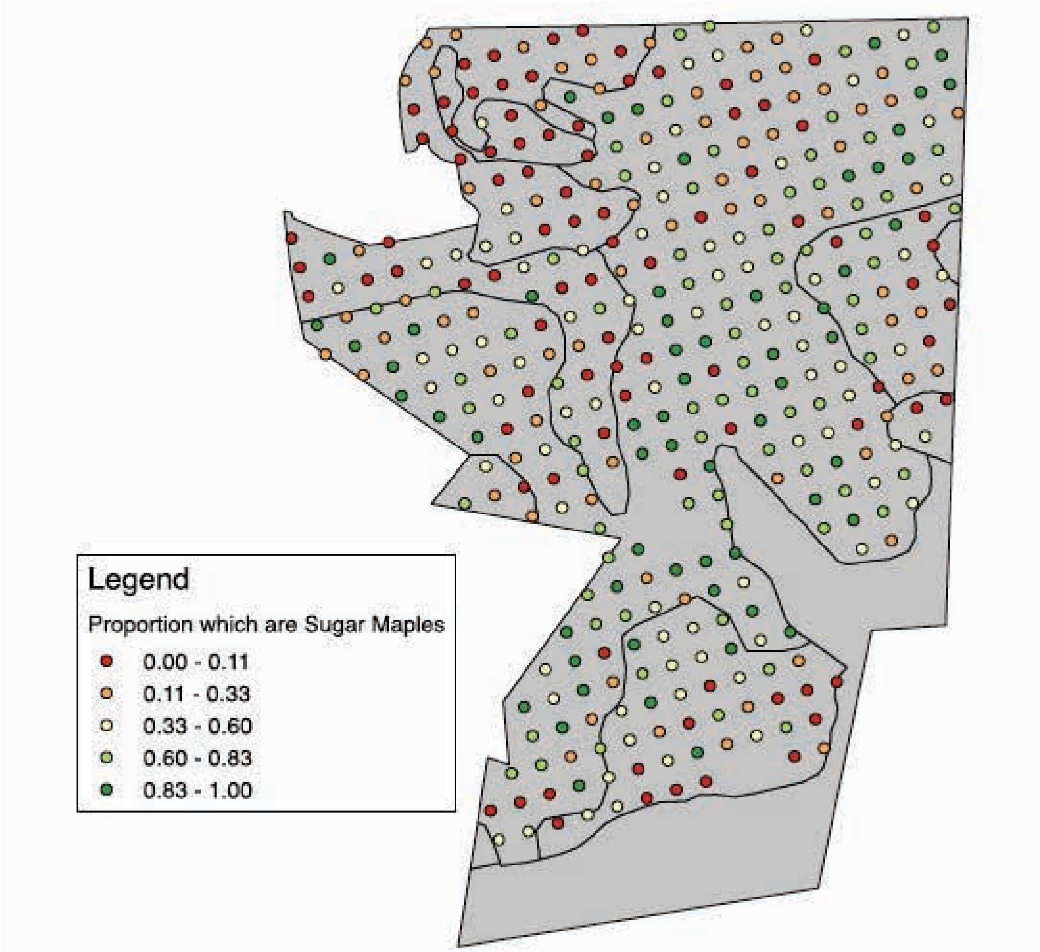
[6] This is calculated by using Excel's "Goal Seek" function to attain an NPV of zero by changing the project acreage.

A baseline scenario and three sensitivity analysis scenarios are investigated, as follows:

	Carbon price rate of increase	Foregone timber revenue	# Landowners
Baseline	5% + Inflation	No foregone revenue	5
Scenario A	5% + Inflation	30% foregone revenue	5
Scenario B	Inflation	No foregone revenue	5
Scenario C	No increase	No foregone revenue	5
Scenario D	5% + Inflation	No foregone revenue	10

The scenarios are elaborated on as follows:

Scenario A: 30% of timber revenue is foregone. The first sensitivity analysis scenario aims to test the baseline assumption that no timber revenue is foregone in implementing the forest carbon project. A back-of-the-envelope estimate of revenue which could be foregone is 30%. This could result, for example, if only small amounts of harvesting is now done in the sections of the Bakersfield sample project where 60% or more of the trees are sugar maple trees in order to maintain forest biodiversity and ecosystem health. This would be possible as, from data provided by the Vermont Land Trust and Mr. Robert Turner, these areas are clustered together (see the diagram below). From the data it is also estimated that such land makes up almost 40% of total forest acreage. As such, a reduction in timber revenue of less than 40% (i.e. 30%) would be reasonable.



Scenario B: Carbon prices increase at a lower rate over time (with inflation). The baseline scenario assumes that carbon prices increase at a rate of 5% plus inflation as this is the ARB's current policy. As an alternative scenario to model more conservative carbon prices, the break-even curve is modelled when prices increase at just the rate of inflation.

Scenario C: Carbon prices do not increase over time. A further alternative scenario could be that carbon prices do not increase over time.

Scenario D: The number of landowners increases from 5 to 10. In this scenario, the number of landowners is increased from 5 to 10. This would be realistic in areas where land is more fragmented. An increase in the number of landowners would mean higher outreach and legal costs.

The scenario analysis could be applied to the Bakersfield project itself with the acreage assumption of 1,831 acres and an initial credits per acre assumption of 20 tCO2e/acre.

In this instance, the Net Present Value (NPV) of the project under each scenario is as follows:

Scenario	Net Present Value
Baseline	$322,614
Scenario A: 30% foregone timber revenue	$248,458
Scenario B: Carbon prices increase with inflation	$73,955
Scenario C: No increase in carbon prices	$6,467
Scenario D: From 5 to 10 landowners	$21,382

As Scenarios C and D clearly significantly impact the NPV of the project and make it only marginally financially viable, a further scenario which combines scenarios C and D could be considered as a worst-case scenario. In this case, the NPV of the project would fall to a negative figure, -$294,765. This suggests that although the project is financially viable in this model, there are significant downside risks that cannot be ignored.

As a more general analysis, graphs could be plotted for an estimate of credits per acre required for a project of various sizes to break even[7]. This could be done for large plots of land of 800-2400 acres, i.e. a size comparable to Bakersfield's 1831 acres. (Analysis for small plots of land of 200-400 acres is discussed later.) For example, if a project of size *x* acres requires *y* t CO_2e/acre of initial carbon stocks to break even, any initial stock levels above *y* t CO_2e/acre would suggest that the project should be considered further. In this regard, as assumptions on costs are conservative but that on revenue is aggressive, the graphs plotted should be considered a minimum requirement; in reality, net revenue in each case might be lower than that estimated in this model.

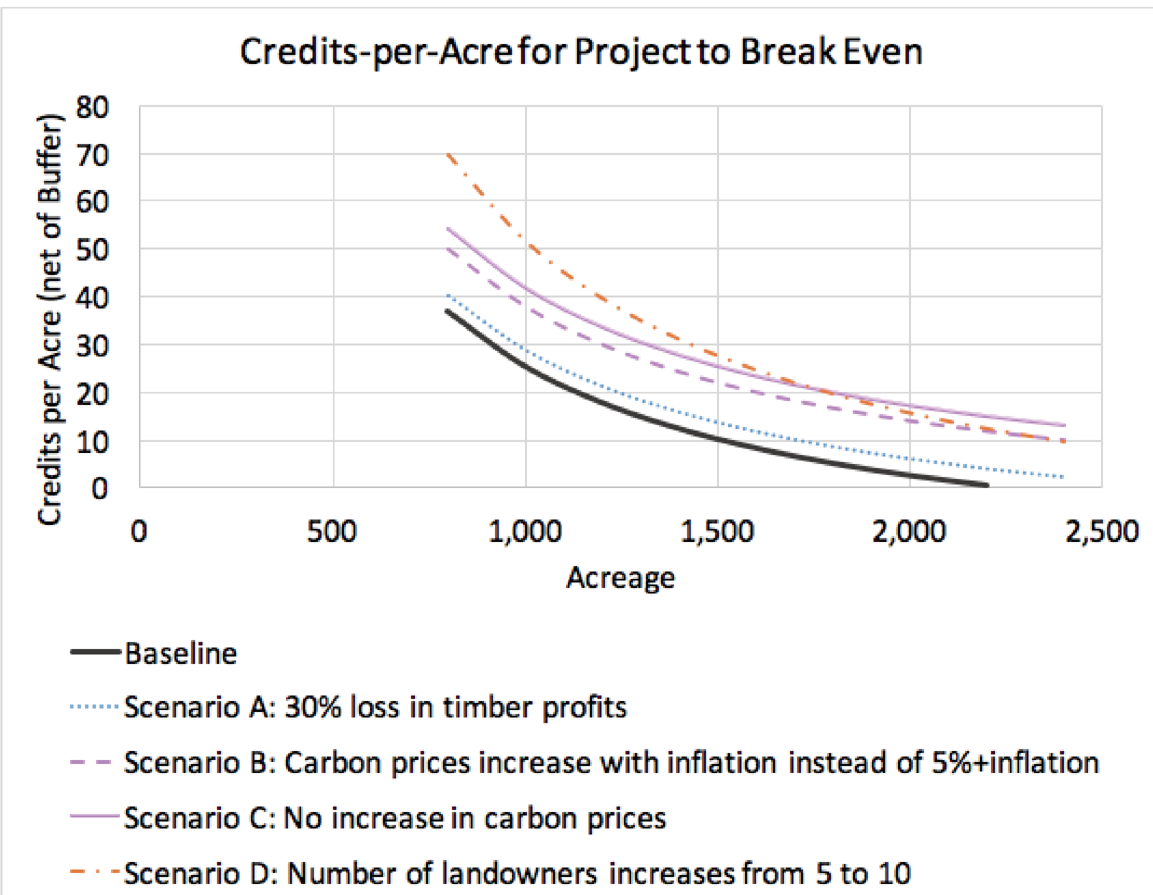
The results are shown in the graph below. For each scenario, projects with credits per acre and acreage above the curve would be worth further consideration. Scenario A for a 30% loss in timber revenue does not change the location of the curve much. Instead, carbon prices and the number of landowners are the major factors. The magnitude of the impact can be visualized in the vertical distance from each scenario's curve to the baseline curve. At acreage levels below around 2,400 acres, an increase in the number of landowners (Scenario D) creates a situation where much

[7] This is calculated by using Excel's "Goal Seek" function to attain an NPV of zero by changing the project credits per acre assumption.

more credits-per-acre are required - this is intuitive as more revenue is required to offset the costs. In contrast, only moderate increases in credits-per-acre are required to offset lower carbon prices. Above 2,400 acres, the detrimental effect of lower carbon prices (Scenario B) becomes more pronounced - again intuitive as more acres means that each drop in carbon prices means more revenue sacrificed.

In the baseline scenario, initial carbon stocks in the northeast US at the lower end of 10-25 t CO_2e/acre would be sufficient for a project of around 1,500 acres to be financially viable. When moving to Scenario A, the requirement becomes slightly higher at around 1700-1800 acres. However, once Scenarios B or D are considered, projects would need to be of 2,400 acres or more, and even larger for Scenario C. Again, this suggests significant downside risks for small-acreage projects.

When applying this to the Bakersfield project, if the Bakersfield project is reduced in size to 1,000 acres, it would require significantly higher initial carbon stocks (about 25 t CO_2e/acre or more) to be viable.



SMALL SIZED PROJECTS

A second type of analysis is to assess the viability of a small-sized plot of land, in terms of the break-even credits per acre required. A secondary model is thus run for the small plot of land. The only sensitivity analysis done is to test how the number of landowners affects the model outcomes.

The results can be classified into four scenarios as follows. When one moves from a normal to small plot of land and from few to many landowners, it is natural that a project would require more credits per acre to be viable. The results show that once aggregation costs are considered, small plots of land are clearly not viable if they are further split up amongst several landowners. Even in a scenario where no aggregation is required but the Vermont Land Trust still needs to work with a single landowner, the break-even credits per acre needed is 52.6 t CO_2e/acre.

Normal (1831 acres)	[Not analyzed]	2.9 t CO_2e/acre	17.1 t CO_2e/acre
Small (300 acres)	52.6 t CO_2e/acre	123.0 t CO_2e/acre	211.0 t CO_2e/acre
Land size / # of Landowners	No aggregation (1)	Few landowners (5)	Many landowners (10)

COMPARISON TO OTHER STUDIES ON FINANCIAL VIABILITY

Compared to other studies by the forestry industry, this paper has found a lower minimum acreage (1,135 acres) for a project to break even. Jenkins (2015) cites 2,000 acres as a minimum requirement. Other studies such as Jenkins & Smith (2013) have cited 4,000 acres as the minimum acreage. The latter paper also noted that carbon stocking should be at or above regional common practice, and that forest harvests should harvest less than growth.

This difference is possibly because of aggressive assumptions on carbon revenues. For example, the model in Jenkins (2015) assumed that revenue streams for carbon projects would only continue up to 2020. Jenkins (2015) further highlighted that if offset prices increased and/or development costs decreased, smaller acreages would become feasible. In addition, by assuming that the project will be self-financed, this paper has not had to consider the cost of sharing revenue with a project developer.

Our model results were also compared with an academic study by Kerchner & Keeton (2015) on "California's regulatory forest carbon market: Viability for northeast landowners". The paper aimed to analyze the viability of small forest carbon offset projects by comparing different size and stocking scenarios. Using very similar cost assumptions to our financial model and targeting a 25% IRR, they calculated that projects under 417 hectares (1,030 acres) are not financially viable except at the most extreme stocking levels. Kerchner & Keeton (2015) also performed a scenario analysis using an assumption that projects have 20% carbon levels over the baseline and found that the minimum viable size is 600 hectares (1,482 acres) assuming no forest harvesting[8]. (However, in the 20% over baseline scenario they found that financial viability is dependent on assumptions that costs related to verification will go down over the lifetime of the project.) The authors also suggest that stocking greater than 39% above baseline is the ideal amount to ensure strong financial returns in a project.

Our financial model based on Bakersfield found a break-even point of 1,135 acres which was similar to that found by Kerchner & Keeton (2015). Our model also assumed a ~20% initial carbon stocking above baseline and shows positive financial returns if it was managed by 1-5 owners. Our Bakersfield model also produced a very similar NPV to what Kerchner & Keaton found at that stocking level ($322K compared to $296K in the paper). Overall, this paper helped verify that our financial model was producing results that were within normal limits and could be used as a basis for future project analysis.

RECOMMENDATIONS & CONSIDERATIONS

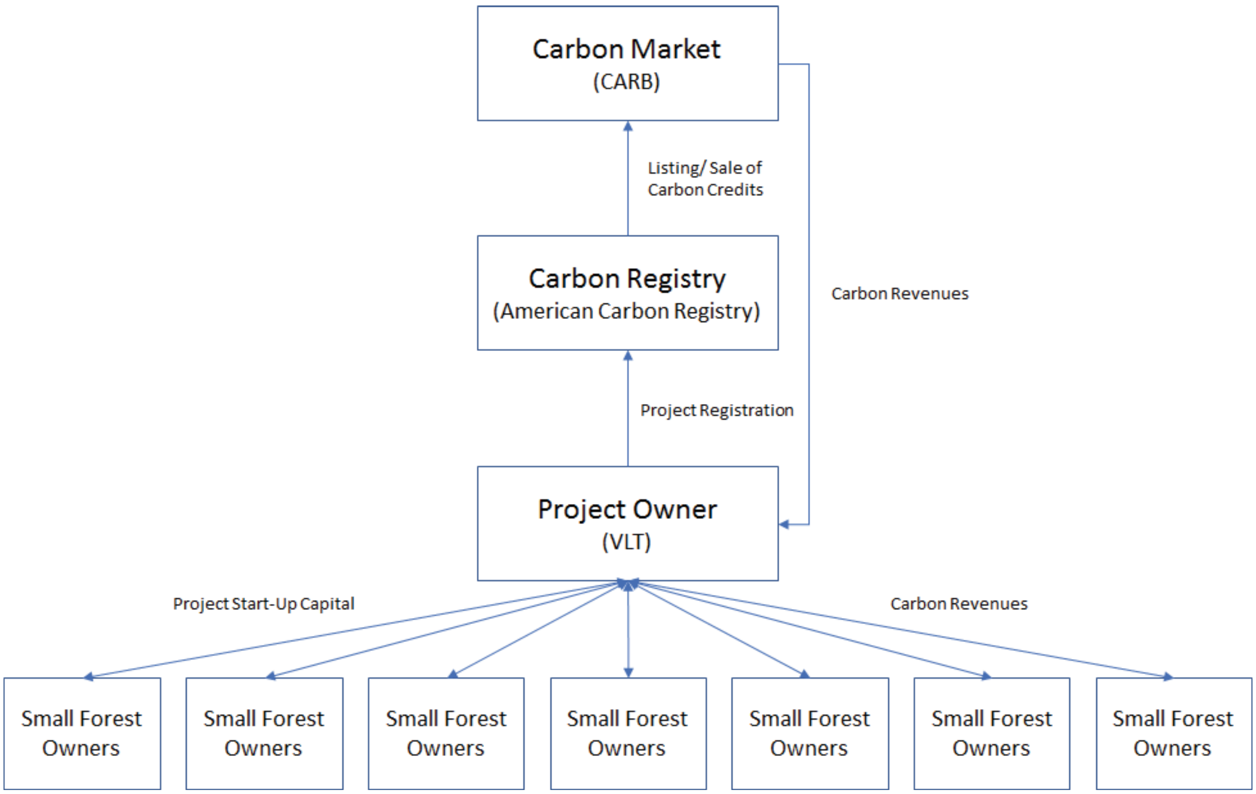
PROPOSED BUSINESS MODEL

OVERVIEW

Through our research and discussions with other industry members, we have formulated a proposed business model for Vermont Land Trust that should enable the success of forest carbon offsets in Vermont and the aggregation of small forest owners into a single project. As we have outlined, small forest properties currently have no access to the carbon offset market due to plot restrictions in various carbon markets and high-upfront project costs. Therefore, we recommend creating an aggregation business model which allows small forest owners to consolidate land holdings and submit a single project through one entity that is compliant with the various carbon market regulations. This also creates a more cost-effective project as all project costs can be shared across the group of owners, creating economies of scale.

[8] Termed in Kerchner & Keeton (2015) as 'passive management'. This would be the closest to this project's model as the other forest harvesting policies analyzed in Kerchner & Keeton (2015) seemed to consist of more aggressive even-aged management.

In order for the state of Vermont to successfully implement this model, a large entity with significant resources, connections to the local population and experience in forestry is required to act as the project owner. We believe that Vermont Land Trust can act as this entity provided they have sufficient capacity to do so. The responsibilities of VLT would be to solicit small forest owners, provide capital for project start-up costs, submit the project to a carbon registry (ex. American Carbon Registry) and then distribute the earnings accordingly to all forest owners. This is an illustration of the proposed model:



Barriers to the successful implementation of this model are the business development costs, compliance with specific carbon market regulations, drafting appropriate contract agreements and the resource capacity of the project owner. In order for the aggregation model to work, a dedicated business development employee would be required to solicit prospective forest owners in local regions, with the goal of getting multiple adjacent (or geographically close) properties together for one single project. This added cost makes the economics of the aggregation model more difficult in comparison to a single owner project. The second major obstacle is the contract agreements between the various small forest owners. Getting a number of parties to agree to the long-term requirements of a carbon offset project (25-100+ years) would be very difficult and would have added complexity when owners want to sell their property or pass it on to their family. This would increase the legal costs compared to a single forest owner project and could create additional costs such as the payback of offset credits should one owner in an aggregated project leave. It is possible that severe penalties for breaking the contract could deter any parties from leaving, however, this would also make the aggregated model a tougher sell to prospects. We have discussed the necessary steps to reduce this cost in more detail in a section below. Lastly, we expect that this model will take significant resources from the entity that acts as the project owner and aggregator in the form of forestry and legal expertise, sales and marketing expenses and administrative capacity. This may be out of scope for an entity like VLT and may require the use of a for-profit entity such as Forest Carbon Works.

Furthermore, we believe that the aim of any aggregated project should be to join the compliance offset market as this will provide the greatest returns and lower carbon price risk. However, as we have outlined, this is also the market with the most regulations around aggregation, so it may be difficult for many of the projects to pass compliance. Any project that fails to make it into the compliance offset market should then aim to join one of the various voluntary carbon markets which have must less stringent regulations, although they currently have a much lower carbon price.

Upon our meetings with forest landowners, it became clear that the key success factor of this model is the relationships with the forest landowners. VLT is the ideal organization for an aggregation model because of their strong relationships and knowledge of the forest owners in Vermont. These relationships are important for a variety of reasons including trust from the landowners that forest carbon offset projects are in their best interest, knowing which landowners would be most receptive to an offset projects and knowing which forests would meet the requirements of a viable offset project. As noted earlier in this report, this has furthermore been quantitatively analyzed by White (2017), which found that a non-profit organization as the key project administrator would make it more likely that forest landowners take part in the project. Should VLT determine that they do not want to become a project aggregator, we suggest that they partner with another aggregator so that their valuable knowledge and reach do not go unused. If VLT chooses to partner with a for-profit aggregator, the landowners may lose 5-40% of the carbon revenues as the aggregators use the revenues to pay for the up-front costs and to earn a profit (Encourage Capital).[9] While this may not be in the best interest of the forest owners of Vermont, it may be a way to mobilize the aggregation model much faster than VLT would be able to.

[9] Kerchner & Keeton (2015) suggest a similar figure of 20-35%.

HOW TO REACH OUT TO SMALL LANDOWNERS

The best approach for VLT to build aggregation projects is to utilize their current industry and forest owner contacts. Business development could take the form of town hall or face-to-face meetings, traditional advertising (flyers, magazine/newspaper ads) and online sources (social media, banner ads). VLT can also easily leverage their current events (of which there are multiple per month) to spread the word about having landowners join a forest carbon offset project. Furthermore, VLT can work with their recreation partners (120 total) who can also join a carbon offset project or add marketing for offset projects on their sites. If a dedicated business development employee was hired/assigned, they would attend all VLT related events and solicit people directly. VLT should focus communication with the landowners they have developed relationships with. Utilizing the confidence that landowners have through Regional Partnership relationships will aid in landowner selection. In addition, landowners that participate in existing conservation easements will already have committed to conservation, making these properties good candidates for an aggregation scheme.

We also suggest that VLT begin their search for aggregated projects by focusing on forests with the highest initial carbon stocking and properties that are already looking to be aggregated into a biodiversity conservation agreement or other type of conservation agreement. Forests with high initial carbon stocking are likely to be managed by responsible owners/foresters, making them likely to be more receptive to a carbon credit contract. Furthermore, forests with higher initial stocking reduce the total land area required for a project to reach economic viability which lessens some of the challenges of aggregating multiple parcels. High initial stocking also provides a large sum of revenue in year 1 which can ensure the financial viability of a project, even with the potential uncertainty of the California compliance market past 2030. We have also learned in our discussions with VLT and other forestry organizations that many forest owners collaborate for biodiversity conservation, using management plans that are contiguous throughout multiple properties. These types of properties would be more straightforward to aggregate, as they are already collaborating on a different kind of aggregation and they may be more receptive to pursuing an aggregated carbon offset contract as an extension of their current collaboration.

LEGAL AGREEMENTS/CONTRACTS

The success of any aggregated forest carbon offset project will be dependent on the legal agreements and contracts. In our discussions with legal contacts, we have identified several key issues that need to be solved in order for this to be feasible. Firstly, the development of a standardized boilerplate legal model for aggregated forest carbon projects is essential. While this could potentially be an expensive document to create, it would significantly cut down on the legal fees per project and would provide greater ease of use for any prospective forest owners. This standardized agreement needs to provide adequate flexibility for multiple landowners which would allow each of their key concerns to be addressed without having to alter the agreement. This flexibility would need to be built in without compromising the legal power and structure of the agreement. For future projects where conservation of land hasn't yet occurred, we encourage the standardized legal model be developed in conjunction with a conservation easement. Conservation easements are a widely accepted contract that already develop "permanence" and easements are seen by offset project operators as a possible way to demonstrate permanence, though the offset project operators also have some requirements in place to address "additionality" concerns. For example, the CARB only accepts easements signed up to a year earlier than the project start date.

We have assessed other aggregators legal agreements and contracts to determine what the best practices are. For example, if you wish to leave an aggregated project under Forest Carbon Works, the forest owner will be legally required by the state of California to replace/payback any CARB forest offset credits that have been previously issued to the project. As part of the contract, even if project land is sold, the new owner must maintain the terms of the original agreement. If there is unintentional damage to the forest on one of the owners' properties (from hurricanes, forest fire etc.), the project owner must assess how much of the buffer pool needs to be used and work with CARB directly to retire credits from the buffer pool or payback the credits.

We also recommend that VLT or any other non-profit aggregator pursue pro-bono legal work or a partnership with a law school (Vermont Law School in the case of VLT) to help develop the standardized agreements and contracts. This is a good way to cut down on the potentially large expense of having these documents created.

CASE STUDY - FOREST CARBON WORKS

Forest Carbon Works is a newly developed platform created by ecoPartners which aims to link small landowners with the forest carbon market. The company's goal is to remove traditional obstacles to the forest carbon market so that projects may be feasible for smaller landowners (less than 1000 acres). In order to do this, they streamline costs and internalize overhead that typically discourage small landowners from entering the carbon market. These techniques include:

1. Standardizing/automating the application process to easily detect properties which may or may not be eligible (via the application on Forest Carbon Works' website).
2. Internalizing the (often very expensive) costs of traditional inventories through use of new technology; they've created a smartphone app which employs a Bluetooth laser and cutting-edge sampling design so that landowners

themselves can take forest measurements without having any prior forestry knowledge. Landowners take photos which are sent back to them and they perform in-house analyses to estimate carbon.
3. Aggregating costs of training (about the smartphone) as well as third party audits (verification) via pseudo-aggregation. Projects in a given region are grouped together for training and audit purposes but function independently as their own projects and in terms of receiving payments for the credits their forests generate.

We have analyzed Forest Carbon Works and incorporated their strategy for our recommended VLT aggregated business model. Forest Carbon Works appears to have solved many of the difficulties of aggregation, however, they still face significant challenges. While their smartphone based inventorying app is said to have no statistical difference to traditional inventorying methods, they are still awaiting the results of a peer-reviewed academic paper to confirm this. Furthermore, the app only helps with the inventorying process and all projects must still pass a traditional verification which are still very laborious and expensive. If the smartphone app does not perform accurately and the projects fail verification, the entire inventorying and verification process needs to be redone which highlights the risk of using new technologies. More importantly, they face the difficult challenge of getting sufficient quantities of landowners in geographically close areas. While they have a history of completing forest carbon projects, they likely don't have the extensive relationships and intimate knowledge of local forests that an organization like VLT has, which will make business development slow and expensive. Despite these challenges Forest Carbon Works looks like a promising example of a dedicated forest carbon aggregator, and VLT can leverage their experience or work with them for the advancement of forest carbon projects in the U.S.

CONSERVATION EASEMENTS

Vermont's "Current Use or Use Value Appraisal" program was developed to maintain the agricultural and farm land in production and slow the development by allowing the lands to be taxed on their use value. Lands that are currently under conservation with qualified nonprofits can also be included. With this the Department of Taxes places a Lien on the property preventing development, if the land is ever developed, a land use change tax must be paid. To be enrolled as part of the Current Use program the land must have a forest or conservation management plan in place and be inspected once every 10 years. As of 2016 about one-third of Vermont's total land was enrolled in this program (Department of Taxes). The properties already enrolled in Vermont's current use program should be targeted by VLT as initial properties interested in carbon offsets since they have already pledged to keep their forest use unchanged.

The Current Use program also provides significant tax benefits to owners enrolled in the program. The program allows owners to pay tax only on the value of the projected revenues from the forests current use, not the potential value and revenues from development or any other “higher values”. This effectively lowers the tax rate on forests in the current use program by up to 90%. Landowners receive this benefit each year they opt keep the land as forest, if they develop they will lose the tax status and pay a financial penalty.

The current use forest tax rate is calculated by the state government and is essentially an estimate on the average timber harvesting revenues per acre across the entirety of the state. This number provides a good average revenue per acre number that can be used in our financial model.

When establishing baseline credits, if an easement is in place one year prior to the project's commencement date, it is considered a legal constraint and need to be modeled into the baseline. Depending on the encumbrances in the easement this could potentially reduce the credits they could receive. If done within a year, it could be considered part of the management of the project (Sarah Wescott, 26 July, 2016).

INVENTORY SOLUTIONS/COST REDUCTION TECHNOLOGY

COST SAVING TECHNOLOGIES

Inventory and verification costs are some of the biggest barriers for the small landowners ability to independently enroll in AB 32. There are great opportunities to use a geographic information, however it is expensive and can only help to reduce costs of on-the-ground inventories if the plot of land is very large or not accessible on the ground such as in Alaska. Many of these technologies also need on the ground measurements to measure carbon storage and calibrate to reduce uncertainty. If the verified sampling does not match with the inventory sample, the inventory must be completed a second time incurring an extra cost. This means that every parcel of land must be reviewed twice. These technologies can be used to produce the forest inventory faster and in a more efficient way along with other projections such as forest fire implications, future development simulations, and more. These different technologies would still need on the ground labor along with the plane or other satellites used. If the parcels of land are close enough to each other, there may be a possibility of it being cost effective and thus it may be worth it to get a costs estimate for using this technology for each project. Total costs for the use of these technologies are unclear as it varies project by project. From interviews with Carbon Developers such as the Climate Action Reserve, the consensus is this technology has cost reduction potential but currently the only projects it is feasible for are remote properties where ground measurement is not possible.

Forest Carbon Works has developed an application for smartphones that allows landowners to collect inventory data using Bluetooth laser and cutting-edge sampling using the phone. The images are then sent back to Forest Carbon Works where the inventory analysis is done. This allows for inexperienced forest owners to collect data without outsourcing the work.

With improvements in drone technology and carbon storage databases, there is potential of getting aerial images of the crown and with data on the age, density and species of the forest being able to calculate carbon storage. In conjunction with the aerial images, Jenkins et al. diameter-based algometric regression equations would be used to calculate the total biomass (USDA). This together would allow for an accurate carbon inventory to be completed. To reduce the cost of obtaining the aerial images VLT could partner with other organizations. There is currently a partnership between Spatial Informatics Group (SIG) and the University of Vermont (UVM) that is exploring the use of unmanned aircraft systems that provide on-demand high resolution imagery with a turnaround time of about 24 hours (SIG, 2016). This would be an opportunity for VLT to get involved in collecting the aerial imagery to have a database for when there are developments in measuring the carbon storage.

There are new development companies taking advantage of the potential for long term payouts such as SilviaTerra who is trying to use data to simulate a virtual forest to project growth. New technology companies such as SilviaTerra show the investment in the carbon offset market and the confidence in the longevity potential (SilviaTerra). There are also community driven approaches such as the The Suruí Forest Carbon Project that incorporates Google images, Open Data Kit and local participation to generate carbon offset data. The study area is divided into plots and after data is communally collected, it is sent back to an office for compilation and analysis (The Suruí Forest Carbon Project). Getting the landowners to work together and collectively store more reliable data would reduce the risk of the inventory being proven incorrect though verification and having to be redone.

Maintaining permanent plots can also be utilized as a cost saving technique. These plots are statistically more efficient in measuring changes in forest carbon stocks. The permanence allows for verifiers to find the plot and measure them at random (USDA). With many aggregated plots and multiple landowners having permanent plots and specific trees for verification in carbon growth would reduce overall costs.

The consensus is that new technology is close to being reliable enough to allow cost savings though the inventory process, but currently the risk is too high for not passing the verification protocols. There are multiple companies and developers that are in the process of completing methods that are compatible with the CARB verification standards. As it currently stands, the best method of inventory is the traditional on the ground measuring.

INVENTORY COST REDUCTION

Duke University has an ambitious carbon offset program which has the goal of becoming "climate neutral by 2024". One of the biggest strategies being used to get there is the use of carbon forest projects in the state of North Carolina (Duke University). They know that the inventorying process can be laborious and very cost prohibitive for landowners and thus they partner with the landowners who will later be providing the carbon offsets to not only provide a specific protocol but also provide inventorying help to reduce the costs. Duke offers graduate students the opportunity to use their skills and knowledge in the field to inventory the forests at a reduced cost to the landowner or organization (Chris Grippo, 2017). For VLT, this could mean teaming up with UVM, Middlebury, or another institution that can offer similar services. A system and partnership as such can provide a low cost inventorying method as well as grow and develop the skills of students at the university. A partnership can also be great to resource for other cost reduction or cost sharing initiatives.

Timber inventories often use the same or similar inventory techniques as carbon inventories. Carbon inventories do require more specific metrics and measurements but it would be in the land owners interest to time up the carbon and timber inventory to be done at the same time. This will not cut out all the costs associated with carbon inventories but it will cut out the costs for the parts of the inventory that the timber inventory already would have done.

RENEWABLE ENERGY

AB 32 establishes multiple renewable energy programs to supplement its other efforts to reduce emissions to 1990 levels by 2020. Utilities presently covered by AB 32 must already comply with legislation requiring them to procure 33% of their electricity from renewable sources, with that proportion rising to 50% in 2030. In 2016, California utilities have been successful at meeting this goal. Renewable energy sources have supplied up to 67.2% of the California grid's power on a single day. Additionally, there is a statewide mandate for the three largest utilities in the state to procure energy storage capacity. The momentum for renewable energy integration is inherent to AB 32's goals and its impacts on the Cap-and Trade program can become substantial over time (Fracassa, 2017).

Renewable energy projects, however, demonstrate other advantages over carbon offset projects in addition to the value of the carbon reduction. Solar and wind projects have standardized deployment mechanisms that are relatively inexpensive to initiate, such as streamlined interconnection application, financing, and permitting processes. The advance of energy storage technology combined with a declining price of materials presents further potential for renewable energy adoption as it would enable the resources to become dispatchable to meet the grid demand regardless of the time of day. Offsets are often seen as permission to continue to emit GHG emission and renewable energy projects help to reduce the GHGs at the source. Despite this, there is a

From the perspective of an entity covered by AB 32, carbon offsets are cheaper than renewable projects in terms of $/t CO_2e avoided. The levelized cost of energy (LCOE) is a calculation of $/MWh that includes average capital costs, operating costs, and fuel costs for different generation technologies to enable comparison. By gathering 2017 LCOE values for each renewable technology and incorporating CO_2emissions per MWh generated in California in 2015, both provided by U.S. Energy Information Administration, $/t CO_2e can be derived and compared between renewable energy and carbon offset projects (EIA, 2017). The emission values measured were restricted for fossil fuel generation that would have been replaced by renewable resources. The estimated values can be found in the chart below for three prominent renewable technologies: solar power, wind power, and hydropower.

Technology	LCOE ($/MWh)	Emissions per MWh fossil fuel (CO_2/MWh)	$/t CO_2e
Wind	44.3	0.47	$21
Solar	58.1	0.47	$27
Hydro	63.9	0.47	$30

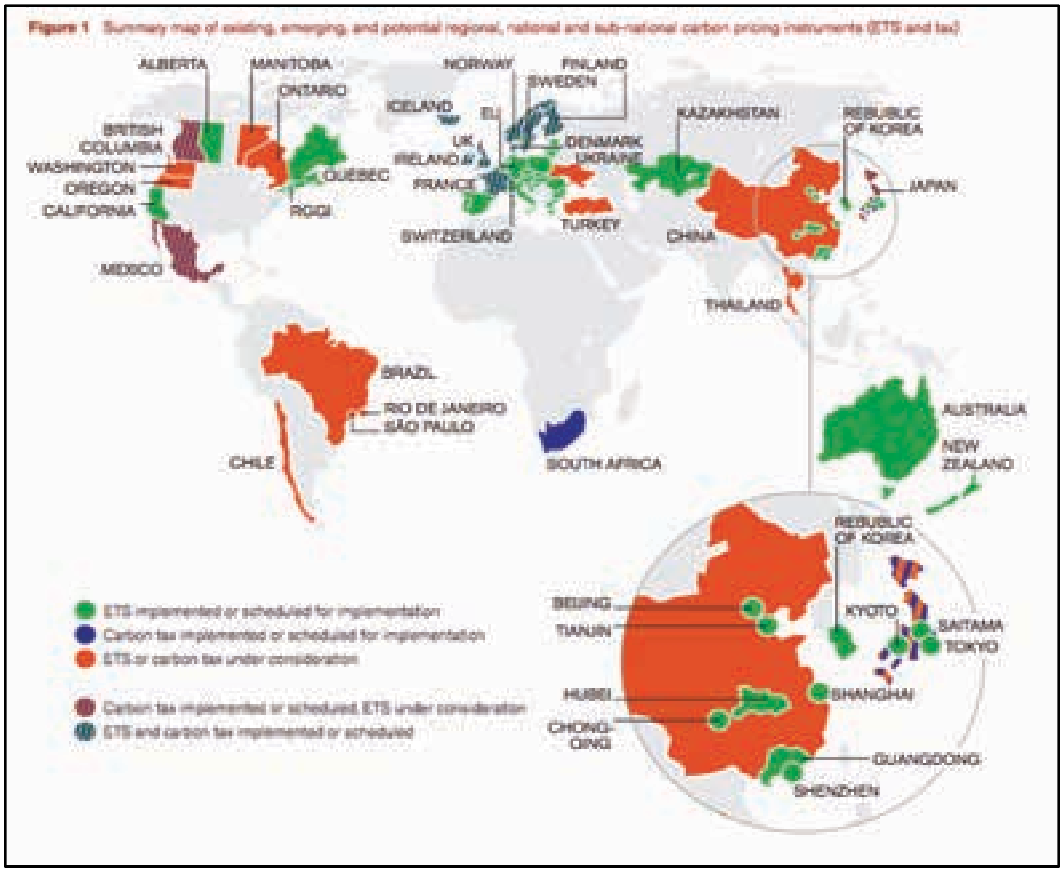
Renewable energy projects enable entities covered by AB 32 to reduce their emissions and the amount of offsets they would otherwise procure from the carbon offset market. This could lead to oversupply in the market, in which case the price for credits would decrease over time. There are two mechanisms, the price floor and the restriction of unsold credits, that prevent that price decline from damaging the stability of the market. The second mechanism, restricting unsold credits and effectively reducing the cap, is an important consideration when evaluating the impact of renewable energy integration.

According to the California Legislation, if credits are left unsold as a result of oversupply, they are resubmitted into the auction for the following two consecutive years. If after this they remain unsold, there is a limit of 25% of the total designated allowances placed on the amount of credits submitted back into auction. If there are more unsold credits than 25% of the total allowances, these excess credits are moved to the Allowance Price Containment Reserve. Once transferred to the Reserve, the credits can no longer be purchased voluntarily, and are only available to the covered entities of AB 32 (CARB, 2016).

Although the integration of renewable energy resource capacity is advancing at an accelerated rate, there is contentious debate over whether this rate of increased adaptation is sustainable. Renewable energy, such as wind and solar energy, are not dispatchable and depend on generation during hours of the day in which the natural resource is abundant. Storage technology in its current state is not cost effective, and as more wind and solar resources are added to the state's power mix, there are larger threats created to the grid's stability. There is debate over whether a goal of 80% renewable energy resources as an alternative to 100% renewable energy resources is a remedy to this threat. Given this complex set of circumstances and market dynamics, it is clear that the carbon offset market will persist in some capacity in the medium and long term.

POTENTIAL OF OTHER MARKETS

Carbon markets are part of both compliance schemes and voluntary programs around the world. Examples such as the U.S. markets with the Regional Greenhouse Gas Initiative(RGGI), Canada's provinces markets, Quebec and Ontario, the European market (EU ETS) and most recently the Chinese market. The figure below by Carbon Brief Ltd illustrates the states of carbon markets around the world. There are existing and emerging national or sub national carbon pricing emissions trading systems and carbon taxes (Carbon Brief, Ltd, 2014).



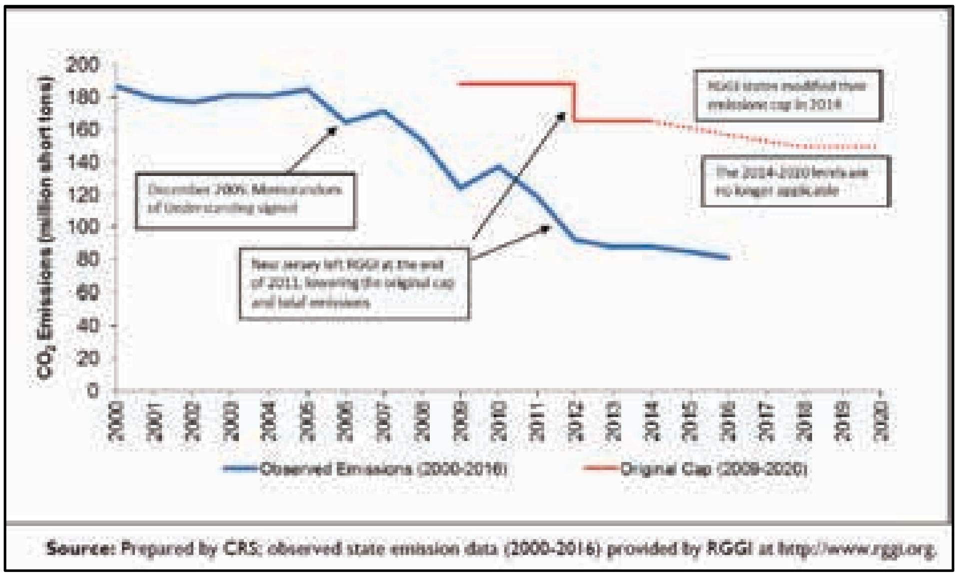
Source of graphic: https://www.carbonbrief.org/the-state-of-carbon-pricing-around-the-world-in-46-carbon-markets

COMPLIANCE MARKETS

THE U.S MARKET

There are two regional schemes in the United States, the California cap and trade system and the Regional Greenhouse Gas Initiative (RGGI). RGGI is the first mandatory cap and trade system for GHG emissions in the United States and took effect on January of 2009. The RGGI scheme only regulates CO_2 emissions from electric power plants with the ability to generate 25 megawatts or more in nine states, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont (Ramseur, 2017).

RGGI was created to set up an ambitious carbon market framework in the United States. However, the first set of emissions cap issued by RGGI in 2009 surpassed the actual amount of emissions emitted by electric companies in the different states, which resulted in the elimination of any demand for carbon offsets or credits (Ramseur, 2017). Electric companies ended up not taking any actions to reduce their emissions or having to buy any offsets or credits during this first period. One of the reasons for this event was that RGGI creators anticipated emissions to increase from 2002 levels. But, this never occurred instead emissions decreased (Ramseur, 2017).



Graph 1: Yearly view of the observed emission and the cap issued through RGGI from 2000-2016. Source of graphic: https://fas.org/sgp/crs/misc/R41836.pdf

In 2012, RGGI took steps to accurately adjust the cap, resulting in a 45% decrease (Ramseur, 2017). Recent studies reveal a significant decrease in CO_2 emissions and link the decline directly to the changes in the energy generation portfolio and energy efficiency programs (Ramseur, 2017).

The price floor for RGGI is designed to increase every year. The average price in 2017 is $2.15 U.S. per ton. RGGI measures allowances at the end of each compliance period, every three years (Ramseur, 2017). In the RGGI system purchased allowances can be banked for the next period, they are also factored into the amount of allowances released for auction (Ramseur, 2017). The price disparity suggests RGGI has not been successful at creating a strong market for offsets or credits.

Companies being regulated by RGGI can choose offset projects in five different categories to comply with the requirements established by RGGI (Regional GreenHouse Gas Initiative, Inc., 2017). Here is are the five categories:

- Landfill Methane Capture and Destruction
- Reduction in emissions of SF6 in the electric power sector
- Sequestration of carbon due to U.S forest projects (reforestation, improved forest management, avoided conversion) or afforestation, which only applies to the states of Connecticut and New York.
- Reduction or avoidance of CO_2 emissions from natural gas, oil, or propane due to the use of energy efficiency in the building sector
- Avoided methane emissions from agricultural work management operations (Regional GreenHouse Gas Initiative, Inc., 2017)

The sequestration of carbon compliance category represents a great opportunity for carbon projects within the nine states. In contrast to the California carbon market, RGGI requires all offset allowances awarded for U.S. projects to represent permanent carbon sequestration (Regional GreenHouse Gas Initiative, Inc., 2017). RGGI requires a conservation easement agreement approved by the relevant state agency wherever the offset project is located. In addition, the conservation easement must be perpetual in duration (Regional GreenHouse Gas Initiative, Inc., 2017).

THE CANADIAN MARKETS

The Canadian market of Quebec is currently integrated with the U.S. California's market. Canada's government is currently working to establish a market or scheme to reduce emissions in Manitoba. Canadian Prime minister Justin Trudeau has set a 2018 deadline for Manitoba's government to adopt a cap and trade approach or establish a carbon price of $10 per ton (CBC Radio-Canada, 2016)

CHINA AND ASIA-PACIFIC CARBON MARKETS

The government of China announced in September of 2016 the opening of a carbon market scheme in late 2017 (World Bank Group, Ecofys and Vivid Economics, 2016). Even though, the market has not officially opened, the government of China has revealed some of the nuances of the future market. The Chinese market is projected to be unprecedented in size due to its nationwide scale approach. It is expected to be in a range of 3 to 5 billion tons of carbon allowances yearly and it will be restricted to companies in eight sectors: petrochemicals, chemicals, building materials, steel, ferrous metals, paper making, power generation and aviation (Climate Change News, 2016).

The government of China plans to cap emissions for any company in these eight sectors who uses more than 10,000 tons of standard coal equivalent of energy annually. Early projections predict 7,000 companies will fall into this category (Climate Change News, 2016). This calculation suggests that nearly 50% of China's emissions will be accounted for in the new market.

THE EUROPEAN MARKET (EU ETS)

The European carbon market is the first and largest mandatory carbon market established around the world (World Bank Group, Ecofys and Vivid Economics, 2016). The European Union initiated the carbon market in 2005 as an effort to reduce GHG emissions in a cost-effective way. It is currently known as European Union Emissions Trading System (EU ETS) (The Directorate-General for Climate Action (DG CLIMA), 2017)

The European Union Emission Trading System is a regulatory carbon market that functions in 31 countries, it includes all 28 European Union countries plus Iceland, Liechtenstein and Norway. The EU ETS regulates Greenhouse Gas (GHG) emissions from approximately 11,000 power generation energy intensive installations, manufacturing companies and the aviation industry (The Directorate-General for Climate Action (DG CLIMA), 2017). The European carbon market phases describe a story of constant change and it shows some of the struggles to maintain the market demand.

- *2005-2007*: the first trading period constituted a process of 'learning by doing.' EU ETS was effectively established as the world's biggest carbon market. However, the number of allowances, based on projected needs, turned out to be disproportionate; subsequently, the price of first-period allowances fell to zero in 2007 (The Directorate-General for Climate Action (DG CLIMA), 2017)
- *2008-2012*: Iceland, Norway and Liechtenstein joined (1.1.2008) during the second trading period. The number of allowances was reduced by 6.5% for the period, but the economic downturn decreased emissions, and consequently demand, by even more. This led to a surplus of unused allowances and credits which weighed heavy on the carbon price. Aviation emission reductions were included into the system in January of 2012 (The Directorate-General for Climate Action (DG CLIMA), 2017)
- *2013-2020*: EU ETS made major changes during the third trading period. EU ETS introduced the EU-wide cap on emissions (reduced by 1.74% each year) and a progressive shift towards auctioning of allowances in place of cost-free allocation. Croatia joined the EU ETS during this period (The Directorate-General for Climate Action (DG CLIMA), 2017)
- *2021-2030*: a legislative proposal for the revision of the EU ETS was presented by the European Commission in July 2015 (World Bank Group, Ecofys and Vivid Economics, 2016) The proposal aims to reduce EU ETS emissions by 43% compared to 2005 levels for its next phase (2021 -2030), which falls in line with the

EU's 2030 climate and energy policy framework (The Directorate-General for Climate Action (DG CLIMA), 2017)

The EU ETS sets a cap on certain greenhouse gases that can be emitted by the sectors covered in the market. The companies regulated by the EU ETS can receive or buy emissions allowances, these can be traded among the same companies as needed. In addition, companies have the option to buy limited amounts of international credits from emissions saving projects around the world (The Directorate-General for Climate Action (DG CLIMA), 2017). Every company must submit sufficient allowances to cover all its emissions yearly, otherwise they can be subject to heavy fines.

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International credits are financial instruments that are generated thru two different mechanisms under the Kyoto Protocol (The Directorate-General for Climate Action (DG CLIMA), 2017). The Clean Development Mechanism and the Joint Implementation (JI). CDM allows industrialized countries to invest in projects that reduce emissions in developing countries and JI allows for industrialized countries to invest in projects to reduce emission in other industrialized countries. The Paris Agreement has set a new market mechanism to replace both financial instruments after 2020 so it can avoid the surplus of allowances (The Directorate-General for Climate Action (DG CLIMA), 2017)

EU ETS does not cover carbon forest sequestration, it focuses on emissions abatement in the power generation sector. Credits are accepted from different projects except from nuclear energy projects, afforestation and reforestation activities and projects involving the destruction of industrial gases (The Directorate-General for Climate Action, 2017).

Policy makers argue that the next logical step is to combine cap and trade efforts into one global carbon market. In theory, linking markets together should promote trading, smooth financial flows and lower the overall cost of reducing emissions. However, the reality is different, creating a global market will require a global policy that can be really difficult to develop.

EUROPEAN AVIATION EMISSIONS REDUCTION MARKET

As mentioned before, the European Union is taking action to reduce GHG emissions in Europe and it is working with the International community to develop measures with global reach. To continue on this path, the European Union Emissions trading system (EU

ETS) a compliance based market, included the CO_2 aviation emissions reduction during the second trading period that began in January of 2012 (The Directorate-General for Climate Action (DG CLIMA), 2017) This compliance based market requirement has successfully reduced the aviation sector carbon footprint by approximately 17 million tons per year (The Directorate-General for Climate Action, 2017).

The EU ETS aviation emission reductions follows the guidelines below:

- All airlines in Europe, European and non-European equally are required to track, report and verify CO_2 emissions, and submit allowances against their emissions yearly.
- Each airline operating in Europe is given tradeable allowances covering a certain level of emissions from flights per year.
- Airlines can reduce emissions by improving their operational measures such as upgrading and improving air traffic management technology, procedures and operating systems.
- Operators are required to submit one allowance per ton of CO_2 emitted on a flight to and from (and within) the European Union. This covers passenger, cargo and non-commercial flights and applies no matter where an operator is based - non-EU carriers will also need to comply with the scheme.
- Non-complying operators face a penalty of €100 per missing allowance, this will be on top of the obligation to procure and surrender missing allowances. In the long term, non- EU carriers are subject to be banned from operating in the European Union.
- EU ETS does not cover carbon forest sequestration, it focuses on emissions abatement in the power generation sector.

The verification data such as transport data and emissions reports must be completed and verified by an accredited independent verifier. The verifiers are pre- selected by the governing agency to ensure accuracy and standardization from the aircraft operator. The verification process usually starts four to five months before the deadline to submit emission reports, i.e. March 31 each year starting from 2011. (The Directorate-General for Climate Action (DG CLIMA), 2017)

In an effort to simplify the process, the EU ETS developed supplementary tools and guidance for aviation operators with small emissions (Less than 25,000 tons of CO_2 per year). Small emitters, European and non- European carriers, may determine the fuel consumption and CO_2 emissions using a simplified tool Small Emitters Tool (SET) from Eurocontrol to verify their emissions using data from the ETS support facility (The Directorate-General for Climate Action (DG CLIMA), 2017).

VOLUNTARY MARKET

The Voluntary markets allows businesses, governments, NGOs and individuals to offset emissions by acquiring offsets that were created thru the CDM or in the voluntary market (Carbon Offset Research and Education , 2017). Offsets are called Verified or Voluntary Emissions Reductions (VERs). In contrast to the compliance market, trading volumes in the voluntary market are smaller than the compliance market due to lower demand (Carbon Offset Research and Education , 2017). As demand is strictly voluntary in this market. Moreover, VERs are usually cheaper than the credits in the compliance markets.

Today, Voluntary Emissions Reductions are primarily used by companies who are looking to offset their emissions to showcase social responsibility and brand themselves as environmentally responsible. For instance, there are U.S. based airlines that offer the ability to reduce carbon footprint associated with the passenger air travel thru the purchase of carbon offsets. A great example of this is United Airlines, who offers a program called Eco-Skies, where personal or business customers have the option to enter the Carbon Choice program where they can participate in the reduction of the carbon footprint associated with their air by purchasing carbon offsets (United Airlines, 2017).

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) proposed by the International Civil Aviation Organization (ICAO) set to start in 2020 offers a new perspective on the voluntary market. Thus far, there are mixed reviews about the proposed program. Some sectors appear to be skeptic at the possible success of the program due to the lack of details offered by ICAO thus far(carbon market watch report), while others such as the International Emissions Trading Association (IETA), have shown optimism or interest about the proposed program. Others interested in the program are environmentalist, NGOs, governments and consumers who are looking forward to the demand of carbon offset projects such as REDD+ to satisfy the future offset demands in the aviation sector (IATA and Verified Carbon Standards, 2017).

ICAO – INTERNATIONAL CIVIL AVIATION ORGANIZATION

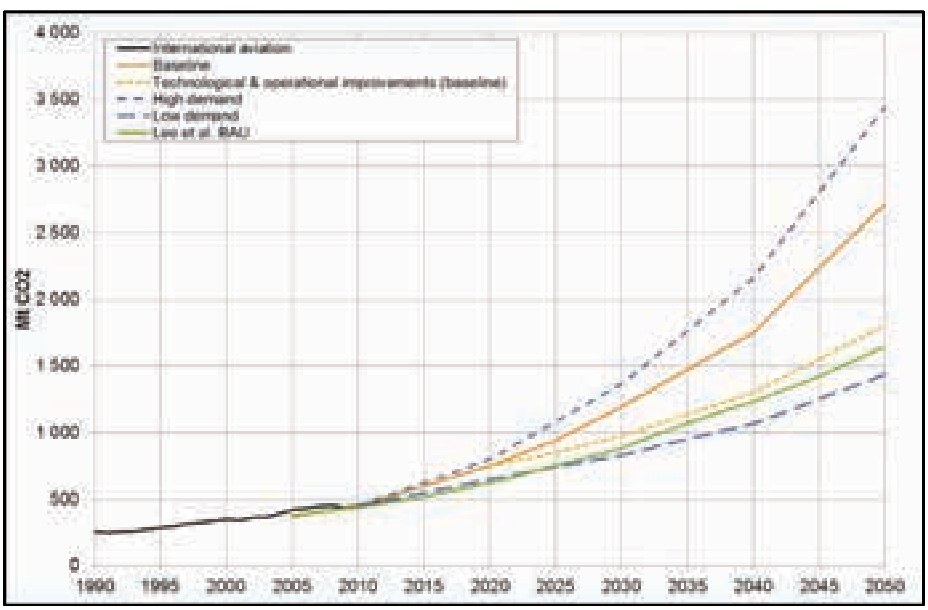
The International Civil Aviation Organization (ICAO) is a United Nations specialized agency established in 1944 to promote safe and organized growth of the aviation industry around the world (International Civil Organization (ICAO), 2017). Today, ICAO has 191 member states who back in October 2016 agreed to implement a global market-based scheme, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (Carbon Market Watch, 2016). This includes countries participating in the Organization for Economic Co-operation and Development (OECD) like the United States. This new scheme will limit future increases in greenhouse gas emissions from the international civil aviation industry from 2020 levels (CNG 2020). The CORSIA agreement is strictly voluntary at this time. As of June of 2017, 71 states have voluntarily agreed to participate in the agreement’s pilot phase set to start in 2021 (International Civil Organization (ICAO), 2017). These 66 countries represent approximately 87% of the International Aviation activity (Carbon Market Watch, 2016).

ICAO state members have agreed to implement the Carbon Offsetting and Reduction Scheme for International Aviation in three phases:
• Pilot Phase 2021 to 2023: the Pilot phase will only include states who participate on a voluntary basis
• First Phase 2024 to 2026: the first official phase will only apply to States that have volunteered to participate in the pilot phase or currently.
• Second Phase 2027 to 2035: It will apply to all states that have an individual share of international aviation activities above the specified threshold or limit.

This threshold is yet to be set and approved by ICAO members (International Civil Organization (ICAO), 2017). This stipulation will not include the Least Developed Countries (LDCs), Small Island Developing States (SIDS) and Landlocked Developing Countries (LLDCs) unless they volunteer to participate in this phase (International Civil Organization (ICAO), 2017).

As mentioned before, it is unclear what the future CORSIA agreement guidelines aviation will be, preliminary information by ICAO states the intend to reduce aviation’s net CO_2 emissions to 50% of what they were in 2005 by 2050.

PROJECTED CO_2 EMISSIONS FROM INTERNATIONAL AVIATION



Source: IEA 2014, ICAO 2013b, Lee et al. 2013

As per the European Commission, all air carriers to operate in the European union territory will still need to comply with the rules of the European union existing market . All aircraft operators, Intra EU flights including operators registered outside the European Union, starting intra-EU flights will continue to be required to comply with the Aviation EU ETS and surrender sufficient allowances during each compliance period to cover those intra-EU flights. According to EU ETS officials, the rules are unlikely to change in the short to medium term as a result of the outcome of the passing of the ICAO Resolution (The Directorate-General for Climate Action (DG CLIMA), 2017).

Flights that take off in the European union territory and land outside the European union territory or vice versa (Extra-EU flights) are not currently covered by the Aviation EU ETS because of the "stop the clock" temporary or provisional derogation established in 2012. Officials have announced, this derogation will automatically cease sometime in 2017, which will change the rules and extra-EU flights would from that date be covered by the Aviation EU ETS and will be treated in the same way as intra-EU flights unless further legislative measures occur to continue their exclusion. It is still too early to determine in what way the new CORSIA agreement will influence change the regulatory market. However, it is safe to say that the EU ETS will need to make amendments to their current rules in order to align with the new CORSIA agreement.

CONCLUSION

Through thorough background research and consulting industry professionals, the financial model created led to a business model to which recommendations are made. By analyzing case studies and identifying barriers we propose that aggregation of parcels less than 1,000 acres is best done using a carbon developer to oversee the project. This allows financial viability to the landowners and ensures that all AB 32 compliance protocols are met. The compliance offset market is still in development with policy changes being periodically passed changing the structure of the protocol. With updated policies and technology advancements it is hopeful aggregated landowners will be able to feasibly enter the market without a third party developer. With the success of other world markets and the recent growth of the aviation market, there is continuing potential for offset credits to be sold.

In conclusion, we believe there is a viable market for forest carbon offsets in the state of Vermont. Project aggregation is possible despite its many challenges, and would allow small forest owners, which comprise the majority of forests in Vermont, to join the compliance or voluntary carbon markets. We recommend that VLT implement our proposed business model or choose to partner with a dedicated forest project aggregator like Forest Carbon Works. We also encourage VLT to continue looking into the technology and other markets outlined, as they may provide significant benefits to the forest offset market in the near future.

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APPENDIX

APPENDIX A: STEPS FOR PROJECT ENROLLMENT

S/n	Item	Description
1.	Project design and planning	Site selection, community engagement, financing proposal, management structure proposal.
2.	Project listing	Akin to a building permit.
3.	Forest inventory	To perform an inventory of all carbon pools.
4.	Growth and yield modelling	To develop models of forest growth and yields, in order to quantify future carbon.
5.	Project documentation	Development of a detailed Project Design Document (PDD) which is given to an offset project registry.
6.	Third-party verification (initial)	This is required for the issuance of carbon credits.
7.	Project registration and issuance of offsets	Carbon credits are actually issued.
8.	Regular monitoring, verification	To continue ensuring the project document is adhered to so that credits can be issued over the project lifetime.

Source: Olander & Ebeling (2011); Jenkins (2015).

APPENDIX B: COSTS FOR A SAMPLE PROJECT (FROM SCS GLOBAL SERVICES)

An understanding of the costs associated with project implementation and ongoing management is essential to determining the feasibility of project aggregation. The results provided below present best estimates[1] of likely costs associated with:

- project development,[2]
- project listing and buffer withholdings[3],
- initial verification[4]
- ongoing project monitoring by the project owner[5], and
- periodic verification[6].

[1] Cost estimates compiled by SCS Global Services' GHG Program staff based upon 10 years of experience in working with numerous carbon offset project developers and verifying over 75 projects developed in accordance with all of the major registries.

[2] Project development includes conducting an inventory of carbon stocks on the property, modeling the carbon yield and preparing a project design plan and supporting materials to submit to the applicable registry.

[3] Project listing refers to having the project listed on the applicable registry, which includes fees for setting up the account and submitting the project. A project proponent must demonstrate project eligibility before the project can be listed.

[4] Initial verification is required before credits can be registered and issued. This entails a site visit, check cruising, modeling, review of the project design document and preparation of a verification report.

[5] The project owner is required to conduct periodic monitoring of the project to ensure consistency with project design and update the inventory and project design projects as appropriate.

[6] The project must be verified by a third-party periodically after implementation. Frequency of verification will vary based on the registry.

[7] Costs are variable and dependent on available information, in-house expertise, and prior experience.

[8] This fee applies when CAR is used as an Offset Project Registry for an CARB compliance project.

[9] CARB has elected not to function as a registry. Rather, independent entities can apply to be endorsed by CARB as registries for projects developed under the CARB protocol. To date, only VCS, CAR and ACR have sought and achieved standing as CARB registries.

Table B1: Estimated Costs for a 200-400 Acre Project

Carbon Registry/ Standard	ARB	CAR	VCS	ACR
Project Type	Compliance Offset Protocol for U.S. Forest Projects	Improved Forest Management	Improved Forest Management (VM0003)	Improved Forest Management (ACR Forest Carbon Project Standard)
Development costs	$25-$60K	$20-$50K	$20-$50K	$20-$50K
Project listing costs[7]	Account Set Up: $500 Project Submittal Fee: $700 (CAR) Project Account Fee: $750 (ACR)	Project Submittal Fee: $700 Account Set-Up Fee: $500 Project Submittal Fee[8]: $500	N/A	Account Opening Fee: $500 Project Account Fee: $750 (ACR) Project Screening: $1000
Initial verification costs	$35-$40K	$25-$30K	$25-$30K	$25-$30K
Ongoing monitoring by owner costs	$0-$15K	$0-$15K	$0-$	$0-$15K
Ongoing verification costs	$10-$12K/year	$10-$12K/year	$15-$20K/year	$10-$12K/year
Marketing and transactional costs (for the sale of credits)	Fees apply from the relevant registry. [9]	Annual Fee: $500 Issuance Fee: $0.22/ton	Annual Registration Fee: $0.10/ton VCS Issuance Levy: $0.10/ton	Activation Fee: $0.15/ton Transaction Fee: $0.02/ton

Table B2: Estimated Costs for a 2,000-Acre Project

Carbon Scheme (Program)	ARB	CAR	VCS	ACR
Project Type	Compliance Offset Protocol for U.S. Forest Projects	Improved Forest Management (Forest Project Protocol V3.2)	Improved Forest Management (VM0003)	Improved Forest Management (ACR Forest Carbon Project Standard)
Development costs	$35-$80K	$30-$70K	$30-$70K	$30-$70K
Project listing costs	Account Set Up: $500 Project Submittal Fee: $700 (CAR) Project Account Fee: $750 (ACR)	Account Set-Up Fee: $500 Project Submittal Fee: $500	N/A	Account Opening Fee: $500 Project Screening: $1000
Initial verification costs	$40-$50K	$25-$32K	$25-$30K	$25-$30K
Ongoing monitoring by owner costs	$0-$25K	$0-$25K	$0-$25K	$0-$25K
Ongoing verification costs	$10-$12K/year	$10-$12K/year	$15-$20K/year	$10-$12K/year
Marketing and transactional Costs (for the sale of credits)	Fees apply from the selected registry.	Annual Fee: $500 Issuance Fee: $0.22/ton	Annual Registration Fee: $0.10/ton VCS Issuance Levy: $0.10/ton	Activation Fee: $0.15/ton Transaction Fee: $0.02/ton

APPENDIX C: SUMMARY OF FEES CHARGED BY OFFSET PROJECT REGISTRIES

	Climate Action Reserve	American Carbon Registry	Verified Carbon Standard#
Account: One-off			
Account setup fee	$500 / account	$500 / account	$300 / account
[if aggregated] Project Owner setup fee	$200 / owner	-	-
Account: Annual fees			
Account Maintenance Fee (annual)	$500 / account-year	$500 / account-year	$300 / account
[if aggregated] Project Owner Maintenance Fee	$200 / owner-year	-	-
Project: Submission fees			
For CARB protocol	$700 / project	$750 / project	$500 / project
For voluntary protocol	$500 / project	$1000 or $2500 / project*	-
Project: Per credit fees			
Issuance fee	$0.19 / credit	$0.15 / credit **	$0.16 / credit ##
Retirement fee	Nil	$0.02 / credit	
Others (if applicable)			
Account re-activation	$500 / account	-	-
Project variance review fee	$1350 / project	-	-

Project transfer fee (between account holders)	$500 / project	$0.08 / credit	-
Project transfer fee (to another OPR)	-	-	$0.10 / credit
Holding fees	-	-	$5000 / project-quarter ###
Credit Transfer fee	$0.03 / credit	$0.02 / credit	$0.03 / credit
Cancellation fee (for conversion from voluntary to ARB)	$0.03 / credit	$0.03 / credit	$0.16 / credit ####
Buffer credit cancellation (if buffer has to be used)	-	-	$0.04 / credit

Sources:
http://www.climateactionreserve.org/how/program/program-fees/ (Climate Action Reserve); http://americancarbonregistry.org/how-it-works/membership/acr-fee-schedule/acr-fee-schedule-june-2015.pdf (American Carbon Registry); http://www.v-c-s.org/project/california-offset-project-registry/vcs-offset-project-registry-fee-schedule/ (Verified Carbon Standard)

Notes:
* $1000 screening fee for projects using ACR methodologies, $2500 screening fee for eligibility of methodology if not an ACR-approved methodology or for CDM methodologies to be implemented in the US.

** The ACR does not charge issuance fees, but issued offsets are considered "inactive" and cannot be transacted, retired or cancelled until "activated" by the account holder at a cost of $0.15 / credit.

The VCS provides special fees for the California Offset Project Registry system. VCS carbon offset fees for their voluntary protocols are separate and not listed here.

The VCS does not charge issuance fees but instead charges for the submission of annual Offset Project Data Reports. Each year, the $0.16 / credit charge is for the estimated number of credits issued net of buffer credits, and is capped at $10,000, as follows:

[(estimated issuance – buffer) ´ $0.16] capped at $10,000

At the time of "activation", the OPDR submission charges help offset the activation fees, as follows:

[(total issuance – buffer) ´ $0.16] + [buffer ´ $0.04] – [Fees earlier paid for OPDR submittal]

This fee is assessed when a project that has issued VCS credits has not activated or cancelled those credits within three months of issuance. This fee will continue to be charged quarterly thereafter until the credits have been activated and cancelled with the total charges not to exceed the balance due at activation/cancellation.

VCS charges the same fees for activation as for cancellation, the latter being for the purpose of converting voluntary credits to CARB compliance market credits##.

APPENDIX D: CONTACT INTERVIEWS

Interview with Eron Bloomgarden and Utkarsh Agarwal of Encourage Capital

The group spoke with Eron and Utkarsh of Encourage Capital about economics and financial metrics for aggregated forestry carbon offset projects. They discussed soft costs required for the application and verification, such as registration, inventory costs, and legal costs. They estimated the typical revenue stream and highlighted some obstacles in working out an agreement among stakeholders. They also discussed the market developments in the future, specifically concerning the political debate surrounding AB 32 and its associated uncertainty. Other carbon markets were reviewed and compared for viability.

Email from Mary Kallock of Eco Partners

Mary of Eco Partners responded to an email request with a description of the firm's success in submitting large forest projects into the California Compliance Market and its launch of Forest Carbon Works. She described Forest Carbon Works purpose, to enable smaller landowners to enter the carbon market, and discussed the techniques utilized by the firm to streamline the process. She emphasized the need for standardizing the application process and reducing costs that might become prohibitive for small landowners. She provided further resources relating to forest management and carbon markets.

Interview with Josh Parrish of the Nature Conservancy

A phone interview was conducted with Josh Parrish concerning his familiarity and work experience with carbon offset projects. He explained that his role at the Nature Conservancy has exposed him to carbon offset project development. In his experience, aggregation of private lands for compliance market offsets has proven too difficult with small land owners. Instead, Parrish focuses on the voluntary offset market as the standards are easier to comply with. He also explained that he is working in conjunction with SilviaTerra on their inventory application, and pushing for a "family forest friendly" carbon offset project protocol so that small land owners can begin to reap the benefits of carbon offsets.

Interview with Marisa Riggi of Northeast Wilderness Trust

The group spoke with Marisa Riggi of Northeast Wilderness Trust about the organization's experience with AB 32 carbon offset projects. She explained that the organization ultimately partnered with a carbon company, New Forest, to help guide them through the complicated process. They discussed the financial allocation of the revenues, the ownership of the land, the verification process, and the timeline of the project. She highlighted the burdensome submission process, which created a barrier to entry or to replication for her organization. She also described the geographical barriers to aggregating small landowners without major difficulty.

Interview with Robert Turner of Vermont Land Trust

The group met with Robert Turner of Vermont Land Trust to barriers aggregation and forest modeling. He highlighted the difficulty of aggregation, but attributed it largely to difficulty in finding like-minded participants located in the same geographic area that will commit to a project that spans 100 years. The group also discussed measuring forest density, inventory and verification barriers, and remote sensing potential. He suggested a combination of a technological solution combined with a manual inventory process, but emphasized that verification must be done manually on the ground.

Interview with Peter Weisberg of The Climate Trust

The group spoke with Peter Weisberg of The Climate Trust collecting initial research about carbon pricing and barriers with aggregation projects. They discussed the 100 commitment as a significant barrier as well as the relationship with the landowner. Peter highlighted three different pricing models for the developers to get landowners onboard. The future of carbon pricing was also discussed with continued growth at 5% each year and a shortage predicted at 2025.

Interview with Sarah Wescott of Climate Action Reserve

The group spoke with Sarah Wescott of Climate Action Reserve about project development and the implementation process, costs, use of technology, and markets generally. They also discussed aggregation of small projects and changes to the CAR's voluntary forest project protocol. She highlighted the inclusion of management risks into the buffer pool for a forestry project, as well as the differences between the CARB Compliance Offset Protocol and the strictly voluntary Forest Project Protocol. The group also brought up the possibility of remote sensing technology deployment, which she responded was usually cost prohibitive. The new features introduced into the Protocol were also discussed, which include revised minimum sampling plots and a new computer inventory tool.

APPENDIX E: TABLE OF APPROVED PROJECTS

The table below is a summary of the data that was collected on approved and enrolled carbon offset projects in the compliance market.

State	Sum of Net Credits	Sum of Acres	Net Credits per Acre
AR	277810	31738.7	8.8
AZ	3824852	89396.5	42.8
CA	13126072	322871.26	40.7
ME	4001098	120268	33.3
MI	2150413	229601	9.4
MO	137536	3982	34.5
NC	1016672	9693.52	104.9
NH	1562957	143203	10.9
NY	830427	205799.94	4.0
SC	1685754	38414	43.9
TN	484887	15396	31.5
VA	2809127	128419	21.9
WA	37875	520.8	72.7
WI	731728	29000	25.2
WY	3615158	97418	37.1
Total	**36292366**	**1465721.72**	