CARBON FOR CONSERVATION

by

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Executive Summary

In this report, we evaluate the prospects for The Nature Conservancy’s North Carolina chapter (TNC NC) to sell carbon offset credits in order to generate revenue for their conservation work. TNC NC is interested in developing offset projects by enhancing carbon sequestration in forestland and pocosins—a type of forested peatland found on the coastal plain of the southeastern US. These two ecosystem types comprise a large proportion of the 700,000 acres that TNC NC has conserved in North Carolina within three conservation focus regions: the Albemarle-Pamlico, Longleaf Pine, and Southern Blue Ridge regions.

Our study began by analyzing trends in current carbon offset markets to understand the options, risks, and opportunities they provide for TNC NC. Offset credits can be transacted in the voluntary market, which is open to businesses seeking to reduce their carbon footprints, or in compliance markets, which are associated with regulatory regimes that require sectoral or economy-wide reductions of carbon emissions. The primary US compliance market exists in California, which supports offset credit transactions through its cap-and-trade program.

Based on information and perspectives we collected from practitioners in the field, we determined that the California compliance protocol would be the most attractive methodology for TNC NC to use in developing forestry offset projects—including reforestation, improved forest management (IFM), and avoided conversion project types—because of its environmental rigor and high compliance offset credit prices. Pocosin offset projects must be developed using the voluntary market protocol for pocosin restoration, released in 2017. Our market analysis also showed that project size is a critical factor in determining financial viability: most forestry projects in the compliance market cover at least 5,000 acres.

To identify locations within TNC NC’s focus regions that could be attractive for an offset project, we conducted a site prioritization using a geospatial model that ranked all non-federal land parcels greater than 500 acres according to the following criteria: size, percentage of target cover types, climate resiliency, conservation priority, and proximity to other parcels protected by TNC NC. Using a subset of these priority parcels as case studies, we then estimated the carbon that would be sequestered under baseline and project scenarios for a forest or pocosin offset project. Finally, we conducted discounted cash flow modeling for any case study sites that sequestered carbon over baseline levels. This analysis allowed us to evaluate what parcel characteristics and project types would lend themselves to a financially viable offset project.

The site prioritization model analyzed 1,937 total parcels. Of these, we selected six parcels with generally high site priority scores to model as case studies of project types available to TNC NC. The case studies included at least one example of each forestry and pocosin project type.

None of the case studies modeled for IFM were shown to be viable offset projects. The Sandhills Game Land Project would be managed for low tree density with frequent burning by TNC NC, simulating natural conditions in a longleaf pine ecosystem. These management activities, while providing high-quality wildlife habitat, would not allow the project’s carbon stocks to grow beyond the baseline scenario. The Balsam Gap Project would likewise see its carbon stocks fall below the baseline due to TNC NC’s expected management regime, which in this case would involve lowering tree density to promote regrowth of native oak species.
through prescribed burns. Finally, the Red Mountain Timber Co Project accumulated carbon stocks above the baseline as a result of extending rotation ages on its loblolly pine plantation, but this project was deemed non-viable due to expected leakage of timber harvests outside the project area. This leakage factor canceled out the project’s entire projected offset credit stream.

The Balsam Gap Project was also modeled for avoided conversion, but the estimated rate of land conversion in the baseline scenario was not high enough to offset the decrease in forest carbon stocks from TNC NC’s expected management activities. A more viable model for avoided conversion was the Robinette Project, which generated a positive stream of offset credits due to the high expected conversion rate of forest to residential development under the baseline scenario and the lack of active management activities expected on the site’s coastal hardwood and cypress forests under the project scenario. This project produced the greatest expected financial return of all six case studies.

Case studies for other project types produced more nuanced findings. For the Murphy Farms Project, a 660-acre parcel modeled for reforestation of longleaf pine, the project revenues did not quite compensate for the planting, management, and project development costs over its 25-year crediting period, though our analysis showed that a slightly larger project with similar attributes would be more financially viable. Meanwhile, the Bryan Farms Project, modeled for pocosin restoration, yielded a positive return within its 20-year crediting period. The actual return of a pocosin project, however, would be dependent on the magnitude of restoration costs, which can vary widely based on site-specific conditions. The financial viability of both the Murphy Farms and Bryan Farms Projects is also highly sensitive to the discount rate and forecast of offset credit prices used in the analysis.

The results of our case studies broadly show that conservation and carbon sequestration goals aren’t always aligned. A management regime that periodically decreases carbon stocks in order to improve wildlife habitat or forest health may preclude a viable carbon offset project on the site. Nevertheless, it is possible to establish a viable offset project on land where conservation and carbon management objectives are more aligned, as they are in the latter three case studies. In line with our findings, we recommend that TNC NC explore sites for avoided conversion, reforestation, and pocosin offset projects. For any potential project, TNC NC should first conduct landowner outreach and collect field data to refine the outputs of our carbon and financial models. This will allow TNC NC to better assess project feasibility before moving forward with offset project development.
Introduction

The Nature Conservancy’s North Carolina chapter (TNC NC) is exploring opportunities to secure additional financing for the conservation work they undertake on forest lands and pocosins in North Carolina. The sale of carbon offsets from lands protected by TNC NC is one potential mechanism to generate revenue for their conservation work. This project evaluates the prospects for TNC NC to develop carbon offset projects in North Carolina for that purpose, and makes recommendations for project types and locations within the state that may be attractive for offset project development.

What are carbon offsets?

As their name implies, carbon offsets are credits that “offset” the greenhouse gas (GHG) emissions of companies or individuals. Offset credits are derived from activities that either reduce emissions of GHG or remove GHG from the atmosphere, with one credit typically equal to one metric ton (mt) of carbon dioxide equivalent (CO$_2$e) in GHG reductions. Offset registries are responsible for approving offset projects and issuing offset credits for their GHG reductions. Offset credits can then be transacted in the voluntary market, which is open to any businesses seeking to reduce their GHG emission footprint, or in compliance markets, which are associated with regulatory regimes that require sectoral or economy-wide GHG reductions. Offset credits benefit buyers by allowing them to meet regulatory obligations (in compliance markets) or internal goals for GHG reduction (in both voluntary and compliance markets), while sellers, which can include landowners, nonprofit organizations, and businesses, benefit from additional revenue to support their GHG-reducing activities.

A wide range of activities can qualify as carbon offset projects, provided that a protocol for quantifying their GHG reductions has been approved by an offset registry. Here, we are primarily interested in offsets from biophysical carbon sequestration, which is the process by which plants remove CO$_2$ from the atmosphere and store it in biomass or soil. Carbon sequestration occurs in forests, grasslands, agricultural lands, wetlands and peatlands. In North Carolina, the greatest potential for carbon sequestration offset projects comes from forests and pocosins—a type of coastal peatland specific to the southeastern United States.

Approved protocols exist for forestry projects that enhance carbon sequestration through afforestation/reforestation, improved forest management (IFM), or avoided conversion of forest to other land uses. A pocosin protocol has also been approved for enhanced carbon sequestration through the restoration of pocosin peatlands. All of these qualifying activities are considered in examining the feasibility for TNC NC to develop a carbon offset project. A full list of protocols that are applicable to carbon sequestration in US forests and peatlands can be found in Appendix A.

Why is TNC NC interested in carbon offsets?

TNC NC has already conserved 700,000 acres of land in the state, including sizeable areas of forest land and pocosins. These lands are managed according to organizational priorities including protection of at-risk species and conservation of climate-resilient
landscapes, i.e., those that can better withstand the shocks expected with future climate change. Many of TNC NC’s existing land management priorities may also result in enhanced rates of carbon sequestration, so implementing carbon offset projects on new lands brought into the portfolio could make sense programmatically as well as financially.

What would TNC NC need to move forward?

In order to proceed with developing an offset project, TNC NC would first need to assess four types of information about the potential project:

1. **Alignment with conservation priorities**: TNC NC has established priority areas for conservation work in North Carolina, and any carbon offset project must further those priorities in order to be consistent with TNC NC’s mission. Alignment with conservation priorities is thus considered as the most important criterion in identifying sites for potential carbon offset projects.

2. **Carbon offset volumes**: Modeling the potential for carbon sequestration on the project site under TNC NC’s management regime will give TNC NC an estimate of the volume of offset credits they could expect to generate throughout the project’s crediting period. This information will be useful in guiding TNC NC’s future management decisions on land that could be suitable for an offset project. Estimating the volume of carbon offsets produced over the lifespan of the project requires time-series models of carbon sequestration in both the baseline and project scenarios.

3. **Project cost and cash flow**: Offset projects require significant outlays of capital to develop, so it will be important for TNC NC to understand the resources that would be required to go down that path. The financial analysis will forecast the cash flow, net present value, and internal rate of return associated with the project, so TNC NC can make informed decisions about whether to proceed with project development and, if it does so, how to manage its financial resources for the project.

4. **Project and market risks**: Like most environmental markets, the carbon offset market includes a non-negligible level of risk for participants. Risks include delays and cost overruns in project development, volatility in offset credit prices, and changes to regulations that could affect the demand for and eligibility of offset credits in certain markets. If TNC NC decides to enter into the carbon offset market, it is essential that it does so with a balanced view of the risks and rewards that accompany that decision.

This report seeks to provide TNC NC with sufficient detail on all of the above information for recommended project types and locations. The next section will more fully detail the project goals.
**Project Goals**

In consultation with TNC NC staff, we have identified four main project goals. Each contributes to the project’s primary objective of recommending suitable locations and project types for TNC NC to pursue in developing a carbon offset project. The four goals are:

1. Analyze trends in current carbon offset markets to understand the options, risks, and opportunities they provide for TNC NC.
2. Identify land parcels within TNC NC’s existing focus regions that could be attractive for establishing an offset project, based on the parcels’ acreage, land cover type, and other factors important to TNC NC’s conservation objectives.
3. Using a subset of these priority parcels as case studies, quantify carbon sequestered under baseline and project scenarios for various types of offset projects.
4. Use cash flow modeling to evaluate what parcel characteristics and project types would lend themselves to a financially viable offset project.
Background

Carbon Sequestration in Forests and Pocosins

Forests

Forests are critical ecosystems for carbon sequestration because trees remove CO₂ from the atmosphere to use in photosynthesis, and they store carbon in their biomass and in the soil as they grow. North Carolina is a heavily forested state, with about 60% of its land area covered by trees.¹ The state’s abundant forest resources therefore make it an attractive location for forest carbon offset projects.

North Carolina is home to at least 40 different forest types.² The Appalachians in western North Carolina support primarily hardwood forests, while the Piedmont in the central part of the state exhibits a mix of pine and hardwood forests and the coastal plain is more dominated by pines, woody wetlands, and pocosins. North Carolina’s forests store, on average, 94 mt CO₂e per acre, and sequester an additional 3.6 mt CO₂e per acre per year.³ On both counts, the state’s forests are substantially more productive than the national average—76 mt CO₂e per acre stored and 2.1 mt CO₂e per acre per year sequestered.⁴ However, these averages do not account for the differences in carbon storage and sequestration rates that occur among forest types within North Carolina.

By considering the carbon storage values of each forest type, we see a distinct spatial pattern of carbon density in biomass across North Carolina (Figure 1). The hardwood forests in the mountains store the most carbon in the state (up to 422 mt CO₂e per acre), while the density generally decreases moving east toward the coastal plain. However, there are also a few regions in eastern North Carolina that show an especially high carbon content (the dark blue patches in the northeastern quadrant of the state). These zones of concentrated carbon correspond with protected areas such as the Great Dismal Swamp and the Roanoke River National Wildlife Refuge, where the forest is more dense than in the surrounding agricultural lands.

This trend highlights the effects of land management on forest carbon sequestration. A forest that is densely packed with growing trees that sequester and store carbon will have a higher carbon content than land that is managed for more open spaces by removing or excluding trees.

¹ North Carolina Forest Service, 2017a
³ Birdsey, 1992
⁴ Ibid.
Figure 1. Distribution of aboveground carbon in North Carolina.\textsuperscript{5}

\textsuperscript{5} Kellendorfer et al., 2013; United States Environmental Protection Agency, 2015
Pocosins

Peatlands play an important role in the global carbon balance, both in terms of their carbon storage capacity as well as the potential for release of stored carbon due to drainage, drought, and rising temperatures. While they only cover about 3% of the earth’s surface, they store one-third of the world’s global soil carbon, or about 445 billion mt.\(^6\) Peat forms very slowly, but can rapidly release huge amounts of carbon dioxide back into the atmosphere under drained conditions. In the pocosins of the Southeastern US coastal plain, peat accretes approximately 33 cm per 1,000 years.\(^7\) Using Cesium-137 and Lead-210 dating in soil cores, Drexler et al. (2017) estimate that vertical accretion rates within the peatlands of northeastern North Carolina range from 0.10 to 0.56 cm per year, with annual carbon accumulation rates of 51 to 389 g C per square meter per year. Carbon density and peat accretion are closely related to porosity and highly affected by drainage, which is known to cause land surface subsidence in peatlands.\(^8\)

Despite their ecological and climate importance, drainage and conversion of pocosins has been commonplace. In North Carolina, there were historically over one million hectares of peatlands but as of today roughly 66% have been drained, largely for conversion to agriculture or timber production.\(^9\) Dry conditions allow peat to oxidize or decompose, releasing carbon dioxide back into the atmosphere. By raising the water table, it is possible to not only restore ecosystem function, but also to prevent further emissions of carbon dioxide and transform them back into net carbon sinks.

Offset Projects

Project Types

The most prominent US-based offset registries offer protocols for three types of carbon sequestration projects from forestry: afforestation/reforestation, improved forest management (IFM), and avoided conversion of forest land. Afforestation/reforestation projects sequester carbon by planting new trees on land that contains little to no current canopy cover, or that was subject to a natural disturbance that removed a significant proportion of its tree stock. IFM projects increase the carbon sequestration rates in existing forests relative to baseline levels by extending the rotation age for harvesting, stocking trees more densely, or implementing other active management practices. Avoided conversion projects prevent emissions from carbon currently sequestered in forest biomass by protecting forest land under significant threat of agricultural or urban development.

While forestry project protocols are well-established in most offset markets, far fewer markets recognize protocols that quantify the carbon sequestration potential in pocosins. The only protocol that addresses carbon sequestration in pocosins was released in 2017 and is

\(^6\) Wang, Richardson, & Ho, 2015
\(^7\) Drexler et al., 2017
\(^8\) Ibid.
\(^9\) Drexler et al., 2017; Richardson, 2003
The protocol applies specifically to carbon sequestration through the rewetting of pocosins that have previously been drained.

**Project Development Process**

Our analysis is intended to help TNC NC identify attractive offset project types and locations. Even once a site is selected, however, the offset project development process can take 12 months or more before any offset credits are issued. The development process may be undertaken by the owner of the land or easement where the project will be implemented, but it is more often instead contracted out to a project development firm, which then receives a percentage of future offset credit revenues. Regardless of whether project development is completed in-house or contracted out, the process can be broken down into the following steps:

1. **Feasibility assessment**: The economics of developing an offset project are very site-specific, so it is critical to perform due diligence on a potential project site up front. This assessment should be informed by any existing documentation of timber inventories and peat depth, if applicable, on the site; the landowner’s management plan; and any legal encumbrances or deed restrictions in effect. This data should allow the project developer to assess onsite carbon stocks in a baseline scenario (i.e. in the absence of an offset project) as well as a project scenario. It is also important to consider landowners’ goals at this stage: Are they comfortable with active management of the land? Would they consider a conservation easement on their property? What is their desired time horizon for receiving revenues from an offset project? What is their primary motivation for implementing such a project?

2. **Field Inventory**: Once a project is determined to be feasible, the project developer must perform a field inventory to collect data on the on-site carbon stocks. For forest projects, this entails measuring the species, diameter at breast height (DBH), height, and any deformities for a preset sample of trees on the property, along with measurements of any snags and shrubbery present. The field inventory must also include a description of species composition, vegetation types, age class distribution, topography, land pressures, and climate.

For pocosin projects, in addition to measuring trees and shrubs within the project area, the field inventory must include measurement of surface elevation and bulk density of the peat. Measurements must also be recorded at a similar site outside the project area to serve as a baseline case for project calculations.

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10 Shoch, Eaton, & Swails, 2017
11 Jeff Johnson, pers. comm., Oct. 18, 2017
12 Josh Strauss, pers. comm., Feb. 20, 2018
3. **Emission Reductions Calculation**: Data from the field inventory is used to calculate carbon stocks over time in the baseline and project scenarios. Depending on the project type and protocol, these calculations may include carbon stocks in on-site biomass, soil, and harvested wood products. These calculations are included in the Project Design Document along with a description of the project site attributes, management practices, relevant stakeholders, inventory methodology, and plan for monitoring and verification.

4. **Registry Submittal**: The Project Design Document is one of several key documents that must be submitted for approval by a carbon offset registry in order to eventually receive offset credits. Other documents include a map or aerial photograph of the project site, a Project Implementation Agreement signed by the landowner, and a Project Submittal Form with basic information about the project.

   Project developers must first create an account with the registry before submitting a project for approval. Registries impose a standard fee for both account setup and project submittal.

   While a number of registries process offset project applications worldwide, most US projects are approved by one of three registries: Climate Action Reserve (CAR), American Carbon Registry (ACR), or Verified Carbon Standard (VCS). All three registries have approved protocols for forest projects, but methodologies differ so it is necessary to design a project for a specific registry’s protocol. Although VCS is the global leader in offset project registration, it certifies only 3% of forest offset projects in the US, while ACR certifies 36% and CAR certifies 60%.\(^{13}\) Currently, only ACR has an approved protocol for pocosin projects.

5. **Third-Party Verification**: All reported data and information for an offset project must be reviewed by an accredited third-party verifier before offset credits may be issued. The third-party verification also includes a site visit. Once the verification has been completed, the verifier submits a verification statement to the registry. Offset credit issuance is contingent on the project receiving a positive verification statement, meaning no significant variances or errors were found.

6. **Registry Verification**: After receiving a positive verification statement from the third-party verifier, the registry completes its own review of the project documents and verification statement to decide whether to approve the project for registration. For projects seeking compliance offset credits issued by the California Air Resources Board (CARB), the registry verification is followed by another separate review by CARB. The CARB verification is considered to be more stringent than the registry verification, and as a result can often add considerable time to the project development process.\(^{14}\)

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\(^{13}\) Hamrick & Gallant, 2017a

\(^{14}\) Jeff Johnson, pers. comm., Oct. 18, 2017
Following the initial verification, projects with offset credits issued by CARB must undergo a full re-verification every six years and repeat an on-site carbon inventory at least every 12 years.\textsuperscript{15} The length of time before a re-verification and inventory are required may vary for other protocols.

7. **Credit Issuance:** Once all verifications have been completed and the project has been approved by the registry (and, for compliance offset projects, by CARB), the project is eligible to receive offset credits. Registries charge a per-credit fee for the disbursement of offset credits to the project developer’s account. The initial issuance of offset credits is equal to the volume of CO$_2$e sequestered by the project in its first verification period. Offset credits may continue to be issued to the project throughout its crediting period as long as the project continues to report additional carbon sequestration. All protocols allow the project to renew its crediting period without limit, but the project must repeat steps 2-6 to demonstrate its continued additionality for a renewed crediting period.

8. **Project Monitoring:** Following registry approval of an offset project, the project must conduct annual monitoring of carbon stocks for the duration of the crediting period plus any additional monitoring period to ensure permanence of the project’s CO$_2$ sequestration. For forest projects, annual monitoring consists of modeling growth in sample plots and incorporating any new inventory data, including for harvests or disturbances. Annual monitoring reports are also required to undergo third-party verification.

Pocosin projects must complete monitoring activities at least every five years, or prior to each verification event if less than five years.\textsuperscript{16} Pocosin projects must monitor burn areas, changes to aboveground and belowground biomass carbon stocks, dry bulk density, and surface elevation change (the sum of subsidence, peat accretion, and root expansion/mortality) at both the project and baseline sites.

**Key Issues**

Projects that seek to offset GHG emissions through carbon sequestration face unique sources of biophysical and economic **uncertainty** that must be addressed through policy mechanisms in order to ensure environmental integrity. Whereas GHG emissions from energy are known to remain in the atmosphere for a fixed length of time, the length of time that carbon remains sequestered in biomass or soil is affected by management practices and disturbance events. Thus, carbon offset rules must specify time requirements for the **permanence** of carbon sequestration projects and make allowances for **reversals**, whether intentional (such as clear-cutting a forest or draining pocosins) or unintentional (such as wildfire).\textsuperscript{17} **Leakage** may also affect the carbon benefits of sequestration projects, as carbon-

\textsuperscript{15} CARB, 2015b
\textsuperscript{16} Shoch et al., 2017
\textsuperscript{17} Gren & Aklilu, 2016
emitting activities such as timber harvests or agricultural production may simply shift outside the project area, thereby reducing the project’s net impact on GHG emissions.\textsuperscript{18}

The environmental integrity of an offset project is also contingent on demonstrating that the carbon sequestration would not have occurred in the absence of the project. To prove its additionality, an offset project must demonstrate both that the project activities are not required by any law or deed encumbrance, and that the project activities have not already been registered as part of another offset project (a phenomenon known as double-counting). Furthermore, an offset project can only receive offset credits for carbon sequestration that exceeds the “baseline” level of sequestration, which approximates what would have happened in the absence of the project.

**Offset Markets: The California Compliance Market**

*Market Background*

CARB developed the regulations to establish North America’s first economy-wide cap-and-trade system in 2011. The cap-and-trade program was the centerpiece of a suite of climate program designed by CARB to meet the goals for reducing GHG emissions laid out in California’s Global Warming Solutions Act, better known as Assembly Bill (AB) 32, in 2006. Compliance obligations under the program began in 2013 for electric power providers and industrial manufacturers, and in 2015 for distributors of liquid fuels including petroleum and natural gas. The compliance obligations require covered entities to cover their reported emissions during a compliance period with an equivalent number of carbon allowances and offset credits.

The program was originally established through 2020, the year by which AB 32 mandated California’s GHG emissions to return to 1990 levels. During that program term, covered entities are permitted to use offset credits for up to 8% of their compliance obligation.\textsuperscript{19}

In July 2017, the California legislature passed AB 398, which extends its signature cap-and-trade program through 2030. The new rules reduce the offset usage limit to 4% of covered emissions from 2021-25, and to 6% of covered emissions from 2026-30. Furthermore, the new rules mandate that half of the offsets used must have direct environmental benefits for California. Thus, AB 398 effectively caps the use of out-of-state offsets at 2% of covered emissions from 2021-25, and at 3% of covered emissions from 2026-30.\textsuperscript{20} This restriction on out-of-state offset credits has important ramifications in assessing the future market potential for offset credits generated by projects outside California.

The California cap-and-trade program is currently linked to similar programs in the Canadian provinces of Quebec and Ontario through the Western Climate Initiative (WCI), a nonprofit organization that manages transactions and auctions of compliance instruments. Linkage means that carbon allowances or offset credits purchased in one jurisdiction can be

\textsuperscript{18} Hall, 2007
\textsuperscript{19} California Cap-and-Trade Regulation, 2017
\textsuperscript{20} Garcia, 2017
used for compliance in any linked jurisdiction. Based on their respective GHG emission caps for 2018, California currently comprises 64.7% of the linked market, compared to 24.6% for Ontario and 10.6% for Quebec.

Market Approach to Key Issues

California’s offset protocol for US Forests (California Protocol) is widely considered to be the most environmentally rigorous forest project protocol. The protocol addresses the issue of permanence by requiring projects to continue monitoring carbon stocks for 100 years after the end of their crediting period. Reversals are accounted for through contributions to the Forest Buffer Account, which are calculated for each project based on a “reversal risk rating” outlined in the protocol.

The California Protocol requires projects to justify their additionality under a Legal Requirement Test, which provides that the project must sequester carbon at a level above and beyond what is required by law or regulation, including legally binding mandates such as existing conservation easements. Any such legal requirements that apply to the project area would be reflected in the project’s baseline, effectively diminishing the volume of carbon sequestration that would be considered additional.

Avoided conversion projects must also complete a Performance Standard Evaluation to verify their additionality, which entails submitting a real estate appraisal for the project property that shows that the land is suitable for conversion to an alternative land use with a higher market value than forestry. IFM projects are not subject to the Performance Standard Evaluation, but are considered additional only to the extent that they reduce emissions and enhance carbon sequestration beyond the baseline scenario.

Leakage is addressed by the California Protocol by reducing the volume of credits awarded to the project by a percentage corresponding to the project’s expected risk of pushing carbon-emitting activities onto other lands, with the specific percentage determined according to project type. Reforestation projects are assigned a leakage factor of 24% if they occur on commercially viable cropland, or anywhere from 10-50%, depending on expected canopy cover density, if they occur on commercially viable grazing land. IFM project leakage is assessed as 20% of any reduction in harvest volume relative to the baseline scenario. Similarly, leakage from avoided conversion projects is estimated as 20% of the change in on-site carbon stocks and carbon stored in wood products relative to the baseline, which accounts for the market response to reduced wood production within the project area.

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21 Brown et al., 2017
22 ICAP, 2012
23 Offset credits directed to the Forest Buffer Account are subtracted from the volume of credits issued to the project developer, and can be retired by CARB in the event of an unintentional reversal. For intentional reversals, project developers must compensate CARB by surrendering additional offset credits equal to the amount of carbon released by the reversal CARB, 2015b.
24 CARB, 2015b
25 Ibid.
Uniquely among all offset registries, offset credits issued by CARB may be invalidated after issuance if CARB finds that one of three conditions is met: (1) the project documents overstate the amount of GHG reductions by more than 5%; (2) the project was not in compliance with all applicable environmental, health and safety laws and regulations during the period for which offset credits were issued; or (3) the project was issued offset credits by another program for the same time period. The invalidation mechanism is thus meant to address elements of the uncertainty and additionality concerns surrounding offsets. Offset credits are subject to possible invalidation for a period of eight years after issuance, although this period can be reduced to three years if the project undergoes a second independent verification within the first three years.\textsuperscript{26}

*Eligibility Requirements for Compliance Offset Projects*

To be eligible for listing under the California Protocol, at least 95% of the carbon stored in live trees within the project boundary must be from native species. Forest projects must either receive a third-party sustainable harvest certification such as from the Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), or the American Tree Farm System (ATFS); operate under a renewable long-term management plan; or employ uneven-aged silvicultural practices and canopy retention averaging at least 40% across the forest. Projects must maintain the higher of one metric ton of carbon per acre or 1% of standing live carbon stocks in standing dead carbon stocks, presuming the area has not recently undergone salvage harvesting.

Additional requirements for specific project types are outlined in Table 1.

**Table 1. Eligibility requirements for CARB Compliance Offset Protocol for U.S. Forest Projects.**\textsuperscript{27}

<table>
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<th>Land Cover</th>
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<th>Eligible Activities</th>
<th>Restrictions</th>
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<tr>
<td>Reforestation</td>
<td>&lt;10% tree canopy cover for 10+ years, OR subject to significant disturbance that removed &gt;20% of live biomass</td>
<td>Private or public, excluding federal land or land subject to an easement with federal holders</td>
<td>Planting trees or removing impediments to natural regeneration</td>
<td>Action cannot involve rotational harvesting of reforested or preexisting trees during first 30 years, or follow the commercial harvest of healthy trees within 10 years</td>
</tr>
<tr>
<td>IFM</td>
<td>&gt;10% tree canopy cover</td>
<td>Private or public, excluding federal land or land subject to an easement with federal holders</td>
<td>Management activities that maintain or increase carbon stocks relative to baseline levels,</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{26} CARB, 2015b  
\textsuperscript{27} Ibid.
including increasing rotation ages, thinning diseased and suppressed trees, managing competing brush, increasing stocking, or maintaining stocks at a high level

<table>
<thead>
<tr>
<th>Avoided Conversion</th>
<th>Currently forested, under threat of conversion to a non-forested land use</th>
<th>Private</th>
<th>Preventing conversion of forest to other non-forest use though conservation easement or transfer to (non-federal) public ownership</th>
<th>Must demonstrate significant threat of conversion to a “higher and better use” in residential, commercial, recreational, or industrial development; agricultural production; or mining</th>
</tr>
</thead>
</table>

All projects:
- 25 year crediting period
- 100 year monitoring and permanence requirements

**Current Market Dynamics**

CARB has issued over 62 million offset credits to US forest projects through 2017, as shown in Table 2. The volume of offset credits supplied for the California market currently represents the vast majority of offset credits available to the linked Canadian provinces as well. Quebec has issued a total of 563,993 offset credits as of September 27, 2017\(^ {28}\), while Ontario has not issued any offset credits to date.

**Table 2.** Cumulative supply of offset credits issued in California as of April 2018.\(^ {29}\)

<table>
<thead>
<tr>
<th>Project Type</th>
<th>ODS</th>
<th>Livestock</th>
<th>U.S. Forest</th>
<th>Urban Forest</th>
<th>MMC</th>
<th>Rice Cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance</td>
<td>10,039,901</td>
<td>2,734,417</td>
<td>66,235,639</td>
<td>--</td>
<td>1,998,414</td>
<td>--</td>
</tr>
<tr>
<td>Early Action</td>
<td>6,336,710</td>
<td>1,695,029</td>
<td>13,276,494</td>
<td>--</td>
<td>2,879,684</td>
<td>--</td>
</tr>
</tbody>
</table>

Table includes all offset credits issued including offset credits placed in ARB’s Forest Buffer Account, offset credits returned to an Early Action Offset Program’s forest buffer pool, and offset credits subsequently invalidated.

Note: ODS = ozone-depleting substances; MMC = mine methane capture

\(^{28}\) Gouvernement du Québec, 2018

\(^{29}\) CARB, 2018
California entities traded 4.1 million mtCO₂e of forest carbon offset credits in the secondary market (i.e. outside of state-run auctions) in 2016.³⁰ This represents a significant drop from 2015, when 6.5 million mtCO₂e of forest carbon offset credits were traded in the secondary market.³¹ However, a huge amount of supply still remains in the pipeline, as CAR and ACR together issued 31 million mtCO₂e in offset credits eligible for the California market in 2016.³²

Offset credits in the California most recently traded at $12.43/mt, about 16% below the price of a CARB allowance.³³ (Offset credits that have had their invalidation period reduced to three years through a second verification trade at a premium, most recently at $13.12/mt.) Historically, offset prices have ranged from $8.84/mt to $12.70/mt, as shown in Figure 2. Fluctuations in offset prices are generally tied to volatility in CARB allowance prices, with the offset-allowance discount floating between 12% (in late 2015) and 28% (in late 2014).³⁴

![Figure 2. Historical offset prices in the California compliance market, based on offset credit delivery year.³⁵](https://www.californiaccarbon.info)

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³⁰ Hamrick & Gallant, 2017b
³¹ Ibid.
³² Ibid.
³³ Trading prices based on quotes for a forward contract with delivery of offset credits in the month following the transaction.
³⁴ California Carbon, 2018
³⁵ Ibid.
**Historical Demand**

In California’s first compliance period (2013-14), compliance entities surrendered a total of 12.8 million offset credits, accounting for nearly 4.4% of all compliance instruments surrendered.\(^{36}\) For the 2015 annual compliance obligation, in which compliance entities had to submit compliance instruments equal to 30% of their covered emissions for that year, compliance entities surrendered 8.1 million offset credits, accounting for over 7.9% of all compliance instruments surrendered.\(^{37}\) Thus, through 2015 a total of 20.9 million offset credits have been surrendered, representing 5.3% of all compliance instruments surrendered.\(^{38}\) This usage rate is significantly lower than the 8% offset usage allowed in the cap-and-trade regulation. It is not clear whether this historically underutilization of offset credits is due primarily to tepid demand from compliance entities or limitations in supply; if the latter, then these market dynamics may change if and when offset credits are issued to the current backlog of forestry offset projects.

In its most recent compliance instrument report, the Air Resources Board (CARB) reported 76.1 million offset credits in circulation, including 52.3 million from forestry projects.\(^{39,40}\) Of all offset credits issued, 62.1 million were either held by compliance entities or had been surrendered, meaning that 81.6% of all offset credits issued have been sold.\(^{41}\) This number includes 38.2 million offset credits from forestry projects.\(^{42}\) Thus, we can calculate that 72.9% of all forestry offset credits issued have been sold—a significantly lower sale rate than the offset market as a whole.

Quebec has issued 563,993 offset credits in total.\(^{43}\) Aside from 12,084 offset credits held by the province in an Environmental Integrity account, all offset credits had been transferred to compliance entities, indicating that they had been sold.\(^{44}\) No offset credits have been surrendered in Quebec.

**Offset Markets: The Voluntary Market**

**Market Background**

The voluntary market for carbon offsets has existed much longer than compliance offset programs. Some 75 million mt CO\(_2\)e had already been traded before 2005, when the European

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\(^{36}\) CARB, 2016a  
\(^{37}\) CARB, 2016b  
\(^{38}\) The 2016 annual compliance surrender event occurred on November 1, 2017, but the compliance report for this period has not yet been published by CARB.  
\(^{39}\) CARB, 2017  
\(^{40}\) This does not include offset credits held by CARB in the Forest Buffer Account.  
\(^{41}\) Ibid.  
\(^{42}\) Ibid.  
\(^{43}\) Gouvernement du Québec, 2018  
\(^{44}\) CARB, 2017
Union launched the world’s first regulatory carbon market. Market volumes grew throughout the late 2000s. Offset credits were first issued for forest carbon projects in 2009.

Beginning in 2010, the establishment of compliance markets for carbon offsets in New Zealand, California, Quebec, Australia, Korea, and several Chinese provinces, among other jurisdictions, dramatically changed the dynamics of the global offset market. Volumes of offset credits transacted on the voluntary market generally declined from 2010 to 2016. However, the voluntary offset market continues to play an important and complementary role to the growing suite of compliance markets, as it supports a wider range of project types, geographies, and certifications. The voluntary offset market also has an advantage over compliance markets in that it is less exposed to policy changes due to political pressure or legal challenges, though shifts in policy do still have some impact on voluntary market dynamics.

**Market Approach to Key Issues**

The three registries that control offset credit issuance for the voluntary market have different strategies to deal with the key issues surrounding offsets, such as permanence and leakage. Generally, CAR is considered to be the most stringent of the three registries, and its protocol contains provisions substantially similar to the California Protocol, which used CAR’s protocol as a template. VCS’s suite of protocols are more flexible, but they are not widely used in the US. Therefore, it is most constructive to explore the approach taken by the ACR forest and pocosin protocols.

ACR requires forest projects to commit to a minimum project term of 40 years, which is substantially shorter than CARB’s 100-year requirement. ACR also offers more flexibility to projects on how they address unintentional reversals: projects can contribute to a buffer pool, similarly to the Forest Buffer Account under CARB, but they can also purchase an insurance product for their offset credits, or undertake another risk mitigation measure approved by ACR. Pocosin projects credited by ACR have no permanence requirements beyond the 20-year crediting period, but they are required to contribute offset credits to a buffer account to protect against unintentional reversals, with the volume of the contribution determined by a project-specific risk rating.

Proving additionality under the ACR protocols is similar to the California Protocol but slightly more involved. Projects must apply a three-pronged additionality test to demonstrate that they (1) exceed any sequestration activities required by law or regulation, (2) exceed common management practices for similar landowners in the project’s geographic region, and (3) face a financial barrier to implementation, such as limited access to capital or an unacceptably low rate of return in the absence of carbon offset revenues.

Leakage for IFM projects under the ACR protocol is assessed as a discount factor to the volume of offset credits awarded, but this discount factor is less project-specific than under the
California Protocol. Any project that demonstrates less than a 5% decrease in wood product production relative to the baseline scenario receives a market leakage factor of zero. A project that reduces wood production by up to 25% receives a market leakage factor of 10%, while projects that reduce wood production to a greater degree are assigned a 40% market leakage factor.\textsuperscript{50} For avoided conversion projects (addressed by the ACR methodology for REDD – Avoiding Planned Deforestation), leakage factors range from 20% to 70% depending on how the proportion of aboveground biomass that is merchantable within the project area compares to the average proportion for that forest type.\textsuperscript{51} ACR afforestation/reforestation projects use a UN Clean Development Mechanism (CDM) methodology to calculate leakage on a project basis.\textsuperscript{52} Finally, the ACR protocol for pocosin restoration (ACR Pocosin Protocol) does not account for leakage, as it excludes any land used productively within the last five years from enrolling as an offset project.\textsuperscript{53}

Unlike CARB, ACR provides no mechanism for invalidating credits that have already been issued. ACR protocols protect against overstatement of GHG reductions for forest projects only by reducing the volume of offset credits awarded in proportion to the uncertainty contained within the GHG calculations in cases where the uncertainty exceeds 10%.\textsuperscript{54} For pocosin projects, uncertainty is considered in the calculation of parameter values for avoided emission calculations, but there is no discount factor applied to the awarded volume of offset credits for uncertainty.\textsuperscript{55}

\textit{Eligibility Requirements for Voluntary Offset Projects}

Requirements for forest and pocosin offset projects to be listed under ACR protocols are outlined in Table 3.

\textbf{Table 3. Eligibility requirements for ACR protocols.}\textsuperscript{56}

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Land Cover</th>
<th>Land Ownership</th>
<th>Eligible Activities</th>
<th>Restrictions</th>
<th>Crediting Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afforestation/Reforestation</td>
<td>Degraded, with minimal natural regeneration expected in baseline scenario</td>
<td>Private or public</td>
<td>Activities to establish or re-establish forest on non-forested land</td>
<td>Project land must not have been cleared of trees within last 10 years, except in case of natural disturbance</td>
<td>40 years</td>
</tr>
</tbody>
</table>

\textsuperscript{50} Ibid.
\textsuperscript{51} American Carbon Registry, 2011
\textsuperscript{52} American Carbon Registry, 2017
\textsuperscript{53} Shoch et al., 2017
\textsuperscript{54} Delaney et al., 2016
\textsuperscript{55} Shoch et al., 2017
\textsuperscript{56} American Carbon Registry, 2010; American Carbon Registry, 2011; American Carbon Registry, 2017; Delaney et al., 2016; Shoch et al., 2017
<p>| IFM | &gt;10% tree stocking, or land formerly having such tree cover and not currently developed for non-forest uses | Private or public | Conversion from conventional logging to reduced impact logging, conversion of managed forests to protected forests (“stop logging”), extending rotation lengths in managed forest, conversion of low-productive forests to high-productive forests, increasing forest productivity by thinning diseased or suppressed trees, managing competing brush and short-lived forest species, increasing the stocking of trees on understocked areas, increasing carbon stocks in harvested wood products, improving harvest or production efficiency, and shifting from shorter- to longer-term wood products | Any harvesting must be certified by FSC, SFI, or ATFS (or become certified within one year of Project Start Date), or (for public lands) have its forest management plan sanctioned by a unit of elected government | 10 years for stop-logging projects; 20 years for all other activities |
| REDD (Avoided Conversion) | Forest (per the US Forest Service Forest Inventory &amp; Analysis definition) for 10 years before project start date | Private or public | Stopping deforestation on forest lands that are legally authorized and documented to be converted to non-forest land, and enhancing carbon stocks of any degraded and secondary forests in project area that would be deforested in the absence of the project activity | Credible evidence and documentation must show that project lands would have been converted to non-forest use if not for the REDD project | 10 years |</p>
<table>
<thead>
<tr>
<th>Restoration of Pocosin Wetlands</th>
<th>Previously drained pocosin, which has not been subject to a land use that could be displaced outside the project area (e.g. agriculture) for at least five years prior to project start date</th>
<th>Private or public</th>
<th>Rewetting previously drained pocosins</th>
<th>No timber harvest may occur in baseline or project scenarios; project must not result in drainage of adjacent areas</th>
<th>20 years</th>
</tr>
</thead>
</table>

All projects:
- 40 year monitoring and permanence requirements

**Current Market Dynamics**

Worldwide, 46.6 million mt CO$_2$e were transacted in voluntary offset markets in 2016, with a market size of $116 million.\textsuperscript{57} The US and Canada collectively accounted for 10.1 million mt CO$_2$e of that total, including 1.2 million mt CO$_2$e from forestry and land use projects.\textsuperscript{58} The majority of those forest offset credits (over 1 million mt CO$_2$e) originated in the US.\textsuperscript{59}

The average transaction price for forest offset credits from the US and Canada in 2016 was $9.2/mt CO$_2$e.\textsuperscript{60} This price far exceeds the average global price for forest offset credits, $5.2/mt CO$_2$e, as well as the average price for all offset credit types in the US and Canada, $2.9/mt CO$_2$e.\textsuperscript{61}

The private sector makes up by far the largest market for voluntary carbon offset sales, with 92% of offset credits globally going to private companies in 2016.\textsuperscript{62} These private buyers span a wide variety of industries, with the largest buyers coming from the energy industry (31% of offset credit sales), the events/entertainment industry (14% of offset credit sales), and the finance/insurance industry (11% of offset credit sales).\textsuperscript{63} The most common motivation for private companies to purchase offset credits in the voluntary market is the need to meet internal targets for reducing greenhouse gas emissions.\textsuperscript{64}

Forest offset projects in particular attract a slightly different type of buyer than the other project types in the voluntary market. In 2016, 70% of offset credit buyers from forest projects intended to retire the offset credits they purchased, rather than re-sell them, and were

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\textsuperscript{57} Hamrick & Gallant, 2017c  
\textsuperscript{58} Hamrick & Gallant, 2017a, 2017c  
\textsuperscript{59} Hamrick & Gallant, 2017a  
\textsuperscript{60} Ibid.  
\textsuperscript{61} Hamrick & Gallant, 2017a, 2017c  
\textsuperscript{62} Hamrick & Gallant, 2017a  
\textsuperscript{63} Ibid.  
\textsuperscript{64} Ibid.
therefore willing to pay higher prices for the credits.\textsuperscript{65} In the market as a whole, however, only 55\% of buyers planned to retire the credits they bought.\textsuperscript{66} Furthermore, buyers of forest offset credits placed a significant emphasis on choosing projects that would provide co-benefits. Over half of buyers selected projects with community co-benefits, and another quarter selected projects for their biodiversity co-benefits.\textsuperscript{67}

According to Ecosystem Marketplace, 238 forest offset projects were either operational or in development in the US in 2016 across both voluntary and compliance markets.\textsuperscript{68} California supported far more projects than any other state. The distribution of forest offset projects by state, broken down by their intended market, is shown in Figure 3.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Map.png}
\caption{Location of voluntary and compliance forest carbon projects in the US as of 2016.\textsuperscript{69}}
\end{figure}

\begin{flushleft}
\begin{tabular}{ll}
\textsuperscript{65} Ibid. \\
\textsuperscript{66} Hamrick & Gallant, 2017a \\
\textsuperscript{67} Ibid. \\
\textsuperscript{68} Ibid. \\
\textsuperscript{69} Ibid.
\end{tabular}
\end{flushleft}
Offset Projects in North Carolina

Forests

Six forest offset projects have been approved by offset registries in North Carolina to date. All six are avoided conversion projects. Five of the projects were registered with CAR by Bluesource, a forest offset project development firm based in San Francisco, and approved by CARB under provisions for Early Action forest projects. The sixth project was registered with ACR by Green Assets, a North Carolina-based development firm, and approved by CARB as a compliance offset project in 2015.

Pocosins

There is significant potential for developing a carbon offset project under the ACR Pocosin Protocol, although no projects have yet been registered. In 2013, TerraCarbon, LLC conducted an extensive feasibility analysis of conservation and restoration potential in pocosins for TNC NC, which identified areas best suited for conservation and restoration activities. The analysis was conducted at a regional scale for the Albemarle-Pamlico Sound, extending west to the Great Dismal Swamp. Rather than making specific parcel recommendations, the study was instead based on three different classification schemas of Landsat imagery. To explore the potential for a carbon project, the study quantified the carbon benefits and costs of developing an offset project, using data from three different pilot project sites. Because it was completed in advance of the ACR Pocosin Protocol, it instead followed the Silvestrum methodology, which is closely related. According to the study, both conservation and restoration could provide avenues for generation of carbon offset credits.

Offset Project Experience in Other TNC Chapters

Although TNC NC does not have experience in developing a carbon offset project, other TNC chapters have successfully established offset projects in the past. In Louisiana, TNC has established a number of reforestation offset projects under voluntary offset protocols with financing from corporate partners. TNC’s main goal of offset project development in Louisiana is to restore native bottomland hardwood forests and provide habitat connectivity between patches. In 2011, TNC established the Bayou Bartholomew offset project on 140 acres of pastureland it had recently purchased in Morehouse Parish. Just south in Franklin Parish, TNC set up the Tensas River Basin Reforestation Project on 400 acres of former cropland and oak

70 Climate Action Reserve, n.d.
71 American Carbon Registry, n.d.
72 R. Dickson et al., 2013
73 The Silvestrum methodology was developed by Silvestrum Climate Associates. It was referenced by TerraCarbon in their pocosin restoration feasibility report for TNC NC, but is not publicly available.
74 Jim Bergan, pers. comm., Apr. 20, 2018
75 Shoch, Eaton, Hardman, Ulmer, & Virgilio, 2011
plantation. That project was financed in part through the revenues from a voluntary offset program TNC operated for individual members and supporters.\textsuperscript{76} The Bayou Bartholomew and Tensas River Basin projects followed what TNC calls the “conservation buyer model,” in which TNC buys land for reforestation, retains the carbon rights, and sells off the fee title to the land for use in recreation.\textsuperscript{77} In 2012, TNC piloted a new project development model focused on landowner aggregation with the Lower Mississippi Valley Grouped Afforestation Project (LMV GAP). In this new model, TNC does not buy the land in fee but instead purchases a conservation easement, and develops a carbon offset project while helping the landowner enroll the land concurrently in a USDA conservation program like the Conservation Reserve Program (CRP) or Wetland Reserve Program (WRP). LMV GAP started with 220 acres of degraded cropland, and now covers 1,500 acres across 11 properties.\textsuperscript{78} Ultimately, all the offset credits generated through LMV GAP will be transferred to TNC’s corporate partner under the terms of their agreement.\textsuperscript{79}

In California, TNC partnered with The Conservation Fund, the California State Coastal Conservancy and the Wildlife Conservation Board in 2004 to protect 24,000 acres of former industrial timber land in the Garcia River Forest on the Mendocino Coast.\textsuperscript{80} The Conservation Fund now owns and manages the forest, while TNC holds a conservation easement for the land. The Garcia River Forest became a certified IFM offset project in 2008, and later transitioned from a voluntary market certification to California’s compliance market certification.\textsuperscript{81} The Conservation Fund sold the project’s projected stream of offset credits through 2012 to help finance management activities on the property.\textsuperscript{82}

TNC’s largest carbon offset project to date can be found in Virginia, where the 23,000 acres of forest it manages through the Clinch Valley program have sequestered nearly 500,000 mt CO\textsubscript{2}e since 2002.\textsuperscript{83} Those offset credits have been registered in the California compliance market through its protocol for “early action” forest projects established prior to 2014. The two landowners TNC worked with in the Clinch Valley were already part of TNC’s Conservation Forestry program prior to beginning development of an offset project, and thus had already received Forest Stewardship Council (FSC) certification. As a result, TNC did not need to implement any new forest management practices in order to establish an IFM offset project.\textsuperscript{84}

While participation in carbon offset markets may be new to TNC NC, these precedents show that considerable institutional knowledge already exists in other TNC chapters around offset project development. TNC staff in Virginia, Louisiana, and California may therefore be able to provide insights on the project development process and potential development partnerships that would be useful to TNC NC as they continue to explore this opportunity.

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\textsuperscript{76} The Nature Conservancy, n.d.-b  
\textsuperscript{77} Jim Bergan, pers. comm., Apr. 20, 2018  
\textsuperscript{78} Eaton et al. 2012; Jim Bergan, pers. comm., Apr. 20, 2018  
\textsuperscript{79} Jim Bergan, pers. comm., Apr. 20, 2018  
\textsuperscript{80} The Nature Conservancy, n.d.-a  
\textsuperscript{81} The Conservation Fund, 2018  
\textsuperscript{82} The Nature Conservancy, n.d.-a  
\textsuperscript{83} Blankenship, 2017  
\textsuperscript{84} Greg Meade, pers. comm., Dec. 12, 2017
Methods

Activity and Market Scoping

Our first step in analyzing the potential for TNC NC to establish a carbon offset project was to collect information and inside perspectives on how the project development process works. To do this, we relied primarily on expert elicitation with practitioners who have experience developing or advising the development of forest offset projects. Personal communication by phone and email with these contacts informed our understanding of the offset project development process, costs associated with project development, and methodologies for estimating offset credit streams.

To estimate the costs associated with project development, we supplemented our expert elicitation efforts with information obtained from scholarly literature, industry reports, public documents provided by offset registries, and internal studies provided by TNC. These sources of information also helped us to assess the feasibility of different offset protocols and project types for land parcels with a range of different ecosystem characteristics.

Site Identification and Prioritization

To achieve our second goal of identifying parcels of land that might be suitable for a carbon offset project, we analyzed parcel data from all counties within each of TNC NC’s three focus regions: the Southern Blue Ridge Mountains, the Longleaf Pine region of southeastern North Carolina, and the Albemarle-Pamlico region (Figure 4). We removed federally owned or managed lands from our analysis using data from U.S. Protected Areas Database, as carbon offset projects on federal lands are prohibited under most regulatory and voluntary protocols. Lands under private ownership, tribal lands, and lands owned by state and local governments are included in this analysis.

We further limited our analysis to parcels greater than 500 acres. Project developers advised us that a project must be larger than 5,000 acres to be financially viable, but that it is possible to aggregate several smaller parcels owned by a single landowner. The 500-acre minimum for our parcel analysis attempted to recognize this reality while allowing for the analysis of smaller parcels that could be aggregated into a single project. By setting this threshold, we identified a total of 1,937 parcels.

After identifying parcels over this acreage threshold, we used multi-criteria decision analysis (MCDA) to prioritize each parcel on its environmental qualities and conservation benefits. MCDA is a decision-making tool useful for analyzing and choosing between competing project or action alternatives, based on their scores for various attributes and the relative importance of those attributes to the decision maker.

85 See the Acknowledgements section for a list of the experts we consulted.
86 NC OneMap, n.d.
88 Josh Strauss, pers. comm., Oct. 19, 2017
89 National Resources Leadership Institute, 2011
To start, we scored parcels based on five variables: size, percentage of target cover type, climate resiliency, proximity to TNC NC’s existing protected areas, and whether the parcel falls within TNC NC’s high priority conservation areas within each of the larger focus regions. We used an ordinal 1-100 scale for each variable, with 100 as the highest possible score for each. Due to the impracticality of quantifying carbon on an individual basis for all 1,937 parcels, these scores narrowed our analysis toward the most likely candidate parcels, for which we then quantified carbon under project and baseline scenarios.

1. **Parcel size**: Due to the high fixed costs of implementing an offset project, the size of a parcel is the most important factor in whether a potential project will be financially feasible. We recalculated acreage for each parcel, as we realized early on that some records from county parcel data had inconsistencies in slivers of land between parcels or several tracts belonging to a landowner all being given the same acreage. Following this recalculation, any remaining parcels not over 500 acres were removed from our baseline parcels layer. We ranked parcel size as shown in Table 4.

90 We considered adding carbon stocking as a variable in this preliminary screening, but decided against it because the intent was to prioritize parcels that TNC might already be interested in. Furthermore, existing carbon stocks do not necessarily translate to a viable offset project, as high initial carbon content results in a higher baseline. The remaining five variables captured the environmental qualities that TNC is interested in for conservation purposes.
Table 4. Scores assigned to parcels of each acreage class.

<table>
<thead>
<tr>
<th>Acreage</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10,000</td>
<td>100</td>
</tr>
<tr>
<td>&gt;5,000</td>
<td>80</td>
</tr>
<tr>
<td>3,000-5,000</td>
<td>40</td>
</tr>
<tr>
<td>&lt;3,000</td>
<td>1</td>
</tr>
</tbody>
</table>

The rationale for scoring was to isolate the largest parcels, as the size of a parcel greatly influences the number of carbon credits that can be generated from the project. In an ideal scenario, TNC NC would be able to undertake a project on a single large property, and these ranking reflect that preference. Although a single parcel less than 5,000 acres is unlikely to work as a carbon project by itself, it could be combined with other tracts belonging to the same landowner. However, combining several small parcels adds difficulty to project logistics, so we assigned a low score of 1 to parcels less than 3,000 acres to reflect this. Any smaller parcel would need excellent scores on other variables in order to make it a prime candidate in the final rankings.

2. **Percentage of target land cover type:** To map the extent of forests and pocosins within each identified parcel, we created a “target cover types” raster mask. Using this data, we were able to identify parcels with a high percentage of forest or pocosin, as well as potential sites for afforestation or reforestation projects. This mask combined the National Land Cover Database (NLCD) and Gap Analysis Program (GAP) land cover data from 2011.\(^\text{91}\) We chose to combine these two datasets to provide for both coarser and finer scales of detail in cover types, and to account for any inaccuracies pervasive in one dataset or the other (for example, GAP tends to classify young pine plantations as row crops, while NLCD correctly identifies them as evergreen forest).

To create the target cover types mask, we identified pixels corresponding with forests and pocosins in each dataset. We then coded each raster in a binary “target/non-target” format and added them together, preserving their unique cover type descriptions. We verified any pixels with a value of 1 (classified as a target cover type under one dataset but not both) and trimmed out any definitively non-forest cover types such as development. We extracted any pixels with a verified value of 1 or 2 to arrive at the final mask of target cover types. We conducted an accuracy assessment that showed our mask to be 91% accurate overall. With this mask raster, we calculated the percentage of each property covered by our target cover types and used the results as another attribute for the site prioritization model. Although in general we looked for parcels with higher amount of forest or pocosin cover, we also separately considered parcels with less than 10% forest cover for reforestation projects.

\(^{91}\) C.G. Homer et al., 2015; U.S. Geological Survey Gap Analysis Program, 2016
3. **Climate resiliency**: We used TNC NC’s 2016 Resilient and Connected Landscapes dataset\(^92\) to assess each parcel’s resiliency to climate change and potential to support future movements of species. Although this dataset is somewhat biased against xeric and savannah ecosystem types, such as longleaf pine, it still is a useful metric, and we used TNC NC’s prioritization of high conservation value areas (see #4) to balance this. Resiliency scores were assigned as shown in Table 5.

### Table 5. Land classifications from the Resilient and Connected Landscapes dataset and the score assigned to each.

<table>
<thead>
<tr>
<th>Label</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient</td>
<td>100</td>
</tr>
<tr>
<td>Resilient area with confirmed diversity</td>
<td>100</td>
</tr>
<tr>
<td>Climate flow zone</td>
<td>70</td>
</tr>
<tr>
<td>Climate flow zone with confirmed diversity</td>
<td>70</td>
</tr>
<tr>
<td>Climate corridor</td>
<td>50</td>
</tr>
<tr>
<td>Climate corridor with confirmed diversity</td>
<td>50</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>1</td>
</tr>
</tbody>
</table>

4. **TNC NC priority areas**: Within each of the three main focus regions, TNC NC has further prioritized high conservation-value locations which capture biodiversity, focal habitat types, and other environmental values important to their work. Because each region has its own ranking system, we created a new shapefile with standardized priority scores across each of the three regions, working with TNC NC to determine which areas should receive higher or lower rankings (Tables 6a-6c).

### Table 6a. Priority scores for the Albemarle-Pamlico region.

<table>
<thead>
<tr>
<th>Value</th>
<th>Priority</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>High restoration suitability</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>High conservation suitability</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Suitable for conservation and restoration</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Explore suitability</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>Low suitability</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>Not in priority areas</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 6b. Priority area scores for the Southern Blue Ridge region.

<table>
<thead>
<tr>
<th>Label</th>
<th>Priority</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>High</td>
<td>100</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Med</td>
<td>80</td>
</tr>
<tr>
<td>Connector</td>
<td>Low</td>
<td>40</td>
</tr>
<tr>
<td>0</td>
<td>Not in priority areas</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^92\) M.G. Anderson et al., 2016
Table 6c. Priority area scores for the Longleaf Pine region.

<table>
<thead>
<tr>
<th>Label</th>
<th>Priority</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient core</td>
<td>High priority</td>
<td>100</td>
</tr>
<tr>
<td>Core enhancement area</td>
<td>High priority</td>
<td>100</td>
</tr>
<tr>
<td>Non-resilient habitat block</td>
<td>Medium-high</td>
<td>80</td>
</tr>
<tr>
<td>Corridor</td>
<td>Medium-low importance (marginal habitat)</td>
<td>40</td>
</tr>
<tr>
<td>0</td>
<td>Not in priority areas</td>
<td>1</td>
</tr>
</tbody>
</table>

5. **Proximity to existing TNC NC projects:** Sites that are near other TNC NC projects offer benefits in that they are likely be easier to monitor, due to reduced travel costs, and maintain the organization’s focus on areas congruent with existing landholdings and easements. For the sake of this analysis, we defined adjacent as within 30 feet of an existing TNC NC property in order to take into account slight boundary discrepancies between the two parcel datasets. We gave priority to TNC NC’s fee-owed properties over conservation easements, because the legal requirements of easements lead to higher carbon baselines and potentially decrease project additionality and credit volumes (Table 7). This makes eased properties less viable for carbon offsets and gives fee-owned properties greater carbon project potential.

Table 7. Parcel scores based on distance from existing TNC NC projects.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjacent to fee-owned property &gt;500 acres</td>
<td>100</td>
</tr>
<tr>
<td>Within 5 mi of any fee-owned property &gt;500 acres</td>
<td>90</td>
</tr>
<tr>
<td>Adjacent to any TNC property</td>
<td>80</td>
</tr>
<tr>
<td>Within 5 mi of any TNC project</td>
<td>70</td>
</tr>
<tr>
<td>Within 10 mi of any TNC project</td>
<td>50</td>
</tr>
<tr>
<td>Within 15 mi of any TNC project</td>
<td>30</td>
</tr>
<tr>
<td>&gt;15 mi from any TNC project</td>
<td>1</td>
</tr>
</tbody>
</table>

After all parcels were scored for each individual variable, we used a weighting system to calculate a site priority score for each parcel and identify the best candidates to move forward with. We used an elicitation process based on MCDA to obtain relative weights or preferences for each criterion from TNC NC. We then combined the scores and weights for each parcel in a weighted average to arrive at a site priority score. For IFM or avoided conversion projects, we calculated each parcel’s site priority score as:

\[
\text{Site Priority Score} = 0.20 \times (\text{size score}) + 0.10 \times (\text{percentage of target land cover type}) + 0.25 \times (\text{resilience score}) + 0.30 \times (\text{conservation priority score}) + 0.15 \times (\text{proximity score})
\]

For reforestation or afforestation, we created a separate shapefile of parcels with less than 10% forest cover, as required by the protocols for this project type. The remaining four variables were then re-weighted, to produce site priority scores as follows.
Site Priority Score = 0.05*(size score) + 0.10*(resilience score) + 0.35*(conservation priority score) + 0.50*(proximity score)

These adjusted scores reflect the fact that TNC NC is likely not interested in reforesting isolated parcels, instead preferring to reforest areas that are already adjacent to or very near existing TNC NC projects in order to achieve their objective of habitat connectivity.

For all project types, we used the site priority scores developed in this model to determine which parcels to consider first for carbon modeling. Given the impracticality of modeling carbon for all parcels statewide, we ranked parcels in descending order in order to quantify carbon for the parcels that would likely be most attractive to TNC based on their conservation values.

Key Modeling Assumptions

There are several important assumptions in this prioritization model. First and foremost, assigning scores on a scale is an inherently subjective process. Although we have consulted with TNC NC about the scores and weights each variable received, there is still some uncertainty about how results might change with slightly higher or lower scores. In addition to scores on individual variables, the results change if the weights assigned to variables change. Parcel size is by far the biggest factor influencing the successful selection of a site for a carbon project, but exactly how much weight it should receive is less clear. We conducted a sensitivity analysis (see Results section) to better understand how changing how variables are weighted changes parcel selection.

Furthermore, the raster used for conservation priority within the Albemarle-Pamlico comes out of a carbon offset feasibility analysis done by TerraCarbon in 2013. As such, it prioritizes pocosins, which are TNC NC’s primary focus within that region. Because we are also looking at forest cover within the region, there are parcels which may score low on being a “priority area” yet are still viable as a forest carbon project.

Carbon Quantification

Using the output from the site prioritization model, we chose six of the top-ranked parcels as case studies to investigate the carbon offset potential for various locations and project types (for a list of other parcels that could make attractive project sites, see Appendix E). Our case studies covered both forest and pocosin projects. The analysis consisted of modeling both baseline and project carbon sequestration scenarios and comparing them to quantify potential carbon offset credits for each case study parcel.

For forest case studies, we modeled the baseline and project scenario following the California Protocol, as described below. We chose this methodology because the California market currently offers the highest prices for offset credits, and because so far all the existing forest carbon projects in North Carolina have been registered with CARB. California Protocol

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93 R. Dickson et al., 2013
baselines require the most robust calculations, which can have a great effect on the potential quantity of offset credits produced by any given project. We prefer to conservatively estimate the offset credit potential in this analysis, so the more stringent baseline calculations match our objectives in that regard. Finally, the California Protocol is considered the most environmentally rigorous, which aligns well with TNC NC’s goals for long-term conservation. For further discussion of our rationale for choosing the California Protocol, see Appendix B.

For pocosin case studies, the ACR Pocosin Protocol for the re-wetting of drained pocosins is the only approved protocol for this project type. This protocol quantifies the GHG emissions reduced by restoring previously drained pocosin peatlands and allows for credits to be calculated by either measuring stocks and land surface elevation or through proxy variables. In either case, field measurements are required.94 We attempted to follow the protocol as closely as possible, in terms of the sites eligible for project development, but had to use a proxy for the site-specific field data that we lacked.

Before beginning carbon modeling, we determined the most likely offset project type for each case study parcel from the following criteria, based on the relevant protocol (Table 8):

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Reforestation</th>
<th>Improved Forest Management (IFM)</th>
<th>Avoided Conversion</th>
<th>Pocosins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>- Less than 10% tree cover (as determined from the target land cover mask) for at least 10 years (determined from Google Earth satellite imagery)</td>
<td>- At least 10% initial tree cover (as determined from the target land cover mask)</td>
<td>- At least 10% initial tree cover AND In close proximity to urban development or agriculture (both determined from the target land cover mask)</td>
<td>- High percentage of histosol soil type and pocosin land cover type</td>
</tr>
<tr>
<td></td>
<td>- Not part of a conservation easement</td>
<td>- Not part of a conservation easement</td>
<td>- Not part of a conservation easement</td>
<td>- No timber or agriculture production in previous 5 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Near agriculture, irrigation canal, or drained land use (as proxy for drainage)</td>
</tr>
</tbody>
</table>

The tree cover thresholds identified above came directly from the California Protocol.95 We avoided conservation easements because of their tendency to raise a project’s baseline and reduce potential credit volumes, and because eased properties are already somewhat

94 Shoch et al., 2017
95 CARB, 2015b
protected and are less likely to need TNC NC’s intervention to ensure their conservation. We evaluated the proximity to urban development and agriculture for an avoided conversion project as a proxy for conversion risk. The Protocol itself requires documentation of proposed and appraised alternative uses for the parcel in question for it to qualify as an avoided conversion project. We did not have a reliable way to find this information across the entire state, so we determined that if a forested parcel was near areas with high proportions of development or agriculture (the most typical competing land uses in North Carolina), it was reasonable to assume that the forest there might be threatened by conversion in the future and should be considered for a potential avoided conversion project.

After identifying the appropriate project type for each case study parcel, we modeled carbon and calculated potential offset credits with the following steps:

**Reforestation Projects**

1. **Baseline Carbon Stocks:** Under the California Protocol, the baseline for a reforestation project is composed of two elements: onsite carbon pools and the carbon stored in harvested wood products, which are products such as timber or pulpwood that are removed and sold commercially. Both factors are roughly based on the current status of the parcel, or a “business-as-usual” (BAU) management scenario, and can be calculated for private or non-federal public lands.

Onsite carbon is calculated from an inventory of the tree cover and other carbon reservoirs currently on the property, and is then modeled out for the 100-year project life. Because of the large spatial scope of this project and our limited timeline, we did not collect field inventory data for any of our modeled parcels. Instead, as a proxy for field data, we used Forest Inventory and Analysis (FIA) plot data from 2011, the same year as our land cover datasets. While FIA data is freely available, the provided geographic coordinates of each plot are fuzzed within roughly 1 km from the actual plot location. When choosing the best FIA plot to represent field data for each parcel, we compared the plot tree species with the expected forest cover type identified by the target land cover mask. We also compared the fuzzed plot location to the surrounding area using Google Earth satellite imagery to visually assess the similarity between the plot and the parcel in question. We then used this FIA plot data as the basis for projected growth of the forest over 100 years.

We conducted our growth and yield modeling of any preexisting trees using the Southern Variant of the U.S. Forest Service’s Forest Vegetation Simulator (FVS) software. Though the California Protocol includes options for several onsite carbon pools, we limited our modeling to aboveground and belowground carbon in both live and dead trees. The reasoning behind this decision is discussed below, in the Key Modeling Assumptions section. We determined the amount of carbon stored in these

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96 U.S. Forest Service Forest Inventory and Analysis Program, 2011
97 Forest Vegetation Simulator, n.d.
four carbon pools from the FVS Carbon Report model output. FVS calculated carbon values in metric tons per acre (mt/ac) on 3-year cycles. We converted these values to mt CO₂e/ac, used a linear interpretation to approximate annual CO₂e volumes from the 3-year model outputs, and scaled up to cover the entire project area for carbon offset credit calculations (in mt CO₂e).

Because of the lack of substantial existing tree cover on parcels eligible for reforestation projects, we assumed that the baseline for harvested wood products would be zero.

2. **Project Carbon Stocks**: The other major component of the carbon offset calculations is actual carbon stocks sequestered on the property and in harvested wood products, based on initial inventory data and measured in the field over the same 100-year period as the baseline. For this analysis, however, we needed to estimate “actual” carbon stocks before a carbon offset project had even been established, to assess the viability of such a project on each parcel.

To do this, we used FVS to model the stand’s growth, including both preexisting trees from the FIA plot and those expected to be planted as part of the reforestation work. We included any basic silvicultural management activities that TNC NC commonly uses on their properties to meet their conservation objectives, to provide as realistic a carbon offset projection as possible. These practices included combinations of regular prescribed burning, thinning, competition control, and replanting. We quantified potential carbon sequestration from the project for the same onsite carbon pools included in the baseline scenario (in mt CO₂e).

Though TNC NC does not actively engage in timber harvests, trees removed during management activities may be sold commercially. Therefore, in this scenario, we treated any management removals as harvested wood products and included the carbon they sequestered as part of the project carbon stocks (in mt CO₂e).

3. **Greenhouse Gas Emissions Reductions**: After calculating the baseline and project scenario carbon stocks in mt CO₂e over the 100-year project life, we used Equation 5.1 from the California Protocol to calculate the possible carbon offset credits on a yearly basis for the project (Figure 5).

We calculated QR, annually for the 25-year crediting period, starting in 2021. We chose this starting year because it is typical for California market offset projects to require roughly 3 years of preparation and verification before the first offset credits can be issued. For any modeled silvicultural management activities during the crediting period, we recorded the frequency and cost of these practices, as well as any potential

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98 Jeffrey Marcus, pers. comm., Feb. 2018; Megan Sutton, pers. comm., Mar. 2018
99 Jeffrey Marcus, pers. comm., Feb 7 2018
100 Josh Strauss, pers. comm., Oct. 18, 2017
revenues from harvested wood products. These values provided the primary inputs for our financial modeling to analyze the cash flow of each reforestation case study.

Equation 5.1. Net GHG Reductions and GHG Removal Enhancements

\[ Q_{R_y} = \left[ (\Delta AC_{ onsite} - \Delta BC_{ onsite}) + (AC_{wp,y} - BC_{wp,y}) \times 0.80 + SE_y \right] \times (1 - ACD) + N_{y-1} \]

(1) \hspace{1cm} (2) \hspace{1cm} (3) \hspace{1cm} (4) \hspace{1cm} (5) \hspace{1cm} (6) \hspace{1cm} (7)

**Equation Components**

1. \( (1) \): carbon sequestered in year \( y \) (mt CO2e)
2. \( (2) \): change in project ("actual") and baseline scenario onsite carbon stocks from previous year (carbon in year \( y \) – carbon in year \( y-1 \), in mt CO2e)
3. \( (3) \): difference in project ("actual") and baseline scenario harvested wood products carbon stocks in year \( y \) (mt CO2e)
4. \( (4) \): market responses to changes in wood products production on the project site
   \( \approx 20\% \) leakage factor assumed for every 1-ton reduction in harvested wood products on site
5. \( (5) \): secondary effects, such as machinery emissions or leakage of non-forest land uses from project site to other lands (mt CO2e)
6. \( (6) \): avoided conversion discount factor, based on difference in appraised land values for current use and proposed alternative use (for Avoided Conversion projects only)
7. \( (7) \): negative carryover from the previous year \( y-1 \) (mt CO2e)

Figure 5. California Protocol Greenhouse Gas (GHG) Emissions Reductions Equation.\(^{101}\)

**IFM Projects**

1. **Baseline Carbon Stocks**: Similar to a reforestation project, the IFM baseline accounts for the carbon stored onsite and in harvested wood products. For onsite carbon stocks, the growth of the parcel’s initial forest cover is again modeled over 100 years under a conservative BAU scenario for both private and non-federal public lands. However, the private land baseline calculations also consider regional averages of aboveground live tree carbon content by forest cover type in addition to the property’s initial tree cover. These regional averages, called the Common Practice value (CP), provide minimum baseline stocking levels that the modeled BAU scenario cannot fall below. Non-federal public land baselines should be based on the last 10 years of management and carbon stocks. Given our lack of specific field data or detailed knowledge of each parcel, determining a reasonable BAU scenario or a 10-year management history was difficult. Therefore, we decided to simply take the CP value for aboveground live carbon stocks and use it to construct the baseline for both private and non-federal public lands.

   To calculate the CP value for each parcel, we used the target cover types mask to identify the relevant forest cover types, referred to as Assessment Areas. We cross-referenced these Assessment Areas with a database provided by CARB for specific use in

\(^{101}\) Adapted from CARB, 2015b
CP calculations\textsuperscript{102} to find the regional average of aboveground live carbon stocks (in mt CO\textsubscript{2}e/ac) for each parcel. We calculated a weighted average of these CP values by their relative acreage within the parcel to arrive at a single baseline carbon stock value for the project. This value was held constant for the 100-year project life.

To calculate the baseline for the other included carbon pools, we researched general relationships between each pool and aboveground live carbon stocks. Based on the average of ratios from two peer-reviewed meta-analyses, we decided to calculate belowground live carbon as 24\% of aboveground live carbon for hardwood forests, 25\% for coniferous forests, and 26\% for mixed forests.\textsuperscript{103} We used FVS mortality equations to determine an average proportion for dead aboveground and belowground carbon stocks, based on species-specific mortality coefficients ranging from 3\%-9\%.\textsuperscript{104}

Our estimation of baseline carbon stocks for harvested wood products was dependent on the current ownership and management of each parcel. For publicly-owned lands, we assumed that current forest management activities would be comparable to TNC NC’s own silvicultural plans (modeled under the project scenario), since both TNC NC and state forest management agencies act with forest health and resilience as priorities. For industrial timberlands, we assumed a maximum sustainable yield harvesting scenario. For non-industrial private forestland, we used information on current ownership and satellite imagery to assess the historical harvesting levels on the property and modeled the baseline accordingly.

2. **Project Carbon Stocks**: To model IFM project carbon stocks, we used FVS to project the growth of the parcel’s initial forest cover. We incorporated any silvicultural management activities according to TNC NC’s information.\textsuperscript{105} Any trees removed during these management activities were included in project scenario harvested wood products carbon stocks.

3. **Greenhouse Gas Emissions Reductions**: We returned to Equation 5.1 (Figure 5) to calculate the potential yearly carbon offset credits over the 25-year project crediting period for each IFM parcel, starting in 2021. We also included the frequency and cost of management activities, as well as revenues from any harvested wood products, in the financial model for each IFM project.

**Avoided Conversion Projects**

1. **Baseline Carbon Stocks**: According to the California Protocol, avoided conversion projects also incorporate onsite and harvested wood products carbon stocks in their

\textsuperscript{102} CARB, 2015a
\textsuperscript{103} Mokany, Raison, & Prokushkin, 2006; Poorter et al., 2012
\textsuperscript{104} Keyser, 2008
\textsuperscript{105} Jeffrey Marcus, pers. comm., Feb. 2018; Megan Sutton, pers. comm., Mar. 2018
baselines. However, only privately-owned lands are eligible for avoided conversion projects. Since this project type is built on the assumption that the existing forest will be removed without an offset project in place, the baseline exhibits a gradual decrease of carbon during the first 10 years of the project life. The rate and magnitude of this decrease depends on the alternative land use, and these values can either be extracted from official conversion planning documentation or from default values for various scenarios outlined in Table 5.3 of the California Protocol.

For our avoided conversion projects, we used the default values for either residential or agricultural conversion to decrease the baseline onsite carbon stocks over the first 10 years of the project, depending on which alternative land use we identified as the highest threat to each parcel. For residential conversion, we compared nearby easements or developments to assess the potential amount of forest conversion. After modeling the appropriate decrease in carbon stocks for the first 10 years of the project, we held the baseline carbon values steady for the remainder of the 100-year project life. We quantified carbon for the aboveground and belowground live and dead carbon pools.

The baseline scenario also included harvested wood products for the first 10 years of the project, when the forest would presumably be converted to an alternative non-forest land use. We assumed that any merchantable timber or other products cleared from the parcel would be utilized, but that once the initial conversion was complete any subsequent harvests would cease.

2. **Project Carbon Stocks**: To estimate the project scenario onsite and harvested wood products carbon stocks, we used FVS to model the growth of each parcel’s initial forest cover over 100 years. We included any silvicultural activities expected to occur under TNC NC’s management. Any trees removed during these activities were included in the harvested wood products carbon stocks.

3. **Greenhouse Gas Emissions Reductions**: Using Equation 5.1 (Figure 5), we calculated the potential carbon offset credits from each avoided conversion project. In addition to the changes in carbon stored onsite and in harvested wood products, we calculated the Avoided Conversion Discount factor (Component 6 of Equation 5.1). The discount factor accounts for the uncertainty of conversion, and is based on the ratio of fair market appraised land values under the alternative land use and the current (forested) land use. We estimated these values from county tax office data for each project and applied the discount factor in years with an increase in carbon sequestration from Components 2-5 of the GHG Reductions Equation.

We calculated GHG Emissions Reductions annually for the 25-year crediting period from 2021 onward. We used these values, along with frequency and cost of silvicultural management activities and potential revenues from harvested wood products, in our financial modeling of each avoided conversion project.
1. **Baseline Carbon Stocks**: The ACR Pocosin Protocol outlines two different ways to account for carbon emissions and removals: the stock approach and the flux approach. The stock approach measures changes in surface elevation, soil parameters, and above- and belowground biomass, while the flux approach links belowground carbon pools to proxy variables. In either case, the focus of the protocol is avoiding greenhouse gas emissions from belowground carbon stocks, defined as the mean annual change in soil organic carbon and belowground biomass pools. Because peat accumulates so slowly, these existing belowground pools are a significant factor in determining the baseline. The number of metric tons CO₂e released or stored by a pocosin peatland under the baseline scenario depends on a number of variables, including water table depth, bulk density, carbon fraction, all of which require site-specific field data. While USGS groundwater well data is publicly available, the locations of wells are too sparsely dispersed to provide reliable estimates for use at the individual parcel scale.

Project area is the other key aspect of accounting for both baseline and project carbon stocks. To determine the area of pocosin in each parcel, we compared areas identified by GAP as pocosin with the extent of histosol soil types as mapped by SSURGO, as histosol soil types are a good proxy for pocosins and peatlands.

2. **Project Carbon Stocks**: Project carbon stocks are calculated as the amount of emissions avoided by raising the water table and preventing peat oxidation, as well as the sequestration potential via biomass.

3. **Greenhouse Gas Emissions Reductions**: Net Emissions Reductions (NER) are calculated as the project scenario subtracted from the baseline. However, because we could not calculate an exact baseline or project scenario due to lack of site-specific data, we used an average Emissions Reduction Factor. TerraCarbon has estimated that raising the water level on a partially drained pocosin yields an emission reduction factor of 3-5 mt CO₂e per hectare per year. Raising the water level on fully drained pocosins, such as former agricultural land, may have higher emissions reduction but no data yet exists on exactly how much more. This represents the GHG emissions avoided by preventing peat oxidation, and although it does include sequestration in peat, the bulk of the CO₂ reduction comes from prevention of GHG losses from pocosins. In projects reported, we used the mean value of 4 mt CO₂e per hectare per year to determine greenhouse gas emissions reductions over the 20-year project crediting period. We then multiplied this

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106 Shoch et al., 2017
107 U.S. Geological Survey National Water Information System, 2018
109 Erin Swails, pers. comm., Feb. 28, 2018
110 Ibid.
emission reduction factor by the area of pocosin in a parcel, as measured by histosol extent and GAP landcover type, to create an estimate of carbon sequestration under project scenarios. Given the lack of field data, this is the best estimate we are able to provide, and suggest that further investigation be done for any individual parcel under consideration.

Key Modeling Assumptions

The carbon quantification process described above was founded on a series of important assumptions, largely based on available data and resources:

- **Included Carbon Pools**: Our quantification methods captured most of the carbon pools listed in the California Protocol, and incorporated the required pools for each project type. However, we did not include onsite soil carbon in any of our modeling. Soil carbon data is sometimes unreliable, and incorporating soil carbon fluxes and the potential effects of management activities would introduce more uncertainty to our carbon model. Excluding this information therefore was a conservative decision based on our project’s focus on the carbon stored in standing trees and harvested wood products.

  However, any potential reforestation projects would likely sequester more soil carbon over time, while avoided conversion projects might benefit from avoiding soil carbon losses. These impacts on potential GHG Emissions Reductions are not included here, but should be considered in TNC NC’s project selection.

- **FIA Plot Data**: In deciding to use FIA plot data as a proxy for actual field inventories on each parcel, we inherently assumed that each plot was sufficiently representative of actual parcel conditions. This was a two-fold assumption: (1) since FIA plot coordinates are fuzzed, we assumed that we’d accurately approximated their location in relation to each parcel; and (2) we assumed that future parcel conditions modeled from this 2011 data were sufficiently similar to conditions now in 2018.

  This was one of the most critical assumptions we made in this analysis. All our calculations were based on approximate or remotely sensed characteristics of each parcel, and actual ground attributes may be quite different. This analysis should provide a general lens for thinking about possible carbon offset projects, which is why we have framed our work around case studies rather than specific site recommendations. For serious consideration of any one parcel, field data should be collected very early on in the process.

- **Baseline Calculations**: We made two major assumptions regarding the baseline carbon stocks calculations. First, for reforestation and IFM projects, we assumed either no commercial harvesting of wood products or no difference from TNC NC’s optimal management and harvesting activities. Second, for IFM projects, we decided that the CP
carbon values were an acceptable substitute for a baseline built from a conservative BAU scenario.

The modeled baseline has a substantial effect on the ultimate viability of a carbon project, because credits are only issued for additional carbon sequestered above the baseline level. Therefore, any assumptions affecting the baseline, such as included management practices, harvesting volumes, or carbon pools, will have compounding effects for the potential of the project as a whole.

- **Forest Management Activities**: We included TNC NC’s common management activities in the 100-year growth and yield models of each project scenario. In doing so, we assumed that our model was an accurate representation of a reasonable management regime, and that no other practices would be necessary on a property to achieve TNC NC’s conservation goals.

For any future project feasibility assessment, it will be important to model both baseline and project scenario management activities accurately to get a realistic picture of carbon sequestration potential and to inform actual management on the ground once the project is established.

- **Pocosin Drainage**: Due a lack of site specific data, we had to make several large assumptions in modeling pocosin projects, namely in determining project area and potential sequestration. Key to both of these is a lack of data on drainage status. To determine the area of pocosin eligible for a carbon offset project, we relied on aerial photography and the presence of agriculture or canals in the surrounding areas.

Additionally, we did not have the necessary data on soil parameters and water table depth to quantify carbon storage potential or potential emissions reductions. There is variability within the estimate of 3-5 mt CO$_2$e per hectare per year emissions reductions, which captures on the expected range of carbon benefits but not a defined, parcel-specific estimate. As such, there is variability both in the amount of carbon sequestered on a per acre basis and the number of acres over which a project could extend. Both of these could dramatically affect a property’s viability, and so all pocosin projects in this report should be treated as illustrative cases only.

Each of these assumptions introduced an element of uncertainty to our analysis, which we were willing to accept for our case studies. We have various suggestions for TNC NC to address these assumptions in the future as they establish carbon offset projects, which we will describe in more detail in our Discussion section.

**Financial Modeling**

To assess the economic feasibility of potential offset projects, we developed a financial
model to simulate the cash flow of the projects and evaluate their returns under different conditions. Key inputs into this model are forest management and project development costs, which we estimated based on literature review and expert elicitation, and offset credit prices, which we forecasted in the compliance market out through 2050. This section will describe our methodology for creating both the offset price forecast and the cash flow model.

**Price Forecast**

To model the carbon offset revenues that a project would receive, we constructed a forecast of offset prices for the California compliance market and voluntary market out to 2050. Using the federal consumer price index, we converted all historical price data to real 2018 dollars.

Developing a forecast of offset prices in the California market required us first to model the auction floor price and traded allowance prices out to 2050. We used historical allowance and offset traded prices from the first trading day of each year for which data was available.\(^{111}\) Annual auction floor prices from past years are publicly available in auction notices from CARB.

While the California cap-and-trade program is currently only authorized until 2030, our price model assumes that the basic structure of the program will be maintained in operation through 2050. This assumption aligns with Governor Jerry Brown’s 2015 Executive Order, which set a statewide 2030 GHG reduction target as a stepping stone to reach a more ambitious 2050 target, and instructed state agencies to implement measures to achieve the GHG reductions in both the 2030 and 2050 targets.\(^{112}\) The state legislature has already approved the use of cap-and-trade to meet the former target through AB 398, so it is reasonable to assume that the legislature may reauthorize cap-and-trade to help the state meet its 2050 target as well. However, there does remain some level of risk that the program will not be re-authorized beyond 2030, which would dramatically affect offset credit prices.

In line with the assumption that the California market will persist beyond 2030, we model the auction floor price increasing at 5% annually in real dollars through 2050. Traded allowance prices are more difficult to forecast because they are highly sensitive to demand for allowances, which may change based on future technological changes or regulatory adjustments to the supply of allowances. For our forecast, we rely on a 2030 allowance price forecast published by former members of CARB’s Emissions Market Assessment Committee, which forecasts an allowance price based on a probabilistic assessment of whether the market will be over- or undersupplied by 2030.\(^{113}\) We assume that allowance prices will maintain their current premium over the auction floor price through 2020, followed by a linear trajectory to Borenstein et al.’s forecasted price from 2021-2030. From 2031-2050, we conservatively assume that allowance prices will rise by 5% per year in real dollars, tracking the annual rise in the auction floor price.

Our offset price forecast includes three scenarios. The base case scenario assumes that traded offset prices track the auction floor price at a constant discount, which is estimated as

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\(^{111}\) California Carbon, 2018  
\(^{112}\) Brown, 2015  
\(^{113}\) Borenstein, Bushnell, & Wolak, 2017
the average discount to the floor price over the past five years. The base case is our preferred scenario, as it is not sensitive to the uncertainty around future supply and demand dynamics in the allowance market, and tracks reasonably well with historical data that shows stochastic variation in the discount between traded offset prices and the auction floor price but no clear trend. The high case scenario assumes that offset prices track forecasted allowance prices at a constant discount, also estimated as the average historical discount between offsets and allowances. This scenario is more in line with an eventual scarcity of compliance instruments in the market, which would cause the price of both allowances and offsets to rise more quickly than the floor price. Finally, the low case scenario accounts for a future in which offset usage limits and restrictions on project location increasingly restrict the offset market in the future, causing offsets to be devalued relative to allowances. In this scenario, offset prices grow by only 2% per year. See Appendix C for more details on the policy and market risks and opportunities that inform these forecast scenarios.

Figure 6. Offset credit price forecast through 2050 for the California compliance market (under high, low, and base case market scenarios) and the voluntary market.

To inform our offset price forecast in the voluntary market, we collected annual average
transaction price data for US forestry offset credits going back to 2011.\textsuperscript{114} Average historical prices range from $8.6/mt CO\textsubscript{2}e to $10.4/mt CO\textsubscript{2}e, with no clear trend over time. To account for the relatively flat historical pricing for voluntary offset credits while recognizing the potential for future market growth (see Appendix C), we forecasted 2\% annual growth in voluntary market prices starting from their reported level of $9.2/mt CO\textsubscript{2}e in 2016.\textsuperscript{115}

Our primary financial analysis for forestry offset projects relies on the base case California market price forecast. We then conduct sensitivity analyses using the high and low cases to test the feasibility of potential offset projects under different market conditions. Our financial analysis for pocosin offset projects, meanwhile, relies on the voluntary market price forecast, as this is currently the only market with an approved protocol for pocosin projects.

The price forecast for all three California market scenarios and the voluntary market is shown in Figure 6.

\textit{Discounted Cash Flow Model}

The profitability of an offset project is not dictated solely by the rate at which the forest or pocosin sequesters carbon from the atmosphere. Financial performance can be heavily impacted by the project’s choice of protocol, which registry it registers its offset credits under, and which market it chooses to sell into. Land title or easement acquisition and project aggregation can also add significant costs to a project, but were not considered in this analysis for reasons described below. While the full range of project development choices is not analyzed here, our discounted cash flow model is intended to compare different projects and identify the most financially viable projects. The outputs from the financial model feed into our later recommendations regarding the most attractive project types and locations for offset project development.

The cash flow model evaluates the financial performance of a project by first calculating its cumulative cash flow, and then using the projected cash flow to calculate a Net Present Value (NPV) and Internal Rate of Return (IRR) to evaluate the profitability of a project.

- \textbf{Net cash flow and cumulative cash flow}: Net cash flow is the total revenue minus total cost over a single period, illustrating the project’s performance for one specific period. Cumulative cash flow is the sum of net cash flows across multiple time periods. It demonstrates the long-term performance of a project and identifies when the project starts to generate profits after paying off initial costs.\textsuperscript{116}

Revenue and cost items included in the net cash flow calculation are shown in Table 9. Land acquisition cost and conservation easement cost are not considered in the analysis. Costs associated with aggregation are also not included since aggregation is not widely adopted in the current market.

\textsuperscript{114} Hamrick and Gallant, 2017; Goldstein and Ruef, 2016; Goldstein, 2015; Peters-Stanley et al., 2013
\textsuperscript{115} Hamrick & Gallant, 2017a
\textsuperscript{116} Mian, 2011
<table>
<thead>
<tr>
<th>Category</th>
<th>Item</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>Carbon Credit Revenue</td>
<td>Income from selling carbon offset credits</td>
</tr>
<tr>
<td></td>
<td>Timber Revenue</td>
<td>Income from selling harvested timber</td>
</tr>
<tr>
<td></td>
<td>Project Startup Cost</td>
<td>Cost need to initiate the project</td>
</tr>
<tr>
<td></td>
<td>Inventory Cost</td>
<td>Cost for developing a carbon inventory</td>
</tr>
<tr>
<td></td>
<td>Monitoring Cost</td>
<td>Cost for monitoring the carbon inventory</td>
</tr>
<tr>
<td></td>
<td>Verification Cost</td>
<td>Cost for verifying offset project data reports</td>
</tr>
<tr>
<td></td>
<td>Site Management Cost</td>
<td>Cost for management activities that maintain or increase carbon stocks</td>
</tr>
<tr>
<td></td>
<td>Account Setup Cost</td>
<td>Fee charged when a project developer files application</td>
</tr>
<tr>
<td></td>
<td>Annual Account Maintenance Cost</td>
<td>Annual fee to maintain the cost</td>
</tr>
<tr>
<td></td>
<td>ARB Project Submittal Fee</td>
<td>Fee charged when the project is under ARB protocol</td>
</tr>
<tr>
<td></td>
<td>Project Variance Review Fee</td>
<td>Cost for requesting a variance on monitoring or calculation methods</td>
</tr>
<tr>
<td></td>
<td>Project Eligibility Screening Fee</td>
<td>Cost for screening the project eligibility under ACR or Non-ACR methodologies</td>
</tr>
<tr>
<td></td>
<td>Issuance Fee</td>
<td>Fee charged upon the issuance of credits</td>
</tr>
<tr>
<td></td>
<td>Transaction Fee</td>
<td>Cost for transferring credits</td>
</tr>
<tr>
<td></td>
<td>Transfer Fee</td>
<td>Cost for transferring credits</td>
</tr>
<tr>
<td></td>
<td>Activation Fee</td>
<td>One-time cost to activate the credits so that they could be transacted</td>
</tr>
</tbody>
</table>

Project revenues include proceeds from selling offset credits and harvested wood products. The offset credit revenue is equal to the number of offset credits multiplied by the forecasted price in each year that offset credits are sold. The number of offset credits sold is calculated as the additional carbon sequestered in each period minus a certain percentage to account for offset credits that are redirected to the CARB Forest Buffer Account. When unintentional reversals happen, CARB will retire the corresponding number of credits from the Forest Buffer Account.\(^{117}\) The percentage of

\(^{117}\) CARB, 2015b
offset credits directed to the Forest Buffer Account is determined by the project’s reversal risk rating, which comprises project-specific financial, management, social and natural disturbance risks.\textsuperscript{118}

To calculate offset credit revenues for forest projects, we used the base case California market price forecast. For pocosin projects, we calculated offset credit revenues based on the voluntary market price forecast, as that is the only market that currently supports that project type.

The timber revenue calculated for forest projects is the product of the amount of harvested timber and timber prices. In the carbon model, the amount of harvested timber is the model output as a result of necessary thinning operations to maintain or increase the carbon stocks of the project. The timber prices vary by the types of timber products. In North Carolina, the average prices of timber have increased by 96.2\% since 1988, compared to the cumulative rate of inflation of 110.5\% (CPI Inflation Calculator, Historic North Carolina Delivered Timber Prices, 1988-2017). Given the moderate difference between price increasing rate and inflation rate, we used the latest timber prices in real dollars as the future timber prices.

The cost associated with project development and operation can vary significantly based on the size of the parcel. To take this factor into account, we set up three benchmark size profiles: small (5,000 acres), medium (10,000 acres), and large (20,000 acres). We categorized each parcel by determining whether it best matched the small, medium or large profile, then used the corresponding cost assumptions for cash flow calculation. The cost assumptions based on size differences are shown in Table D1 of Appendix D.

Besides the size of the parcel, different registries also have different fee schedules that will impact the cost of a project. Given the fact that no protocols from VCS are considered plausible in our study, we only compared the fee schedule differences between CAR and ACR (Appendix D, Table D2).

- **NPV and IRR**: NPV is the net present value of all cash inflows minus costs. Since costs occur during every period of the project, the adjusted NPV formula should be the present value of all the net cash flows. When the NPV is positive, we consider the project to be profitable, otherwise the costs exceed the total earnings of the project\textsuperscript{119}. The NPV can be calculated as:

\[
NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+r)^t}
\]

Where:
NPV = Net present value
NCF\textsubscript{t} = Net cash flow of year \textit{t}

\textsuperscript{118} CARB, 2015b
\textsuperscript{119} Mian, 2011
\[ r = \text{Discount rate} \]
\[ t = \text{Year} \]
\[ n = \text{Project crediting period} \]

IRR is the rate of return at which the project could break even and can be calculated with a built-in function in Excel.\(^{120}\) When the discount rate equals the IRR in the NPV formula, the NPV is zero. IRR can be compared with the minimum rate of return or IRR of other projects to provide insights on profitability. When the IRR of one project is greater than the minimum rate of return requested by TNC NC, this project could be considered as profitable. If the IRR of one project is greater than the IRR of other projects with the similar project length, this project is more profitable.\(^{121}\)

- **Discount Rate**: The long timespan required for carbon offset projects makes their financial performance, especially NPV, very sensitive to changes in the discount rate used for future costs and revenues. The discount rate reflects the opportunity cost of the investment and also the project’s minimum expected required rate of return. If TNC NC is not financing the carbon offset project development, it would be infeasible to calculate the weighted average cost of capital (WACC) as the discount rate. According to publicly available project documents from CAR, projects widely adopt 7% as the discount rate to reflect the regulatory uncertainties and land pressures in California.\(^{122}\)

In 2010, TNC used 6.5% as the discount rate for the analysis of potential forest carbon projects in the Clinch Valley.\(^{123}\) Considering the facts mentioned above, we decided to use a moderate 6.5% of discount rate for NPV calculation, while conducting a sensitivity analysis to assess how changes in the discount rate would affect projects’ profitability.

**Key Modeling Assumptions**

Given constraints of project scope and limited data availability, the cash flow model is based on a series of assumptions that may not reflect the actual conditions of a project.

- **Cost estimates**: While we differentiate the costs based on small, medium and large parcel sizes, other factors could also contribute to the cost variances such as the location of the project site.\(^{124}\) Moreover, due to the lack of market data, we could not forecast trends in future costs. Thus, we assumed no changes to the cost assumptions in real dollars during the project’s life.

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\(^{120}\) Gallo, 2016
\(^{121}\) Ibid.
\(^{122}\) CAR, 2017b
\(^{123}\) Gregory S. Meade, pers. comm., Jan. 19, 2018
\(^{124}\) Josh Strauss, pers. comm., Oct. 18, 2017
• **Land acquisition and conservation easement**: Land acquisition and conservation easement costs could add a significant amount of upfront cash outlay. These costs often vary significantly depending on the location, the negotiation process, and site-specific conditions. We believe that including these cost elements would compromise the transferability of the case study results. Therefore, as suggested by TNC NC, we decided not to include the land acquisition conservation easement costs in the financial analysis.

• **Inventory interval**: We are assuming the project needs to be re-inventoried every six years, even though the maximum limit is twelve years, so that the project is more likely to pass key site verifications. However, the high inventory cost that results from this assumption could affect the project’s profitability.

• **Project aggregation**: Due to a lack of successful aggregated project examples and the difficulty in coordinating with multiple landowners, we assumed no aggregation for potential projects.

**Case Study Evaluation**

Using the carbon quantification and cash flow modeling results for each case study parcel, we evaluated the viability of a potential offset project for the various locations and project types that we modeled. We then isolated key characteristics of each case study that contributed to the project’s viability. For non-viable projects, we also analyzed sensitivity to the carbon modeling assumptions to pinpoint the most critical assumptions or data limitations. Finally, we used these results to draw larger inferences about the most promising locations and offset project types in North Carolina. We synthesized this information into concrete recommendations for TNC NC to offer some guidance as they seek out viable carbon offset projects in the state.

\[^{125}\text{Josh Strauss, pers. comm., Feb. 16, 2018}\]
Results

Site Identification and Prioritization

Of the 1,937 parcels identified, only 57 are larger than 5,000 acres (Table 10). As previously discussed, 5,000 acres is often considered to be the minimum size necessary for an offset project to be financially viable. However, there are a number of landowners whose total landholdings are more than 5,000 acres even if no single parcel meets this threshold. The State of North Carolina is the most common landowner within our focus regions, owning approximately 390,000 acres across 221 separate parcels. Several timber companies also have significant landholdings. Weyerhaeuser owns approximately 257,470 acres across 164 parcels, and Red Mountain Timber Company, LLC has 134,000 acres in 47 separate parcels. Landowners with ownership of multiple parcels in the state could potentially aggregate parcels into a single offset project. Both non-federal public lands and industry-owned timber lands are eligible for carbon projects (see Tables 1 and 3). However, timber companies would have to change their silvicultural practices to qualify for an IFM project, and all harvested timber must be accounted for in calculating carbon sequestration under baseline and project scenarios.

Table 10. Distribution of parcel size by size class and total acreage per size class.

<table>
<thead>
<tr>
<th>Size Class (acres)</th>
<th>Number of Parcels</th>
<th>Total Acreage in Size Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10,000</td>
<td>21</td>
<td>406,507.6</td>
</tr>
<tr>
<td>5,000-10,000</td>
<td>36</td>
<td>239,181.1</td>
</tr>
<tr>
<td>3,000-5,000</td>
<td>67</td>
<td>252,150.7</td>
</tr>
<tr>
<td>500-3,000</td>
<td>1,813</td>
<td>1,784,716.3</td>
</tr>
</tbody>
</table>

Slightly less than half of the parcels identified are in the Albemarle-Pamlico focus region, or 866 out of 1,937 total parcels (Figure 7). In the Longleaf Pine region, there are 726 candidate parcels, or 37.5% of the total parcels considered. These regions likely have more large parcels due to their flat topography. The Southern Blue Ridge and foothills region is known to have generally smaller parcels, and accordingly only 345 parcels, or 17.8% of all parcels, are within this region.

After weighting and combining all the variables each parcel was scored on, we found four parcels which scores greater than 90 out of 100 possible points, and 14 which scored between 80 and 90 (Figure 8). Scores range from a low score of 1 to a maximum score of 96. The mean score is 34.1 with a standard deviation of 19.8.
Figure 7. Distribution of parcels between the three focus regions.

Figure 8. Distribution of site priority scores of candidate parcels.
Case Study Findings

Of the six case study projects we modeled (Figure 9), only two showed positive offset credit accumulation (Table 11). We discuss the project specifics and reasons for failure or success below:

Figure 9. Case study locations.

Sandhills Game Land Project

This 24,644-acre parcel is part of the Sandhills Game Land complex in the Longleaf Pine focus region. It is dominated by longleaf pine (*Pinus palustris*) forest, and received a high site priority score of 96 driven by its size, resilience, and location in core longleaf pine habitat.

This parcel is not viable as an IFM project because of the typical way that TNC NC manages for longleaf pine habitat. Longleaf pine stands are managed for low tree density (50-80 sq ft of basal area), and are frequently subjected to prescribed burns because the ecosystem is naturally fire dependent. These management activities do not allow the project carbon stocks to grow beyond the CP regional baseline (Figure 10), which results in turn means the project will not generate offset credits (Table 11). This finding is consistent with other studies on the carbon offset potential of longleaf pine ecosystems.

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127 Galik & Cooley, 2012; Remucal et al., 2013
### Table 11. Case Study Carbon Model Results.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Project Type</th>
<th>Project Area (acres)</th>
<th>TNC Priority Landscape</th>
<th>Site Priority Score</th>
<th>Ownership</th>
<th>Cumulative Carbon Offset Credits (mt CO\textsubscript{2}e)</th>
<th>NPV ($)</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandhills Game Land</td>
<td>IFM</td>
<td>24,644</td>
<td>Longleaf Pine</td>
<td>96</td>
<td>State</td>
<td>-839,790</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
| Balsam Gap                   | IFM          | 3,853                | Southern Blue Ridge    | 85                 | Private   | -14,566
-90,264                                               | N/A     | N/A  |
| Red Mountain Timber Co       | IFM          | 34,666               | Longleaf Pine          | 58                 | Private   | -22,423                                               | N/A     | N/A  |
| Robinette                    | AC           | 2,063                | Longleaf Pine          | 77                 | Private   | 101,067                                               | $427,801| 17.2%|
| Bryan Farms                  | Pocosin      | 2,607                | Longleaf Pine          | 83                 | Private   | 84,467*                                               | $52,577 | 8.5% |
| Murphy Farms                 | Reforestation| 660                  | Longleaf Pine          | 26                 | Private   | 41,495                                                | -$21,269| 6.0% |

*Based solely on estimated Emissions Reduction Factor of 1.62 mt CO\textsubscript{2}e per acre per year
For crediting period (25 years for forests, 20 years for pocosins)

For more information on each parcel, see Appendix E.
Because this project does not produce carbon offset credits, we have determined it is not a viable offset project. Therefore, we have not conducted a financial analysis of this case study.

_Balsam Gap Project_

This project, near Waynesville in the Southern Blue Ridge focus region, is 3,853 acres in size. The majority of the Balsam Gap property is covered by Southern Appalachian montane oak, northern hardwood, and cove forest. The parcel scored 85 for site priority based on its high conservation priority, resiliency, and proximity to previous TNC NC projects.

This parcel has potential for either an IFM or avoided conversion project, but does not generate carbon offset credits under either scenario (Table 11). TNC NC would manage this property to promote the oak-dominated forests that have historically stood in this area of the state.\(^{128}\) This management would include controlling understory hardwood competition with regular prescribed burns, which in turn brings the parcel’s carbon sequestration below baseline levels (Figures 11-12).

As an IFM project, this drop below the baseline would lead to project reversal and termination. Under an avoided conversion scenario, the estimated conversion rate of the forest

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\(^{128}\) Megan Sutton, pers. comm., March 22, 2018
is only 13%. We based this estimate on parcel size and number in neighboring subdivisions, as an indication of the development rate that might occur on the Balsam Gap property. This project is also restricted by slope in some areas: the California Protocol states that average slope in an avoided conversion project area cannot exceed 40%\textsuperscript{129}, yet the mountains in the project area have slopes ranging from 30-50%\textsuperscript{130}. These slope limitations decrease the project acreage that can be considered threatened by development. This keeps the estimated conversion rate at a low 13%, which does not produce a large enough drop in the baseline to bring it below the project scenario carbon stocks in order to accommodate the onsite carbon fluctuations from TNC NC’s likely management activities. Therefore, this project is not viable under either project type.

Because this project does not produce carbon offset credits, we have determined it is not a viable offset project. Therefore, we have not conducted a financial analysis of this case study.

![Baseline vs Actual Carbon, Balsam Gap Project (IFM)](image)

Figure 11. Onsite carbon sequestration for the Balsam Gap Project under IFM baseline and project scenarios.

\textsuperscript{129} CARB, 2015
\textsuperscript{130} North Carolina Mountain Resources Commission, 2012
Red Mountain Timber Co Project

This parcel is 34,666 acres in size and is currently used as an industrial loblolly pine \((Pinus taeda)\) plantation. Located in the Longleaf Pine focus region, this property received a low site score of 58 because of its low conservation priority—but it is also located close to existing TNC NC projects.

This case study was modeled under an IFM scenario by extending the timber rotation lengths, but it did not appear to produce a viable carbon offset project. Though establishing the project would increase the carbon sequestered on the property (Figure 13), the disruption of the assumed current industrial harvesting regime introduced a high amount of leakage to the GHG emissions reduction equation. This leakage negated any credits generated from carbon sequestration, and ultimately this project did not produce saleable offset credits (Table 11, Figure 14).

Interestingly, this result is highly dependent on the assumed timing of harvesting activities in both the baseline and project scenarios. For example, if all management activities on the property are lumped into one year, rather than distributed through time in a more realistic fashion, the project would generate over 200,000 offset credits due to a smaller impact from leakage. This finding illustrates the importance of our forest management assumptions in determining project viability.
Figure 13. Onsite carbon sequestration for the Red Mountain Timber Co Project under baseline and project scenarios.

Figure 14. Overall GHG emission reductions for the Red Mountain Timber Co Project. The large drops in GHG reductions over the 25-year crediting period are due to expected leakage of timber harvesting outside the project area.
Robinette Project

This privately-owned property is 2,063 acres of primarily swamp hardwood and cypress forest as well as pocosin land cover types. The project is located in the Longleaf Pine focus region just outside the coastal town of St. James, and has a mid-range site priority score (77) driven by its high climate resiliency, local conservation priority, and proximity to existing TNC NC preserves.

This case study shows good potential as an avoided conversion project, generating 101,067 offset credits over the 25-year crediting period (Table 11). This positive credit stream is largely due to the expected 70% decrease in forest cover from conversion to residential development and a project scenario that exceeds the baseline from the beginning of the project (Figure 15). Because of the swamp and pocosin land cover types, this project may not require active management activities, and therefore does not experience the same fluctuations in biomass that previous case studies have shown.

**Figure 15.** Onsite carbon sequestration for the Robinette Project under baseline and project scenarios.

The project recovers all of its initial investment in the first year because of the considerable offset credit revenues, which yield a net cash flow of $245,231 (Figure 16). This particularly short payback period could be ideal for potential investors who would seek to recover their investment in a short period of time. After the fifth year, the project’s net cash flow fluctuates around zero as the growth of the forest slows down and generates fewer credits.
than in the early stages of the project. As a result, the cumulative cash flow stays relatively steady and has a NPV of $427,801.

![Figure 16. Robinette Project cash flow.](image)

The Robinette project has an IRR of 17.2% and a NPV per acre of $207.40, making it one of the most profitable case studies (Table 12). The biggest expenditure is the verification, which costs $375,000 over the project crediting period.

### Table 12. Robinette Project financial summary.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Credits Generated (mt CO₂e)</td>
<td>101,066.90</td>
</tr>
<tr>
<td>Offset Credit Revenue</td>
<td>$1,146,131.79</td>
</tr>
<tr>
<td>Timber Revenue</td>
<td>$-</td>
</tr>
<tr>
<td>Total Inventory Cost</td>
<td>($151,000.00)</td>
</tr>
<tr>
<td>Total Verification Cost</td>
<td>($375,000.00)</td>
</tr>
<tr>
<td>Total Site Management Cost</td>
<td>$-</td>
</tr>
<tr>
<td>NPV</td>
<td>$427,801.51</td>
</tr>
<tr>
<td>NPV per acre</td>
<td>$207.40</td>
</tr>
<tr>
<td>IRR</td>
<td>17.2%</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

*Bryan Farms Project*

This 8,563-acre property is located in the Longleaf Pine focus region and is illustrative of a potential pocosin project. Approximately 2,607 acres of the property appear to be at least partially drained pocosin, as determined from comparing aerial photography with soil type and land cover classification, and therefore eligible for an offset project. Areas excluded from the
project area consist of agricultural fields and an undrained Carolina bay. The property received a high site priority score of 64, but scored well on all variables other than proximity.

This property appears to be a viable pocosin project, generating a positive offset credit stream over the 20-year crediting period. At a rate of 1.62 mt CO₂e per acre per year, the project sequesters 84,467 mt CO₂e. However, it is important to note that without site-specific data on water table depth, soil characteristics, and existing water control structures, this is only an estimate of the property’s sequestration potential. However, this project serves to illustrate the potential for generating carbon offsets were TNC NC to restore a large, partially drained pocosin tract.

The Bryan Farms Project is profitable over the 20-year project period (Figure 17). Its cumulative cash flow becomes positive in the 11\textsuperscript{th} year. The initial project development cost is $363,804 (Table 13), and annual offset credit revenue remains relatively steady. The cash flow dips in the 6\textsuperscript{th}, 12\textsuperscript{th}, and 18\textsuperscript{th} year are mainly a result of additional verification costs incurred.

However, the actual cost of a pocosin project could vary widely based on project site conditions. For example, depending on whether the project needs a berm, the number of water control structures needed, and other factors, the restoration cost could range from $38/acre to $150/acre. Due to the lack of field data, the financial analysis for this project remains hypothetical and may not represent realistic returns for a project on this site.

![Figure 17. Bryan Farms Project cash flow.](image)

**Table 13.** Bryan Farms Project financial summary.

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Credits Generated (mt CO₂e)</td>
<td>84,476.52</td>
</tr>
<tr>
<td>Offset Credit Revenue</td>
<td>$1,042,446.96</td>
</tr>
<tr>
<td>Total Verification Cost</td>
<td>($325,000.00)</td>
</tr>
<tr>
<td>Total Site Management Cost</td>
<td>($245,086.20)</td>
</tr>
<tr>
<td>NPV</td>
<td>$52,576.61</td>
</tr>
<tr>
<td>NPV per acre</td>
<td>$20.17</td>
</tr>
<tr>
<td>IRR</td>
<td>8.5%</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>6.5%</td>
</tr>
</tbody>
</table>
Murphy Farms Project

The 660-acre Murphy Farms property is located in the Longleaf Pine focus region, and is currently occupied by active cropland and a concentrated animal feeding operation (CAFO). There are no visible trees on the property, making it a viable candidate for a reforestation project, and it has a site priority score of 26 due to its relatively small size and low climate resiliency. However, it is directly adjacent to longleaf pine core expansion areas and corridors identified by TNC NC, and is less than 0.5 miles away from core longleaf pine habitat.

This parcel is viable as a longleaf pine reforestation project, generating 41,494 offset credits over the 25-year crediting period (Table 11). The property’s current lack of tree cover leads to positive GHG emissions reductions under the project scenario (Figure 18), even given that TNC NC’s typical management for longleaf pine ecosystems leads to lower stocking levels than other forest types (as described for the Sandhills Game Land Project).

![Baseline vs Actual Carbon, Murphy Farms Project](image)

**Figure 18.** Onsite carbon sequestration for the Murphy Farms Project under baseline and project scenarios. The slight dip of the project scenario from reporting periods 6-9 is due to projected emissions from prescribed burning.

The cumulative cash flow becomes positive at the 20th year and the net cash flow gradually increases as the forest sequesters more carbon per year (Figure 19). However, because the cumulative cash flow does not consider the time value of money, and future revenues are discounted when calculating NPV, the project ends up with a negative NPV of -$21,269 and an IRR that is lower than the discount rate.
As shown in Table 14, even though the IRR is positive, the fact that it is lower than the discount rate means that the project is financially non-viable. The verification cost across the project’s life is more than $400,000, which is the biggest cost item among all the major project development costs.

**Table 14. Murphy Farms Project financial summary.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Credits Generated (mt CO₂e)</td>
<td>41,494.68 k$</td>
</tr>
<tr>
<td>Offset Credit Revenue</td>
<td>$1,492,234.28</td>
</tr>
<tr>
<td>Timber Revenue</td>
<td>-</td>
</tr>
<tr>
<td>Total Inventory Cost</td>
<td>($188,000.00)</td>
</tr>
<tr>
<td>Total Verification Cost</td>
<td>($405,000.00)</td>
</tr>
<tr>
<td>Total Site Management Cost</td>
<td>($294,015.32)</td>
</tr>
<tr>
<td>NPV</td>
<td>($21,269.32)</td>
</tr>
<tr>
<td>NPV per acre</td>
<td>($32.19/acre)</td>
</tr>
<tr>
<td>IRR</td>
<td>6.0%</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

Based on our analysis, it appears that reforestation projects may be financially viable for TNC NC to pursue on parcels significantly smaller than 5,000 acres. Although the Murphy Farms Project, which is 660.71 acres, returns a negative NPV, our analysis shows that a project with the same model parameters and site conditions could break even at a size of 707.43 acres.
Discussion

From the results presented above, we are able to draw several conclusions about TNC NC’s prospects for carbon offset projects in North Carolina. These lessons, discussed below, inform our final recommendations for TNC NC in the next section.

Influence of Land Management Objectives

Most of the case studies modeled illustrate the importance of forest management in a carbon offset project. For the Sandhills Game Land Project, the typical low-density management of longleaf pine is not conducive to a successful IFM project. Similarly, the restoration of oak forests on the Balsam Gap property leads to a decrease in carbon stocks over time, which, while beneficial for forest health, is not a management style that results in additional carbon sequestration.

These two case studies highlight a very important theme—that **conservation and carbon don’t always agree**. In the case of TNC NC, the typical conservation management objectives for these forest types may be to restore the native ecosystem and make it more resilient, but achieving this may require decreasing onsite carbon stocks, even if just temporarily. A management regime that periodically decreases carbon stocks may preclude a viable carbon offset project on the site, just as managing the land specifically to maximize carbon sequestration may not provide the best ecosystem benefits.

This management tradeoff is further supported by the Red Mountain Timber Co Project. The parcel modeled for this case study is currently being managed to yield maximum sustainable timber volumes. While altering this management regime and lengthening harvest rotations may sequester more carbon, the resulting decrease in timber production from the property results in a high risk of harvesting leakage to other timberlands outside the project area, either encouraging current plantation owners to harvest even more frequently or entic ing new forest owners to enter the timber market. In both situations, ecosystem health and resilience on these lands may be compromised, and this is not the conservation outcome TNC NC is looking for.

The non-viability of offset projects in these three case studies points to an important opportunity for TNC NC—to **find lands where conservation and carbon management objectives are more aligned** with each other. The case studies of Robinette and Bryan Farms illustrate that this is possible. In these situations, TNC NC may be able to advance its conservation objectives (particularly in the Longleaf Pine focus region) and use the carbon offset credits generated from its work as an additional, if modest, funding source.

Even in the case where conservation and carbon goals do align, this does not guarantee a financially viable offset project—as demonstrated by the Murphy Farms case study. Even though reforestation of longleaf pine is a chief conservation objective for TNC NC, the project area was just too small to generate positive discounted returns within the crediting period. With just 50 more acres, however, an offset project with similar site conditions could break even, indicating that a project like Murphy Farms could be viable given the right circumstances.
Considerations in Choosing an Offset Project Type

These case study results give us insight on the feasibility of the various offset project types in North Carolina. Of the three IFM projects modeled, not one resulted in a viable carbon offset project. Avoided conversion, reforestation, and pocosin projects seem to be more promising options, as they more successfully align conservation and carbon management goals.

Reforestation Projects

Reforestation projects require parcels with less than 10% cover for at least 10 years and generate most of their offset credits from the growth of new trees planted at the beginning of the project. It takes these trees several years to grow large enough to sequester significant amounts of carbon, meaning that the first stages of a reforestation project produce minimal offset credits and therefore minimal revenue. For most landowners, this is an economic hardship that is difficult to overcome, since project development and verification costs are front-loaded in the project timeline. TNC NC may be uniquely situated to take advantage of potential reforestation projects since their primary objective is not to maximize revenue from a carbon offset project, and their conservation work can continue even with a small initial revenue stream from offset credit sales.

In North Carolina, most parcels with reforestation potential are farms in the Albemarle-Pamlico focus region, though some farms in the Longleaf Pine focus region may also be viable (see Appendix E, Table E1). While many of these farms are near currently protected areas and may seem like attractive conservation projects, the leakage effects of converting a parcel from cropland or pastureland to forest can be high. The leakage factor imposed on the project’s crediting stream can range from 0-50%, depending on the current use and commercial viability of the land\textsuperscript{131}, and this will ultimately discount the potential volume of offset credit generation from a reforestation project. It may be preferable to attempt reforestation on barren or unproductive lands, but there are no unutilized parcels in the state that might be large enough for an offset project. As we saw with the Murphy Farms Project, parcel size is an important factor in the success of a reforestation offset project because of the high verification and management costs involved.

IFM Projects

IFM projects are best suited for large contiguous tracts of forest where the CP regional average carbon content is comparatively low. A lower baseline allows for more flexibility in silvicultural management and forest restoration activities without forcing project scenario carbon stocks to fall below the baseline, as occurred with the Sandhills Game Land and Balsam Gap Projects. Parcels with higher carbon content than the CP baseline are ideal for IFM projects, as the project owners may not need to significantly alter their management activities as long as they can maintain the average level of carbon sequestration they currently support. Forest types with intensive management needs or low stand density requirements, such as

\textsuperscript{131} CARB, 2015
montane oak or longleaf pine forests, are not a good match for IFM projects because they contain relatively low amounts of carbon compared to the CP regional average and also require high management costs.

The majority of large parcels in North Carolina that could qualify for IFM projects are either public lands—often state game lands or state forests—or industrial timber operations, primarily located in the Southern Blue Ridge and Longleaf Pine focus regions. We did not find many viable privately-owned properties for IFM outside of these categories, largely because there are few private landowners with tracts large enough to be considered for this type of offset project. Since TNC NC has working relationships with most of the North Carolina state land management agencies, focusing on public lands may present an easier option for finding potential IFM projects. While partnering with timber companies has the potential to impact some very large tracts, the Red Mountain Timber Co Project illustrated the effects of potential leakage on an offset project established on active timberlands. There may be a viable IFM project on industrial forestland in North Carolina, but it will have to be very carefully considered and modeled to ensure that leakage of timber harvesting will not negate the carbon sequestration benefits of the project.

Avoided Conversion Projects

Regions with potential for avoided conversion projects can be modeled by using satellite imagery or other land use data to examine the concentration of alternative non-forest land uses, such as residential development or agriculture, surrounding forested areas. However, specific projects are more difficult to locate on a broad spatial scale because they require an actual proposed and appraised conversion threat, which cannot be identified using spatial data alone. It may be helpful to have localized knowledge of conversion threats in a certain area in order to find potential avoided conversion projects. These properties may not require active or intensive management activities, as the generation of offset credits will be bolstered during the first 10 years of the project by decreasing baseline carbon stocks. This initial influx of offset credits is often what makes these projects financially viable. However, as the Balsam Gap Project illustrated, the expected conversion rate needs to be high enough to create the marked decrease in the baseline scenario that allows for a positive credit stream. The Robinette Project is a good example of how an avoided conversion project can be successful given the right conditions.

Since avoided conversion projects are only permitted on private lands, the majority of the parcels in North Carolina that might qualify could also be considered for IFM. As discussed above, there are not many privately-owned parcels large enough for a viable IFM project. However, the baseline carbon calculations are quite different between the two project types, which means that avoided conversion may provide a better project option for smaller parcels that do not sequester large amounts of carbon under an IFM scenario.

In North Carolina, most potential avoided conversion parcels are in the Southern Blue Ridge focus area, which has dense forests and has experienced high rates of residential development in recent years. While the Balsam Gap Project was not viable for avoided conversion because of its low conversion rate and steep slopes, it may be possible to find a more suitable option in the area by screening for parcels on flatter ground—which is more
attractive for residential development—and with a higher projected conversion rate. A similar situation in the Albemarle-Pamlico or Longleaf Pine focus regions could also create a viable offset project, similar to Robinette, but since the majority of the coastal plain is already dominated by agriculture or development, these opportunities may be more difficult to find.

Pocosin Restoration Projects

Potential sites for pocosin restoration projects are more limited geographically than for the forest project types, since pocosins are found exclusively in the coastal plain. Re-wetting of pocosins offers a host of environmental co-benefits in addition to carbon storage, as wetlands play an important role in nutrient cycling and support a unique flora. However, the viability of a pocosin offset project depends on site-specific characteristics.

Most importantly, pocosins must have been previously drained to quality for the ACR Pocosin Protocol. Intact pocosins are not eligible for offset projects, due to the requirement for additionality resulting from project activities. From a financial perspective, the most attractive sites are those where existing water control structures require only relatively small adjustments to raise the water table. Projects that require new water control structures to be built, or that require a berm to prevent water from leaking onto neighboring drained lands, will be far more costly to undertake. Ultimately, the specific rules and legal considerations of individual drainage districts will factor significantly into whether a site is logistically and financially viable for an offset project.

Another key protocol requirement is that the site must not have been in agricultural or any other commercial use that could result in displacement of activities to outside the project area for five years prior to the project start date. Because of this requirement, many of the currently viable parcels in North Carolina are part of state game lands or wildlife refuges in the Albemarle-Pamlico and Longleaf Pine focus regions (Appendix E, Table E2). However, some pocosin sites may still qualify for IFM or avoided conversion even if they currently are in timber or agricultural production. If these active uses are discontinued, these parcels may become eligible for a pocosin offset project in the future.

Influence of Site Prioritization Variables

Because assigning scores and weights is a subjective process, we experimented with several different weighting schemes to test model sensitivity. Using weights elicited from TNC NC, size received 20% influence, cover type 10%, resilience 25%, conservation priority 30%, and proximity to existing projects 15%. This weighting scheme captures TNC’s values and priorities when acquiring or protecting a piece of land.

However, due to the considerable influence of parcel size on project viability, we also wanted to test a different weighting scheme to see how it might affect parcels scores. To assess this, we ran a model where size received 90% influence and land cover 10%. This change in

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132 Richardson, 2003
133 Shoch et al., 2017
134 Eric Soderholm, pers. comm., Mar. 27, 2018
weighting provides an interesting sensitivity analysis, as it reflects scoring of parcels for two very different objectives. The TNC-elicited weighting scheme captures environmental variables, while the second scheme reflects a preference for large—and therefore more likely profitable—carbon projects.

Only one parcel remained in the top ten of both weighting schemes. This parcel, owned by the State of North Carolina, is a 10,600-acre property in Pender County in the Longleaf Pine focus region. It has 98.6% forest or pocosin cover types, with approximately 1,691 acres of histosol soil. Under TNC’s weighting scheme, this parcel received a site priority score of 86 and was the ninth-ranked parcel. Under the size-dominated weighting system, it received a score of 100 and was the third-ranked parcel.

All of the other top ten parcels changed under the new weighting scheme. This finding demonstrates that the types of parcels that are important when considering conservation values are not necessarily just the largest parcels with the highest percentage of the target cover type. This underlies the fact that carbon projects—which are often dependent on size and economies of scale—may sometimes be best sited on land that is not the highest conservation priority.

**Sensitivity to Financial Assumptions**

The discount rate is one of the key assumptions that will impact the result of our financial analysis, as it will determine the present value of future cash flows. The default discount rate is 6.5%, and the project’s NPV could change as a different discount rate is applied. To test the sensitivity of the NPV to the discount rate, we used a range of discount rates from 3% to 10% with an incremental increase of 1% to calculate alternative NPVs and compare them with the original NPV. Taking the Murphy Farms project as an example, the NPV is 995% higher with a discount rate of 3%, and is 443% lower with a discount rate of 10% (Table 15).

**Table 15. Sensitivity to discount rate for the Murphy Farms Project.**

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>NPV</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>$190,437.16</td>
<td>-995%</td>
</tr>
<tr>
<td>4%</td>
<td>$111,793.82</td>
<td>-626%</td>
</tr>
<tr>
<td>5%</td>
<td>$49,281.87</td>
<td>-332%</td>
</tr>
<tr>
<td>6%</td>
<td>($401.65)</td>
<td>-98%</td>
</tr>
<tr>
<td>7%</td>
<td>($39,860.63)</td>
<td>87%</td>
</tr>
<tr>
<td>8%</td>
<td>($71,153.34)</td>
<td>235%</td>
</tr>
<tr>
<td>9%</td>
<td>($95,911.05)</td>
<td>351%</td>
</tr>
<tr>
<td>10%</td>
<td>($115,429.87)</td>
<td>443%</td>
</tr>
</tbody>
</table>

The modeling results are not only sensitive to the discount rate, but also to other key assumptions like the price of offset credits. Especially considering the long project crediting period, a sensitivity analysis is helpful in understanding the how a change in assumptions could influence the project’s performance. To test the sensitivity to offset credit prices, we used the California market price forecasts based on high and low case scenarios to re-calculate the NPV and IRR of the projects and compare them with the original model outputs. The high case
represents the most optimistic outlook of offset credit prices, while the low case has the most conservative expectation of future credit prices. These scenarios are compared against the base case price forecast used in the Discounted Cash Flow Analysis.

With respect to Murphy Farms Project, the NPV under the high case is more than twenty times higher than the base case, and the IRR increases by 7.89% (Table 16). Using the low case reduces the NPV by 868% and the IRR by 7.11%. Thus, the future carbon offset credit prices could significantly affect the project’s financial viability.

**Table 16.** Sensitivity analysis of offset credit prices for the Murphy Farms Project.

<table>
<thead>
<tr>
<th></th>
<th>California High Case</th>
<th>California Base Case</th>
<th>California Low Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV</td>
<td>$470,187.37</td>
<td>($21,269.32)</td>
<td>($205,841.64)</td>
</tr>
<tr>
<td>IRR</td>
<td>13.88%</td>
<td>5.99%</td>
<td>-1.12%</td>
</tr>
</tbody>
</table>
Recommendations and Next Steps

In line with the results and discussion presented above, we recommend that TNC NC explore potential sites for avoided conversion, reforestation, and pocosin offset projects. Our analysis shows that these project types could have the best potential viability in the Longleaf Pine and Albemarle-Pamlico focus regions. Certain site attributes may also allow for viable projects in the Southern Blue Ridge focus region, but we were not able to model such a location in our case studies.

There may be more risk associated with developing reforestation and pocosin projects, as neither project type has yet been developed in North Carolina. Because reforestation projects tend to have a long payback period, especially on sites with small acreages, TNC NC must be willing to take on longer-term risk of reversals or policy changes that could prevent TNC NC from recouping its investments in the project. For pocosins, the wide variability in site management costs could dramatically affect a project’s viability, making field data collection essential. There is also some additional risk in working with a brand-new and untested protocol, though if TNC NC is successful, they may be able to gain first-mover advantage in the emerging field of pocosin offset project development. We therefore recommend that TNC NC assess the risks associated with these project types as they consider whether to pursue reforestation or pocosin offset projects.

With respect to avoided conversion projects, we realize the importance of forest management for project feasibility, and recommend that TNC NC consider land parcels like the Robinette Project with less need for active forest management. The magnitude of the development risk that TNC NC can demonstrate also plays a substantial role in setting the baseline for these projects, so it is advantageous to explore sites where a large percentage of the forest area could be eligible for conversion.

Though our analysis did not yield any viable locations for IFM projects, we believe that such a project could be feasible in North Carolina. A suitable site, however, must require little in the way of active management to avoid the pitfalls of the Sandhills Game Land and Balsam Gap Projects, or else have a low regional baseline to allow for more management flexibility without jeopardizing the success of an offset project. For highly managed forests such as timber plantations, an offset project may be viable so long as it can minimize the impact of leakage on timber production, as demonstrated in the Red Mountain Timber Co Project.

For any potential offset project, we highly recommend that TNC NC work with internal and external partners to collect field data for the purposes of feasibility analysis. More field data will allow the carbon sequestration models to generate more accurate and realistic outputs, which can help TNC NC with the decision-making process of whether to proceed with the project. Another critical step in screening potential project sites is reaching out to landowners to determine whether their goals are aligned with offset project development.

If TNC NC does locate a willing landowner with an attractive site for an offset project, they may want to partner with an offset project development firm to conduct an in-depth feasibility analysis. These firms typically do not charge upfront for these analyses, and their expertise would be invaluable in verifying or adjusting the assumptions made in our models to assess project feasibility.
Acknowledgements

We would like to acknowledge the numerous experts that advised us throughout the course of this project. Their expertise was invaluable, and we could not have done this work without them! We extend a big thank you to:

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- Cakey Worthington

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- Jamie Dunbar

- Jeff Johnson
- Hunter Parks

- Tara Keyser

- David Shoch
- Erin Swails

- Alex Finkral
References


CARB. (2017b, October 4). Linked California and Québec cap-and-trade programs compliance instruments aggregated by type and account. California Air Resources Board.


Regulation for the California Cap on Greenhouse Gas Emissions and Market-Based Compliance


Appendices

Appendix A. List of carbon offset protocols that may be relevant to future work by TNC NC.

Table A1. Offset protocols relevant to TNC NC. Bolded protocols were analyzed for this study.

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Offset Registry</th>
<th>Protocol Title</th>
<th>Date Adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>American Carbon Registry</td>
<td>Quantifying N2O Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crops v3.0</td>
<td>7/1/2012</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Verified Carbon Standard</td>
<td>Adoption of Sustainable Agricultural Land Management v1.0</td>
<td>12/21/2011</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Verified Carbon Standard</td>
<td>Quantifying N2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction</td>
<td>9/30/2013</td>
</tr>
<tr>
<td>Agriculture, Grasslands</td>
<td>Verified Carbon Standard</td>
<td>Soil Carbon Quantification Methodology v1.0</td>
<td>11/16/2012</td>
</tr>
<tr>
<td>Avoided Conversion</td>
<td>American Carbon Registry</td>
<td>REDD - Avoided Planned Deforestation V1.0</td>
<td>4/1/2011</td>
</tr>
<tr>
<td>Avoided Conversion</td>
<td>Verified Carbon Standard</td>
<td>Avoided Ecosystem Conversion, v3.0</td>
<td>6/6/2014</td>
</tr>
<tr>
<td>Avoided Conversion, IFM, Reforestation</td>
<td>California Air Resources Board</td>
<td>US Forest Projects</td>
<td>6/25/2015</td>
</tr>
<tr>
<td>Avoided Conversion, IFM, Reforestation</td>
<td>Climate Action Reserve</td>
<td>Forest Project Protocol Version 4.0</td>
<td>6/28/2017</td>
</tr>
<tr>
<td>Grasslands</td>
<td>American Carbon Registry</td>
<td>Avoided Conversion of Grasslands and Shrublands to Crop Production v1.0</td>
<td>10/1/2013</td>
</tr>
<tr>
<td>IFM</td>
<td>American Carbon Registry</td>
<td>Improved Forest Management for Non-Federal US Forestlands v1.2</td>
<td>12/1/2016</td>
</tr>
<tr>
<td>IFM</td>
<td>Verified Carbon Standard</td>
<td>Improved Forest Management through Extension of Rotation Age, v1.2</td>
<td>5/17/2010</td>
</tr>
<tr>
<td>IFM</td>
<td>Verified Carbon Standard</td>
<td>Improved Forest Management: Conversion from Logged to Protected Forest, v1.3</td>
<td>2/1/2011</td>
</tr>
<tr>
<td>IFM</td>
<td>Verified Carbon Standard</td>
<td>Improved Forest Management in Temperate and Boreal Forests (LTFF), v1.2</td>
<td>4/19/2011</td>
</tr>
<tr>
<td>Peatland</td>
<td>Verified Carbon Standard</td>
<td>Rewetting Drained Temperate Peatlands</td>
<td>7/17/2017</td>
</tr>
<tr>
<td>Pocosin</td>
<td>American Carbon Registry</td>
<td>Restoration of Pocosin Wetlands v1.0</td>
<td>10/24/2017</td>
</tr>
<tr>
<td>Reforestation</td>
<td>American Carbon Registry</td>
<td>Afforestation and Reforestation of Degraded Lands v1.2</td>
<td>5/1/2017</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Verified Carbon Standard</td>
<td>Coastal Wetland Creation v1.0</td>
<td>1/30/2014</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Verified Carbon Standard</td>
<td>Tidal Wetland and Seagrass v1.0</td>
<td>11/20/2015</td>
</tr>
</tbody>
</table>
Appendix B. Rationale for Choice of Offset Protocol

**CARB U.S. Forest Projects**

The California Protocol, which includes provisions for reforestation, IFM, and avoided conversion offset projects, emphasizes rigorous accounting of GHG emission reductions to ensure that offset credits “pass regulatory muster” for inclusion in the state’s regulatory cap-and-trade program.\(^\text{135}\) The high standard for emissions accounting and technically complex nature of the protocol means that developing an offset project under the California requires more specialized technical capacity, capital, and time than voluntary protocol development. While these requirements may limit the ability of smaller developers to use the California Protocol, we believe the protocol’s focus on ensuring real and additional carbon sequestration results could align well with TNC NC’s conservation mission.

The California Protocol is also attractive because of the higher sale price of offset credits in the California compliance market relative to the voluntary market. In 2016, the most recent year for which voluntary market price data is available, the price of a compliance offset credit exceeded the price of a voluntary offset credit by over 26%.\(^\text{136}\) Compliance offset credit prices have risen over 5% since that point, and are expected to continue to rise in tandem with the prices of carbon allowances in the California cap-and-trade market. The future trajectory of voluntary market prices, meanwhile, is less certain. The price premium and greater price certainty associated with compliance offset credits inform our recommendation that TNC NC follow the California Protocol where feasible in developing offset projects.

**CAR Forest Project Protocol Version 4.0**

The CAR Forest Project Protocol is a voluntary protocol that covers improved forest management, avoided conversion, and reforestation projects. Generally, the content of the CAR protocol, including permanence, leakage, and additionality requirements, is similar to the California Protocol. Thus, project owners would be better off pursuing the California Protocol to capture higher offset credit prices while meeting similar project verification and monitoring requirements.

**ACR Improved Forest Management for Non-Federal US Forestlands**

The ACR Improved Forest Management for Non-Federal Forestlands protocol offers a different carbon baseline calculation methodology that is more flexible and less stringent compared to the California Protocol. Rather than comparing the project scenario to regional common practice and modeled growth of initial carbon stocks on the site, the ACR baseline allows for the calculation of an alternative harvesting regime on the project site that would maximize the NPV of harvested wood products.\(^\text{137}\) This project-specific flexibility provided by

\(^{135}\) Kelly & Schmitz, 2016  
\(^{136}\) California Carbon, 2018; Hamrick & Gallant, 2017b  
\(^{137}\) Delaney et al., 2016
the ACR calculation methodology could potentially allow projects that would not be feasible under the California Protocol to be developed under this protocol, despite lower offset credit prices in the voluntary market. While ACR also has protocols for Afforestation and Reforestation and for avoided conversion (known as Avoided Planned Deforestation), the methodologies for these protocols do not offer any significant advantages over the California Protocol for these project types.

**ACR Restoration of Pocosin Wetlands**

The newly approved ACR Restoration of Pocosin Wetlands is the first carbon offset protocol in U.S. that targets pocosins. As one of the organizations that was involved in the protocol development, TNC NC has could have the first-mover advantage with its internal resources. Adopting this protocol for project development is also in line with TNC NC’s conservation interests. However, without successful project examples, TNC NC could face a greater potential risk of project failure and higher costs due to lack of experience.
Appendix C. Future Risks and Opportunities in Offset Markets

The compliance offset market under the Western Climate Initiative (WCI) linked cap-and-trade program, which currently includes California, Quebec, and Ontario, is considered to be the most lucrative offset market in the world. However, participation in the market is not without risk for offset developers. Risks include actual and potential future changes to the policies governing offset usage in the program, and legal decisions that could affect the viability of the offset market or the underlying cap-and-trade program. Conversely, changes in policies, markets, and politics could also represent new opportunities for offset developers, for instance by growing the size of the compliance market or increasing offset demand from certain industries. This section will explore the current outlook for risks and opportunities in the offset market in each of those areas.

Growing (or shrinking) the market: potential linkages and de-linkages

By changing the size of the overall WCI cap-and-trade market, future linkages and de-linkages could have a significant impact on demand for offsets. As California plans to limit the share of offsets coming from out-of-state after 2020 (see below), other linked jurisdictions without such offset restrictions could become increasingly important for the offset market.

The most likely future linkage to the WCI market is the state of Oregon. In 2016, at the direction of the legislature, Oregon’s Department of Environmental Quality (DEQ) conducted a study on cap-and-trade. DEQ concluded that cap-and-trade would harmonize well with Oregon’s existing climate policies, and would have a small economic impact on the state.138 Legislators failed to pass a cap-and-trade bill in their 2018 short session, but plan to take up the legislation again in 2019.139 If Oregon were to adopt a cap-and-trade rule with identical provisions to California’s current program, the state could initially add over 4.5 million mt of annual demand for offsets, based on qualifying GHG emissions of close to 60 million mt CO2e in the state.140

Although Washington state was once considered a front-runner to join the WCI market, the lack of legislative support for a cap-and-trade bill has led carbon pricing advocates in the state to focus their efforts instead on a carbon tax. Most recently, after the governor failed to pass a carbon tax bill through the legislature in early 2018, a coalition of environmental, labor and tribal groups filed a carbon tax ballot initiative that will go before voters in November 2018.141 The ballot initiative contains no provisions for using offsets.

Meanwhile, the largest de-linkage risk for the WCI market comes from Ontario, which just formally began its linkage with California and Quebec in January 2018 and has yet to complete its first compliance period. The Progressive Conservative party has pledged to de-link Ontario from the WCI market by July 2019 if it comes to power in the June 2018 general

138 State of Oregon Department of Environmental Quality, 2017
139 Danko, 2018
140 Oregon Global Warming Commission, 2017
141 Bernton, 2018
Such an occurrence would be the first experience with de-linkage for the WCI market, and could temporarily chill demand for allowances and offsets in the other linked jurisdictions.

The governor of California has recently held discussions on much larger-scale linkages—for instance, linking California’s cap-and-trade market with the European Union or emergent Chinese cap-and-trade market. Either of these linkages could drastically reshape the WCI market dynamics, potentially opening up a much bigger market for offsets if they are deemed eligible compliance instruments in Europe or China. However, because the existing markets in the European Union and China operate under significantly different rules from the WCI market, negotiating linkages with either of those jurisdictions would likely be a much lengthier and more difficult process than the linkages effected to date.

Planning for the future: cap-and-trade program extension

In July 2017, the California legislature passed AB 398, which extends its signature cap-and-trade program through 2030. The measure was passed by a two-thirds majority in both chambers, which is required to enact any new taxes in the state. The extension of cap-and-trade allows CARB to use that market-based measure as a primary tool to meet the state’s ambitious goal of reducing greenhouse gas (GHG) emissions 40% below 1990 levels by 2030. That goal, which was codified in 2016 under SB 32, would represent up to a 40% reduction in GHG emissions over ten years, meaning that the new emission caps set for the cap-and-trade program post-2020 will likely need to ratchet down significantly each year to keep the state on track.

While the ten-year extension of cap-and-trade is good news and provides regulatory certainty for market participants planning transactions of allowances and offset credits, the extension is not all good news for the offset market. AB 398, the California law that extends its cap-and-trade program through 2030, also restricts the ability of compliance entities to use offsets. The offset usage limit, currently set at 8% of a company’s covered emissions, will drop to 4% in 2021 before rising to 6% in 2026. The reduced offset limit responds to legislative pressures from environmental justice groups in the state, which were concerned that polluting power plants and factories could buy offsets to avoid reducing their emissions under current rules. Furthermore, the new rules mandate that half of the offsets used must have direct environmental benefits for California. This requirement could shrink demand for offset credits from projects in other states, potentially bifurcating the offset market so that non-California offsets trade at a discount to California-based offsets. (Kahn, 2016).

No news has come out about Quebec’s plans for continuing cap-and-trade post-2020. However, it seems likely that Quebec will follow California’s lead and elect to continue pursuing the linked market. Under the Pan-Canadian Framework Clean Growth and Climate Change enacted in 2016, all provinces must implement some form of carbon pricing mechanism from

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142 Weisberg, 2017b
143 Stupp, 2017
144 Kahn, 2016
2018 onwards; Quebec’s linked cap-and-trade program would satisfy that requirement. Additionally, Quebec has a much smaller market with generally more expensive opportunities for GHG emission reduction than California, so maintaining the linked market with California allows Quebec to keep the overall cost of its program relatively low.

In Ontario, the prognosis for cap-and-trade post-2020 is less certain. The current government has made its intentions clear by proposing an amendment to its cap-and-trade regulation that establishes a methodology for setting emission caps through 2030. However, as mentioned above, an upcoming election in June 2018 could lead the province to reverse course: the Progressive Conservative party, which currently leads polls for the election, has promised to end Ontario’s cap-and-trade and withdraw from WCI. The uncertainty in the future of Ontario’s cap-and-trade program was reflected in the market for carbon allowances at the province’s November 2017 auction, where 17% of current-year allowances on offer went unsold. If the new government does withdraw the province from the WCI cap-and-trade program, current efforts to establish offset protocols for Ontario would likely be abandoned.

If Quebec and Ontario do extend their cap-and-trade regulations beyond 2020, market analysts widely expect the provinces to maintain the current 8% offset usage limit rather than following California’s lead and adopting more restrictive offset provisions.

**Hanging in the balance: Legal challenges**

Legal challenges to the cap-and-trade program in California have hung over the market for most of its existence, injecting an additional source of uncertainty into an already dynamic policy landscape. The earliest lawsuit was levied in 2009 by the Association of Irritated Residents, a coalition of environmental justice advocates that contested that CARB had failed to investigate the costs and benefits of its cap-and-trade proposal for public health and the environment in its original Scoping Plan. On the eve of its first cap-and-trade auction in 2012, CARB was hit by another lawsuit from the California Chamber of Commerce, claiming that state-run auctions of carbon allowances amounted to an illegal tax on businesses.

The resolution of these cases in CARB’s favor has helped to restore confidence in the market. An appellate court ruled against the Association of Irritated Residents in 2012, concluding that CARB had acted within its authority granted by AB 32 in establishing a cap-and-trade system, and had not acted arbitrarily or capriciously in selecting that approach. In May 2017, CARB secured another victory in appellate court when the court ruled that the auctions did not constitute an illegal tax, upholding a 2013 district court ruling and denying the injunctive relief sought by the Chamber of Commerce and other business groups. The California Supreme Court declined to hear the Chamber’s case on appeal, cementing the

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145 Canada Environment and Climate Change, 2017
146 Dyck, Mahony, Ren, & Milne, 2017
147 Weisberg, 2017b
148 Hamshaw, 2017
149 Takade, 2013
150 Horowitz, 2013
favorable ruling for CARB.\textsuperscript{151} The California legislature subsequently pre-empted any future litigation of cap-and-trade as an illegal tax by securing a two-thirds majority vote to pass AB 398, the cap-and-trade extension bill. A two-thirds majority is required to enact any new taxes in the state, which means the cap-and-trade program post-2020 would be legal whether or not the courts determine that it constitutes a tax in the future.

With the resolution of the Chamber of Commerce case, the California carbon market is now able to operate for the first time without the shadow of ongoing litigation hanging overhead. This decline of policy risk related to legal challenges should naturally encourage compliance entities to become more active in the market, paying higher prices for compliance instruments and perhaps banking more instruments now that the threat of a court striking down the program appears to have passed.

More legal challenges, however, may emerge on the horizon. One possibility comes from the new offset provisions of AB 398, which carves out half of the offset credit limit for offset projects that bring direct environmental benefits for California. Critics argue that this “California-first” offset policy is unconstitutional because it violates the dormant Commerce Clause doctrine, which prohibits anyone other than Congress from controlling interstate trade.\textsuperscript{152} If and when a legal challenge is filed on these grounds (likely to happen once the provision takes effect in 2021), the offset market may suffer once again as compliance entities scale back their trading activities in response to new sources of policy uncertainty. If courts eventually find that the “California-first” policy is unconstitutional, however, out-of-state offset projects could get a boost as demand for their credits rises.

\textit{Taking flight: Bringing aviation into the offset market}

While the policy risks described above pertain only to the WCI compliance market, there is now a policy development in the works that could create a brand new compliance market with a much broader scope. In 2016, the member countries of the International Civil Aviation Organization (ICAO) reached an agreement to make all post-2020 growth in the industry carbon-neutral. Because it is extremely difficult with current technologies to reduce the carbon content of jet fuel, the ICAO plan for carbon-neutral growth will rely exclusively on carbon offsets. The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is scheduled to launch in 2021 with two voluntary compliance periods, followed by mandatory participation for airlines in certain countries beginning in 2027.

Rather than creating its own offset protocols for CORSIA, ICAO plans to accept offset credits generated through existing protocols, which could include current voluntary protocols. The ICAO Council will establish a technical advisory body to recommend which offset credits issued through existing programs should be eligible for use in CORSIA.\textsuperscript{153} By creating a unified global market for offset credits, CORSIA could reshape the international market for forest offset credits, which is currently marked by wide variation in transaction prices from region to region. If US forest projects must compete against developing country projects to participate in

\textsuperscript{151} Whitcomb, 2017
\textsuperscript{152} Weisberg, 2017a
\textsuperscript{153} Biniaz, 2017
CORSIA, the market would likely be less attractive to US project developers, who historically have received significantly higher offset credit prices than the global average. However, if US airlines elect to fulfill their obligations under CORSIA with offset credits from US-based projects, offset credits generated under any protocols approved by CORSIA could see a big boost in demand.

*Policy Risk Summary*

The future of the California compliance market for offset credits is subject to many forms of policy risk. The political uncertainty around a possible program linkage with Oregon and de-linkage with Ontario, legal questions around the “California-first” offset provisions passed in AB 398, and the uncertain future of cap-and-trade itself in California beyond 2030 may all serve to dampen demand for compliance instruments in the years ahead. The potential de-linkage with Ontario and a failure to link with Oregon could disproportionately chill the California offset market, as those linkages would provide a proportionally greater slice of demand for offset credits when California restricts offset usage in its own program after 2020. If the “California-first” offset provisions survive court challenges, that could further decrease demand for offset credits from projects outside California.\(^{154}\)

Despite these risks, however, the WCI compliance market remains the most lucrative market for offset credits. Unlike in the voluntary market, compliance market offset prices trade at a relatively constant discount to California carbon allowance prices, which are set by regulation to rise by 5% plus inflation each year. Thus, even if the gap between offsets and allowances grows in the future due to policy risks, it is likely that compliance offset prices will continue to rise in comparison to voluntary offset prices. Furthermore, demand for compliance offsets, which is driven by covered entities’ annual compliance obligations, is more stable than demand for voluntary offsets, which may be influenced by the market behavior of a few large companies that have set schedules to voluntarily reduce their own GHG emissions.\(^{155}\)

Even independently of demand from covered entities in the California cap-and-trade system, compliance offsets may be especially attractive to corporate buyers with sustainability pledges because of the superior environmental rigor of the California forest protocol. These buyers pay a premium for compliance offsets over voluntary offsets solely based on their stringent environmental requirements. There is some precedent for this behavior in Washington State, where the Nisqually Land Trust sold compliance-grade forest offset credits to Microsoft, a voluntary offset buyer.\(^ {156}\) The environmental premium and more stable demand for compliance offsets in that case justified the additional costs associated with generating offsets under the California Protocol.

The upcoming implementation of CORSIA represents something of a wild card for offset project developers, as it is not yet known what offset protocols will be eligible to participate in the market or how much demand there will be in the first voluntary phase. Currently, however, much of the discussion around CORSIA focuses on international forest offset credits, which

\(^{154}\) Hamrick & Gallant, 2017b  
\(^{155}\) Swedeen, 2016  
\(^{156}\) Ibid.
would likely outcompete US-based forest offset credits on price.\textsuperscript{157} Thus, the introduction of CORSIA does not change the recommended choice of the California Protocol for any forest offset project development that TNC NC undertakes.

\textsuperscript{157} Biniaz, 2017; Hamrick & Gallant, 2017b
## Appendix D. Costs Included in Financial Model

**Table D1. Financial Model Cost Assumptions.**

<table>
<thead>
<tr>
<th>Initial Cost</th>
<th>Small (5000 ac)</th>
<th>Medium (10000 ac)</th>
<th>Large (20000 ac)</th>
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158 ACR, 2015; CAR, 2017a
### Table E1. Potential forest carbon offset projects. Bolded entries were modeled as case studies.

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<th>Parcel Number</th>
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<td>37177_8619924170</td>
<td>AP</td>
<td>506.27</td>
<td>KILKENNY FARMS LLC</td>
<td>37</td>
<td>Reforest.</td>
<td>Near TNC projects</td>
</tr>
<tr>
<td>37017_1338246895</td>
<td>LLP</td>
<td>660.71</td>
<td>MURPHY FARMS INC ATTN: JORDAN HEATH</td>
<td>26</td>
<td>Reforest.</td>
<td>modeled as Murphy Farms Project</td>
</tr>
<tr>
<td>37093_194110001008</td>
<td>LLP</td>
<td>542.34</td>
<td>MURRAY FORK, INC.</td>
<td>25</td>
<td>Reforest.</td>
<td>Ag land</td>
</tr>
<tr>
<td>37141_2351-27-5987-0000</td>
<td>LLP</td>
<td>1129.33</td>
<td>ORANGE FARMS LLC</td>
<td>25</td>
<td>Reforest.</td>
<td>Ag land</td>
</tr>
</tbody>
</table>
Table E2. Potential pocosin restoration offset projects. Bolded entries were modeled as case studies.

<table>
<thead>
<tr>
<th>Parcel Number</th>
<th>Focus Region</th>
<th>Owner Name</th>
<th>Property Name</th>
<th>Priority Score</th>
<th>Area (acres)</th>
<th>% Pocosin</th>
<th>% Histosol</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>37141_3297-65-0205-0000</td>
<td>LLP</td>
<td>State of North Carolina</td>
<td>Holly Shelter Game Land</td>
<td>87</td>
<td>47469.50</td>
<td>0.86</td>
<td>0.45</td>
<td>drainage unknown</td>
</tr>
<tr>
<td>37095_8661-11-6271</td>
<td>AP</td>
<td>NC Wildlife Resources Comm.</td>
<td>Gull Rock Game Land</td>
<td>81</td>
<td>17751.82</td>
<td>0.52</td>
<td>0.97</td>
<td>On Pamlico Sound; saltwater intrusion possible</td>
</tr>
<tr>
<td>37095_7760-32-6187</td>
<td>AP</td>
<td>Hyde County Partners, LLC</td>
<td>Roxbury Tract</td>
<td>65</td>
<td>12598.59</td>
<td>0.79</td>
<td>1.00</td>
<td>TNC High Priority; 3000 ac in CWMTF easement</td>
</tr>
<tr>
<td>37141_3344-45-8313-0000</td>
<td>LLP</td>
<td>State of North Carolina</td>
<td>Angola Bay Game Land</td>
<td>83</td>
<td>11363.88</td>
<td>0.96</td>
<td>0.97</td>
<td>drainage unknown</td>
</tr>
<tr>
<td>37095_7696-15-8952</td>
<td>AP</td>
<td>James E. Johnson, Jr.</td>
<td>Whitetail Farms</td>
<td>68</td>
<td>10789.86</td>
<td>0.44</td>
<td>0.82</td>
<td>TNC High Priority</td>
</tr>
<tr>
<td>37019_118400465441</td>
<td>LLP</td>
<td>State of North Carolina</td>
<td>Juniper Creek Game Land</td>
<td>85</td>
<td>13123.03</td>
<td>0.19</td>
<td>0.49</td>
<td>drainage unknown; potentially for IFM</td>
</tr>
<tr>
<td>37029_0389810087175200</td>
<td>AP</td>
<td>Coastal Forest Resources Co.</td>
<td>-</td>
<td>73</td>
<td>6535.41</td>
<td>0.50</td>
<td>0.82</td>
<td>On Albemarle Sound; saltwater intrusion possible; IFM possible</td>
</tr>
<tr>
<td>37049_6-212-003</td>
<td>LLP</td>
<td>Camp Bryan Farms Inc.</td>
<td>Bryan Farms</td>
<td>64</td>
<td>8653.39</td>
<td>0.51</td>
<td>0.61</td>
<td>drainage unknown; modeled as Bryan Farms Project</td>
</tr>
<tr>
<td>37061_333600905730</td>
<td>LLP</td>
<td>NC Dept. of Conservation</td>
<td>Angola Bay Game Land</td>
<td>79</td>
<td>6723.95</td>
<td>0.73</td>
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</tr>
<tr>
<td>37013_7618-54-0996</td>
<td>AP</td>
<td>Pungo Co., LLC</td>
<td>-</td>
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<td>4012.41</td>
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</tr>
<tr>
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<td>State of North Carolina</td>
<td>Angola Bay Game Land</td>
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<td>3052.75</td>
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</tr>
<tr>
<td>Parcel Number (cont.)</td>
<td>Focus Region</td>
<td>Owner Name</td>
<td>Property Name</td>
<td>Priority Score</td>
<td>Area (acres)</td>
<td>% Pocosin</td>
<td>% Histosol</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>37141_3372-08-3735-0000</td>
<td>LLP</td>
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<td>37141_3353-82-0214-0000</td>
<td>LLP</td>
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<tr>
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<td>-</td>
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</tr>
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</table>