July 14, 2020

California Air Resources Board Response to Item 3900 of the Supplemental Report of the 2019 Budget Act

Item 3900 of the 2019 Budget Act requires the California Air Resources Board (CARB) to submit a description of the methods, data, and key assumptions used to estimate the greenhouse gas (GHG) removal enhancements (e.g., carbon sequestration in trees) and emissions reductions for projects using the Compliance Offset Protocol U.S. Forest Projects (Protocol), under the State's Cap-and-Trade Regulation (title 17, California Code of Regulations, section 95801 et seq.). The Cap-and-Trade Program (Program), which became effective in 2012, sets a declining cap on statewide GHG emissions to help the State meet its 2020, 2030, and longer-term emissions reduction targets. As part of the Program, emitting sources must acquire and surrender compliance instruments (state-issued allowances and a limited number of carbon offset credits) against their reported and third-party verified emissions. The Protocol is one of the eligible offset methodologies included in the Cap-and-Trade Regulation. Only those offset projects that meet the stringent requirements of the Protocol are eligible to be issued offset credits by CARB. (The Cap-and-Trade Regulation uses the term ARB offset credits to describe California-issues offset credits, and this document will refer to them as such). Emitting sources may surrender ARB offset credits, including credits from U.S. Forest Projects to meet a small percentage of their emissions compliance obligations.

The Item further requests answers to several questions related to how the Protocol calculates the number of ARB offset credits to issue for the enhanced carbon sequestered in trees:

1. What are the assumptions about the degree to which a reduction in timber harvesting at a project site results in timber harvesting elsewhere?
2. What is the timing of when offset credits are issued compared to when the GHG reductions occur?
3. What is the length of time that forestland owners are required to maintain onsite growth under the protocol?
4. What is the evidence and research that serves as the basis for the current methods and assumptions in the protocol?
5. Evaluate the degree to which the current methods and assumptions reflect the best available research.

At a very high level, the enhanced sequestration of onsite carbon in trees by a forest offset project is estimated by comparing the actual onsite carbon stocks to the project baseline, a business-as-usual assessment of the carbon stocks that would have been

there absent the project. CARB's forest offset project crediting is very conservative. Estimates of timber harvesting moving to other lands (a type of leakage), measurement uncertainty, reductions in wood products produced, and the risk of sequestered carbon being released back to the atmosphere are all deducted from ARB offset credits issued to the forest project operator. Additionally, the project baseline has a conservative backstop that may cause the baseline to be even more restrictive than business-as-usual or than what is legally allowable. A more detailed description of project accounting can be found in the appendix to this response. The following responses are provided in the order in which the questions were presented in Supplemental Report Item 3900.

1. **What are the assumptions about the degree to which a reduction in timber harvesting at a project site results in timber harvesting elsewhere?**

Leakage, in the context of this question, is an evaluation of the degree to which a reduction in timber harvesting at a project site results in timber harvesting elsewhere. This harvest-related leakage is sometimes called activity-shifting leakage. The Protocol contains three distinct project types (reforestation, avoided conversion, and improved forest management (IFM)), and leakage is evaluated differently for each of the three types. IFM, which involves managing forests better to enhance carbon sequestration in trees, is the most common project type. The Protocol evaluates activity-shifting leakage for IFM by taking a deduction in project crediting based on reductions in actual harvesting versus the predicted business-as-usual baseline scenario. Based on the best available science at the time of Protocol adoption (and currently), CARB found this to be a scientifically sound and accurate method for accounting for activity-shifting leakage. A detailed description of all three project types and their leakage evaluations can be found in the appendix to this response.

2. **What is the timing of when offset credits are issued compared to when the GHG reductions occur?**

Forest project ARB offset credit issuance is always ex post, meaning it is based on actual results rather than projections or forecasts. An offset project operator will monitor the project area for a period of 12 months, report the carbon sequestered in trees over that time period, have the reported carbon sequestration verified by CARB-accredited third-party verification bodies, then seek ARB offset credit issuance. Pursuant to the Global Warming Solutions Act of 2006 (Assembly Bill (AB) 32; Chapter 488, Statutes of 2006), one ARB offset credit for a US forest project represents an enhanced sequestration of one metric ton of carbon dioxide equivalent. In order to receive an ARB offset credit, the enhanced sequestration must meet the statutory and regulatory criteria of being real, additional, quantifiable, permanent, verifiable, and enforceable. No offset credits are issued based on speculative future carbon sequestration. A detailed

description of the ARB offset issuance process can be found in the appendix to this response.

3. What is the length of time that forestland owners are required to maintain onsite growth under the protocol?

As noted in the previous response, AB 32 requires all GHG removal enhancements and emissions reductions to be permanent (i.e., remain sequestered). The Cap-and-Trade Regulation and Protocol define permanent as sequestering carbon in trees for at least 100 years.[1] The Protocol has three main mechanisms to assure permanence. First, projects must continue to monitor, report, and verify carbon stocks and sequestered carbon for 100 years after the last ARB offset credits have been issued to the project. Second, all projects must contribute a certain percentage of credits to an insurance pool of credits called the forest buffer account. In the event of a natural disaster, such as a wildfire, that releases carbon that has previously been issued ARB offset credits, an equal amount of ARB offset credits will be retired from the forest buffer account (see Appendix for additional detail). Finally, project operators are responsible for replacing any ARB offset credits that have been issued for carbon that is intentionally released to the atmosphere by actions such as over-harvesting or for terminating a project.

4. What is the evidence and research that serves as the basis for the current methods and assumptions in the protocol?

All methods and assumptions in the Protocol were taken from the best science and data available at the time of Protocol development, as well as during two subsequent updates to the Protocol. The Protocol was developed through an extensive public regulatory process where stakeholders commented on all aspects of the Protocol. All comments were considered during the rulemaking process and addressed in the Final Statement of Reasons.[2] The public process (two years of workshops, meetings, correspondence, and conversations before the adoption of the initial forest protocol) included engagement with forestry experts, academics, project developers, verifiers,

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[1] In 2012, CARB was challenged in a lawsuit contending the design of the Cap-and-Trade Regulation and Compliance Offset Protocols did not conform to statutory and regulatory requirements, particularly related to permanence and additionality. Both the trial and appellate courts found that CARB's design and implementation of the offset program met the requirements of AB 32. The California Supreme Court denied a petition for review. *See Our Children's Earth Foundation v. California Air Resources Board* (1st Dist. 2015) 234 Cal.App.4th 870 (upholding *Citizens Climate Lobby and Our Children's Earth Foundation v. California Air Resources Board* (2012) Case No. CGC-12-519554; 2013 WL 861396) (petition for review by California Supreme Court denied June 10, 2015).

[2] See full rulemaking docket for CARB's adoption of the Cap-and-Trade Regulation, including Compliance Offset Protocols, in 2011, *available at* https://ww3.arb.ca.gov/regact/2010/capandtrade10/capandtrade10.htm.

regulated entities, Tribes, environmental groups, environmental justice advocates, and other members of the public. This process followed the requirements of the Administrative Procedure and California Environmental Quality Acts. A detailed description of the data sources for the major methods in the Protocol can be found in the appendix to this response. In general, the Protocol is based on the methods used by the U.S. Forest Service (USFS) to calculate the national forest inventory. The national forest inventory was also used to develop many of the default values used in the Protocol.

5. **Evaluate the degree to which the current methods and assumptions reflect the best available research?**

The Protocol reflects the most accurate and conservative research available on forest practices. CARB has committed to periodically updating the Protocol to reflect the latest science, data, and technologies, and has done so twice since its initial adoption in 2011 – once in 2014 and again in 2015.[3] Based on stakeholder feedback during previous rulemakings, CARB balances the forest project operator's need for certainty in developing projects with the constant advancement of science. The development phase for forest offset projects can take several years, and frequent updates to the Protocol can make it difficult to determine the viability of new projects. There have been no significant changes in recent years in forest science, or major concerns with the implementation of the Protocol, that would have triggered CARB to immediately propose a new, updated Protocol for Board adoption since 2015. While there have been data updates by the USFS, CARB staff believe that the Protocol continues to reflect the best available science and a conservative assessment of creditable GHG removal enhancements and emissions reductions.

In sum, the current Protocol is conservative and continues to represent the requirements of AB 32. CARB staff is continuously looking for ways to improve all of CARB's Protocols and to reflect the best available science and technologies. Future improvements will also consider any recommendations from the Compliance Offset Protocol Task Force required by AB 398 (Chapter 135, Statutes of 2017), and will be proposed pursuant to the same public process described earlier in this response prior to seeking Board adoption in the future.

[3] Compliance Offset Protocol U.S. Forest Projects adopted November 14, 2014 and June 25, 2015 respectively. Links to the full rulemaking dockets for these updated versions of the Protocol are included at the end of the appendix to this response.

APPENDIX

Overview of the Compliance Offset Protocol U.S. Forest Projects

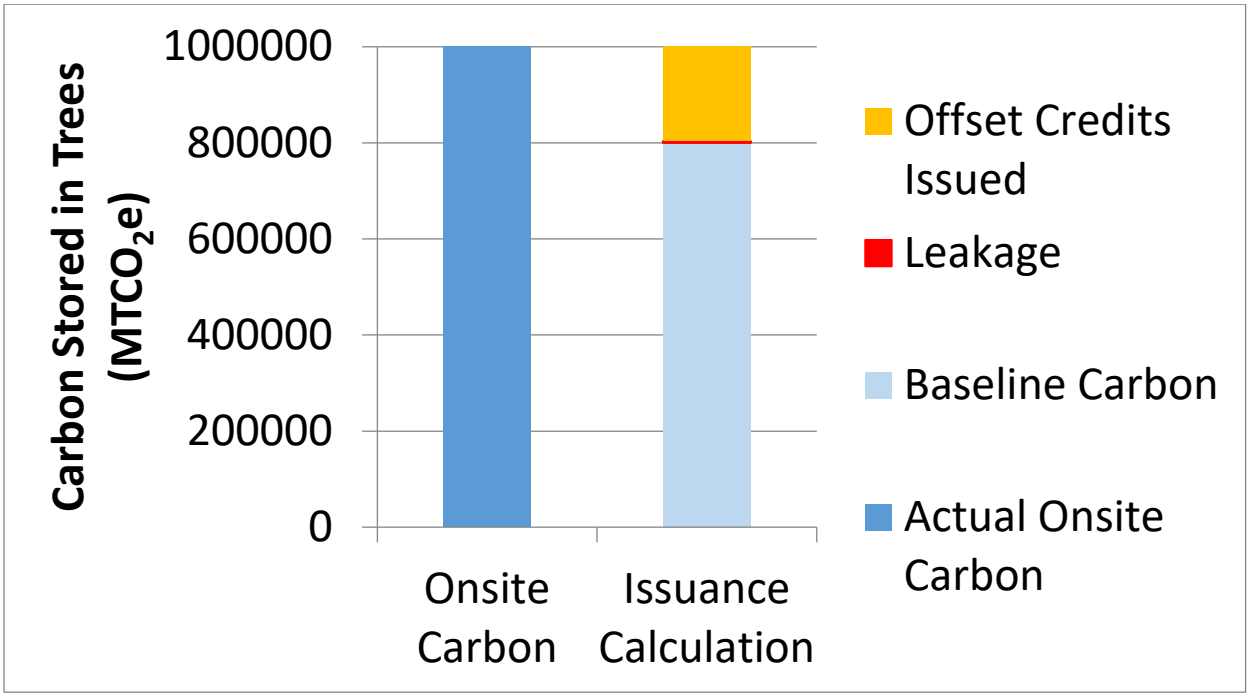
The California Air Resources Board's (CARB or ARB where regulatorily identified, including when referring to California-issued offset credits as ARB offset credits) Compliance Offset Protocol U.S. Forest Projects (Protocol) contains the methodologies and requirements to accurately quantify greenhouse gas (GHG) removal enhancements (i.e., carbon sequestration in trees) or emissions reductions from forest practices. The Protocol provides offset project eligibility requirements, methods to quantify atmospheric GHG removals (including deductions for leakage), processes for assessing the risk of reversals (release of GHGs back to the atmosphere), and monitoring, reporting, and verifications requirements. The Protocol assures that all sequestered carbon in trees via issued ARB offset credits is real, additional, quantifiable, verifiable, enforceable, and permanent. The Protocol was developed through a rigorous and transparent public process using the best science, data, and technology available at the time of Board adoption. The full record of the original rulemaking, as well as those for two subsequent rulemakings to update the Protocol, is linked at the end of this appendix.

The Protocol recognizes three types of forest offset projects: reforestation, improved forest management (IFM), and avoided conversion. Reforestation projects involve restoring tree cover on lands that do not have many living trees, provided the lesser tree cover is not the result of a recent harvest. IFM projects involve management activities that maintain or increase the number and age of trees. Avoided conversion projects involve preventing the conversion of forestlands to non-forest uses, such as housing, agriculture, or mining. All three project types have unique eligibility, baseline, and additionality requirements. The majority of forest offset projects receiving ARB offset credits to date are IFM projects.

Overview of quantification of carbon sequestered in trees

In general terms, ARB offset credits are issued for the difference between actual sequestered carbon and baseline sequestered carbon, taking into account any accounting uncertainty and any carbon emissions that could shift to areas outside the project as a direct result of the project (referred to as leakage). Leakage is described in more detail below. In practice, quantifying sequestered carbon is typically a several-month process involving field measurements, complex modeling, and forestry expertise to calculate the sequestered carbon in a forest project. Each project type has a different mechanism for determining the baseline and leakage risk.

Below is a simplified graphical representation of the first-year crediting for a typical forest offset project. The left-hand bar represents the total carbon sequestered in trees at the end of the first year of the project. The light blue portion of the right-hand bar represents the carbon that would have been sequestered in trees in the absence of the offset project, taking into account all legal and financial constraints (e.g., forest protection laws, conservation requirements under the Endangered Species Act, and financial constraints on forest management practices). The red portion of the right-hand bar represents the calculated carbon leakage. The yellow portion of the right-hand bar represents the additional carbon sequestered in trees that is eligible to receive ARB offset credits.



Determining the total carbon sequestered in trees

All project types must start with an accurate estimate of the total carbon sequestered in trees in the project area. It is not physically possible to weigh every tree in the project area, so the Protocol relies on methods used by the U.S. Forest Service (USFS) to establish the national forest inventory. First, projects conduct a sampling of a portion of the trees in the project area. Trained foresters physically measure the heights and diameters of these trees. The heights and diameters are then used with tree species-specific equations to estimate the total amount of carbon sequestered in the sampled trees. These commonly accepted statistical methods can give an accurate estimate of the total carbon sequestered in trees in the project area. A CARB-accredited third-party verification body independently reviews this estimate by redoing a selection of the tree

measurements and calculations to confirm the estimate. This forest carbon estimate is the input to all baseline modeling calculations as well as the calculation of sequestered carbon for the three forest project types (reforestation, avoided conversion, and IFM). Because statistical sampling is used, the Protocol methodology calculates a deduction in ARB offset credits based on the uncertainty in the inventory measurements. The Protocol specifies that the greater the number of trees measured, the smaller the uncertainty deduction; it also specifies that if a sufficient number of trees are not physically measured, the project is not allowed to receive ARB offset credits because the estimate of sequestered carbon is not accurate enough to assure all ARB offset credits are real. In addition to measurement uncertainty, the Protocol also reduces crediting for activity-shifting leakage, reductions in wood products produced, and reversal risk for all three project types. The next paragraphs describe how these estimates are determined for each of the three forest project types.

Reforestation

The baseline is set by modeling carbon stocks over 100 years, based on the vegetation that would likely be present in the absence of project activities, and taking into account natural regeneration and any legal requirements for reforestation. Reforestation projects often occur after a forest fire or other catastrophic event which results in little to no vegetation being present at offset project commencement. The offset project operator will then plant trees or remove impediments to natural regeneration.

The offset project operator must also account for leakage based on shifting agricultural activities outside the project area. Reforestation leakage evaluates the likelihood that reforestation activities displace agriculture or cattle activities, resulting in other forest lands being cut down to satisfy the need for additional croplands or grazing pastures. The leakage factor ranges from zero to 50 percent depending on the current and historic uses of the project area that reflects the likelihood of the reforestation project causing activity shifting. Additionally, the offset project operator must account for any fossil fuel emissions (tractors or other machinery) that occur as a result of preparing the site for the reforestation activities.

Improved Forest Management

The baseline is set by modeling carbon sequestered in trees over 100 years based on the trees present at offset project commencement and taking into account all legal and financial constraints related to harvesting. The baseline value also cannot be lower than the average amount of carbon sequestered in trees on nearby forestlands; a value obtained from publicly available USFS data. This methodology prevents modeling excessive harvesting in the baseline, even though legally allowed and financially

feasible, thereby assuring a conservative baseline. IFM projects take place on lands that can be managed better to sequester additional carbon in trees. The offset project operator will improve management practices by extending the length of time between harvests, or switching from even-aged management (clear cutting) to more selective harvesting. The offset project operator must also commit to sustainable harvesting practices and maintaining a diversity of native tree species.

The offset project operator must also account for activity-shifting leakage based on a reduction in timber harvesting at a project site that results in timber harvesting elsewhere. Twenty percent of any reduction in timber harvesting due to the project is debited against the ARB offset credit issuances. The assumption, as discussed more below under Data Sources, is that 20 percent of any reduced harvesting would move to lands outside the project area.

Avoided Conversion

The baseline is set by modeling the loss of carbon stored in trees over time due to the conversion of project lands to non-forest uses (e.g., residential, agriculture, mining, etc.). The rate of conversion is based on planning documents or default conversion rates found in the Protocol and must take into account any legal constraints on conversion. A discount factor is applied to account for any uncertainty in the conversion with the discount decreasing as the appraised value of the alternative land use increases relative to the appraised value of the forestland. Avoided conversion projects must record a conservation easement on the property that grants CARB the right to enforce all obligations under the easement.

The offset project operator must also account for leakage based on the likelihood of the land use conversion activity shifting to lands outside the project area. This activity-shifting leakage is fixed at 3.6 percent of the annual avoided conversion, as discussed more below under Data Sources. This indicates that, annually, a small amount of forest lands outside the project area would be converted to residential, agriculture or mining activities to compensate for protecting the project area. Using the default assumption that conversion would occur over 10 years, for each of those ten years 3.6 percent of the conversion would be deducted from ARB offset credit issuance.

All project types – long-term carbon storage in wood products

The Protocol also accounts for reductions in wood products produced as a result of participating in the Protocol. Any reduction in timber harvesting as a result of participating in the Program will also cause a reduction in wood products. After harvest, the majority of cut trees are sent to mills for processing into useful products (e.g.,

lumber, plywood, and paper). A small percentage of these products will store carbon for at least 100 years (e.g., houses, furniture). The Protocol estimates this percentage based on mill efficiencies (how much of the log makes it into wood products) and the types of wood products produced. Then crediting is reduced by 80 percent of the reduction in wood products between the baseline and the actual project harvesting. This 80 percent value corresponds to the 20 percent activity-shifting leakage for IFM projects.

All project types – reversal risk/permanence

Offset project operators agree to permanently maintain the credited carbon in trees for 100 years after the last ARB offset credits have been issued. Given the 25-year project crediting period provided for in the Protocol, this results in a minimum 125-year commitment, referred to as the project lifetime. Permanence is assured in several ways. First, the project operator is required to monitor, report, and verify for the entire project lifetime to assure the sequestered carbon is still present in the trees.

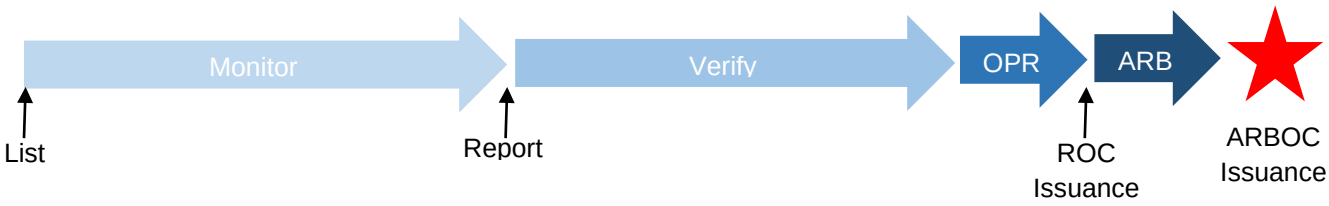
Second, based on the risk of the sequestered carbon in a project being released back to the atmosphere, CARB places a portion of all credits issued to forest offset projects into an insurance pool called the forest buffer account. A project's reversal risk is calculated using a formula in the Protocol representing the likelihood of events occurring that could cause the release of sequestered carbon. A projects reversal risk is most commonly around 20 percent. This percentage is used to calculate the number of ARB offset credits that must be placed into the forest buffer account that would compensate for any unintentional release of stored carbon. An unintentional release could occur because of a wildfire, insect infestation, or other natural occurrence, that is not the result of a negligent or intentional action by the offset project operator. Currently there are over 22.6 million ARB offset credits in the forest buffer account.

Third, if there were to be an intentional release of stored carbon in trees, for instance, due to overharvesting, the offset project operator would be responsible for replacing an amount of ARB offset credits equal to the released carbon. If the offset project operator does not comply with this requirement, ARB offset credits would be retired from the forest buffer account and the project operator would be subject to enforcement action by CARB.

To date, ARB offset credits have only been retired from the forest buffer account once. This resulted in less than one million ARB offset credits being retired to account for an unintentional reversal due to a wildfire.

ARB Offset Credit Issuance

The issuance of ARB offset credits is a multi-step process that typically takes over two years from the beginning of the offset project until the first ARB offset credits are issued. ARB offset credits represent real GHG removal enhancements or emissions reductions that have actually occurred prior to issuance. ARB offset credits are not issued based on speculative or predicted future carbon sequestration.



The offset project must be listed with a CARB-approved Offset Project Registry (ORP). There are currently three approved OPRs in the program: American Carbon Registry, Climate Action Reserve, and Verra. Once listed, the project must monitor and measure its carbon sequestration for a year. At the end of the year, the project will submit a report of the carbon sequestered in the trees to an OPR. Then, a CARB-accredited third-party verification body must complete a verification of the data provided in the report within 11 months. If the verification body agrees with the estimates of carbon sequestration, the project is sent to the OPR for review prior to issuance of registry offset credits (ROC). ROCs can be used in the voluntary carbon market but cannot be used for compliance with the Cap-and-Trade Program.

After issuance of ROCs, the project may seek review by CARB. If CARB agrees with the previous findings of the offset project operator, third-party verifier, and the OPR, CARB will issue ARB offset credits to the offset project operator. Prior to transferring the ARB offset credits to the offset project operator, the OPR must cancel the ROCs to ensure that the sequestered carbon is not double counted. The ARB offset credits represent the carbon sequestration in trees that occurred during the previous year. The detailed requirements for listing, monitoring, reporting, and verification are contained in the Protocol.

Data Sources

All methods and assumptions for the Protocol were taken from the best science and data available at the time of Protocol development. The Protocol was subject to an extensive public regulatory process where stakeholders were able to comment on all aspects of the Protocol.

Improved Forest Management Leakage

During the original development of the Protocol, all available information related to the degree to which a reduction in timber harvesting at a project site results in timber harvesting elsewhere was considered in the selection of the activity-shifting leakage value. Leakage is difficult to quantify, and to date there still is not any peer-reviewed literature on leakage as a result of using the Protocol. CARB's approach is to look at the existing literature and try to identify which sources are most relevant or similar to the actions taken under the Protocol.

Recently, there has been a suggestion that leakage rates should be in excess of 80 percent.[4] The policy brief that provides this suggestion relies on two papers to support its findings. However, the two papers used in the policy brief to promote this 80 percent figure are not relevant to the Protocol as they focus on forest areas with a complete prohibition on harvesting, unlike the Protocol, which does not place significant restrictions on harvesting. In fact, a co-author of one of these papers, Dr. Brian Murray, provided a letter addressed to several legislators that clearly explains why his referenced paper should not be used as a model for the leakage factor in the Protocol. Another reference, from Dr. Christopher Galik, which is often cited, identified a 40 percent leakage rate. Dr. Galik also provided comments that this estimate of leakage should also not be used as a model for the leakage factor.[5]

Dr. Murray's letter, which is attached to this response (Attachment 1), references two other peer-reviewed leakage articles he contributed to, including a 2004 article (Murray et al. *Land Economics* 80(1):109-124), as the best available sources of forest project leakage data. The 2004 article found a wide variety of estimates that were generally lower than 80 percent. The conclusion of the article was:

> The empirical results here suggest that forest carbon leakage may be somewhat larger than the energy sector estimates (previously cited as roughly 5 to 20 percent), although part of this gap could be due to differences in the methods used across studies.

This 2004 article was available during the development of the Protocol, and Dr. Murray was involved with the development of the leakage factors for the Protocol. Given that this is the best available data on forest project leakage from a peer-reviewed journal,

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[4] Dr. Barbara Haya, Policy Brief: The California Air Resources Board's U.S. Forest Projects offset protocol underestimates leakage. Berkeley Carbon Trading Project Policy Brief, Center for Environmental Public Policy, Goldman School of Public Policy, UC Berkeley (May 2019)

[5] http://www.climateactionreserve.org/wp-content/uploads/2019/06/FPPV5.0-Public-Comment-Christopher-Galik.pdf

use of the 20 percent factor for activity-shifting leakage in the existing Protocol is scientifically sound.

CARB is aware there is ongoing research into leakage. Now that there are multiple projects, in a variety of locations across the U.S., representing several years of project activity, the data may be available to even more accurately quantify the degree to which a reduction in timber harvesting at a project site results in timber harvesting elsewhere. Once these results are peer-reviewed and made publicly available, CARB will evaluate them for incorporation in an updated Protocol.

Assessment Areas

USFS's Forest Inventory and Analysis Program (FIA) is the basis for Protocol Assessment Areas used in the development of project baselines. Assessment Areas are combinations of similar forest types, as identified by FIA, within a defined region. FIA also provided all the data used to calculate the Common Practice statistic, which is the conservative backstop used when setting the baseline for IFM projects.

Common Practice Statistic

The Common Practice statistic is used in the development of IFM project baselines and helps assure that the baseline is conservative. The FIA data from the continuous forest census are grouped by assessment area and then site class (essentially a measure of productivity) and averaged. The census uses nationally standardized measurement protocols and all plots are updated on a five- to 10-year cycle. The current version of the Protocol uses the available census data from 2014. The current census has been updated with some 2019 data but mainly consists of 2016 to 2018 data. When the Protocol is next updated, the most recent census data will be evaluated.

Wood Density, Mill Efficiencies and Native Species Composition

Wood densities are from the USFS Wood Handbook. Mill efficiencies, wood product values, and average storage factors are taken from the U.S. Department of Energy (DOE) 1605 (b) program (Voluntary Reporting of GHG Program). Native species composition come from a variety of references by state. For California forests, the data for the native species composition was based on the Jepson Flora Project from the Jepson Herbarium at the University of California, Berkeley.

Reforestation Leakage

Reforestation leakage values were from Murray et al. (2005) EPA-R-06-006. "*Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture.*" Washington D.C.: U.S. Environmental Protection Agency, Office of Atmospheric Programs.

Avoided Conversion Leakage

Avoided conversion leakage was based on data from the California Department of Forestry and Fire Protection Fire and Resource Assessment Program (FRAP). The maximum conversion rate in the state is 1.8 percent. This rate reflects the conversion rate across all forestlands, regardless of consideration of attributes that place certain lands at a higher risk of conversion than others. Assuming that 50 percent of forested landscapes are available for conversion, the 1.8 percent was doubled for a defined avoided conversion leakage risk of 3.6 percent.

Allometric Equations

All volume and biomass equations used in the Protocol are the same equations used by the FIA in the national census. Volume and biomass equations for California, Oregon, and Washington are provided directly from the FIA. Equations for the rest of the U.S are from Woodall et al. (2011) "*Methods and Equation for Estimating Aboveground Volume, Biomass, and Carbon for Trees in the U.S. Forest Industry, 2010.*" Pennsylvania: U.S. Forest Service.

Site Prep for Reforestation Projects

Default emissions from site preparation were developed using data for typical hourly equipment emissions and conservative experience-based estimates from the Protocol development workgroup for the number of hours to complete site preparation for the three brush classes included in the Protocol.

Vegetation Classes for Stratification

The vegetation class carbon ratings are mathematically derived values that express the relative carbon intensities of the various vegetation classes. This is used to prevent biased selection of the project area.

Default Avoided Conversion Factors

Avoided Conversion Factors are based on the work of the Protocol development workgroup. This is a conservative recognition of the fact that most conversion projects do not remove 100 percent of the tree canopy. The factors selected are based on

extensive evaluation of completed conversion projects for all candidate conversion activities.

Reversal Risk Factors

Fire reversal risk is based on the work of, and in consultation with, Dr. Matthew Hurteau.[6] Dr. Hurteau is a forest fire scientist at the University of New Mexico. The remaining reversal risk factors were developed using the professional experience of the members of the Protocol workgroup to provide an overall conservative estimate of reversal risk. To date, the estimates have proven to be conservative, with only one unintentional reversal requiring retirement of less than five percent of the forest buffer account.

Protocol Updates

CARB has committed to periodically updating the Protocol to reflect the latest science, data, and technologies. Based on stakeholder feedback during previous rulemakings, CARB attempts to balance forest project operators' need for certainty in developing projects with the constant advancement of science. New data is constantly being developed by the FIA that is used to set the Common Practice statistic described above, which would be used in any future Protocol update. There have been significant advancements in remote sensing technology, including drones and publicly available satellite data, that may aid in developing forest inventories (the measure of carbon stored in trees). New data and resources for determining wildfire risk used in calculating the reversal risk rating are also available. CARB also understands that studies on leakage information for IFM projects are currently being developed. Future improvements will also consider any recommendations from the Compliance Offset Protocol Task Force required by AB 398 (Chapter 135, Statutes of 2017), and will be proposed pursuant to the same public process described earlier in this response prior to seeking Board approval in the future.

Relevant Rulemaking Dockets

Protocol Adoption Date	Link to Rulemaking Documents
Oct. 20, 2011	https://ww3.arb.ca.gov/regact/2010/capandtrade10/capandtrade10.htm
Nov. 14, 2015	https://ww3.arb.ca.gov/regact/2014/capandtrade14/capandtrade14.htm
April 25, 2015	https://ww3.arb.ca.gov/regact/2014/capandtradeprf14/capandtradeprf14.htm

[6] Hurteau, M. et al. (2009). *Accounting for Risks in Valuing Forest Carbon Offsets.* Carbon Balance and Management 4:1, available at https://cbmjournal.biomedcentral.com/track/pdf/10.1186/1750-0680-4-1.

Attachment 1

Duke ENERGY INITIATIVE

June 3, 2019

Sen Bob Weickowski
Asm Laura Friedman
Sen Bill Monning
Asm Eduardo Garcia
Sen Ben Allen

Members of the California State Legislature
Sacramento, CA

cc: Mary Nichols, Chair, California Air Resources Board
Jared Blumenfeld, Secretary, California EPA
Bruce McCarl, Professor, Texas A&M University

Dear Members of the Legislature,

It has recently come to my attention that my research has been cited by parties commenting on the issue of leakage relevant to the forestry protocols for California's cap-and-trade program. Having read the policy brief that cites my research to argue that California substantially underestimates leakage (diverted emissions to other locations) from its current forest protocol, it appears that the policy brief misinterprets my research in making the argument.

The policy brief in question, titled "The California Air Resources Board's U.S. Forest offset protocol underestimates leakage", written by Dr. Barbara Haya, a Research Fellow at UC-Berkeley's Center for Environmental Public Policy cites a 2004 article I co-authored with Dr. David Wear in the *Journal of Environmental Economics and Management* (JEEM) on timber harvest restrictions in the Pacific Northwest.

- Wear, D.N. and B.C. Murray. 2004. "Federal Timber Restrictions, Interregional Spillovers, and the Impact on U.S. Softwood Markets." *Journal of Environmental Economics and Management* 47(2):307-330.

I will confine my comments to the use of my JEEM paper to make their point and not to other evidence presented.

The brief accurately states that that the JEEM article examines timber harvest restrictions on federal lands commencing in the late 1980s and finds that the restrictions effectively diverted harvests to other North American forests and that the volume of diverted harvests was more than 80 percent of the volume of harvests avoided in the Pacific Northwest federal forests. The brief then concludes that the carbon leakage from those diverted forests (the losses in carbon diverted elsewhere) must also be in excess of 80 percent of the carbon savings for projects/programs that protect forests. This interpretation is mistaken for a number of reasons.

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First, the flow of timber is not the same as the flow of carbon. Forests in the Northwest are more carbon-dense than forests in the US South, where much of the diversion is found. Thus the diverted carbon is less than the diverted timber. One needs to have a carbon accounting mechanism to estimate these effects. The JEEM paper does not have that.

Second, an accurate estimate of carbon leakage must capture the land use change that is induced by the intervention. Most forest harvesting and management in the US occurs on private lands and the vast majority of private land is used for forestry or agriculture. Therefore, any change that affects markets in the forest sector will affect both the intensity with which forests and agricultural lands are managed (affecting their carbon content) and the allocation of land between forests and agriculture on private lands (in this case, likely affecting the establishment of new forests to make up for the forests "lost" via protection). This must be taken into account. Forest and agricultural markets operate over larger geographic regions than just the location where the forest project intervention occurs so the land use change effects will also be dispersed spatially. The JEEM paper does not capture this.

Third, because of the two factors above, the leakage from any forest carbon project intervention will depend tremendously on where that intervention occurs. Leakage from an avoided deforestation project in the Northwest could be substantially different from a similar project in the South. Yet the JEEM paper only addresses interventions in the Pacific Northwest and, even putting aside the two technical shortcomings referenced above, should not be used to attribute leakage effects for projects in other regions that may be generating offsets for the California market.

Realizing that the JEEM paper on timber markets might be used as a proxy for leakage, I embarked on a body of research with Professor Bruce McCarl of Texas A&M University, who is the developer of the FASOMGHG model of the US forest and agricultural sectors that captures forest and agricultural commodity markets, land use allocation and comprehensive greenhouse gas accounting across all sectoral activities. That work, among other things, estimated the potential for leakage from regional forest carbon activities incorporating the features that I mention above. This work was published in the following outlet:

- Murray, B.C., B.A. McCarl, and H. Lee. 2004. "Estimating Leakage from Forest Carbon Sequestration Programs." *Land Economics* 80(1):109-124.

I do not know why the policy brief cited the JEEM article rather than the Land Economics article since they were both released at about the same time and the Land Economics piece was far more appropriate sources given that it was actually targeted at carbon leakage, which the JEEM article was not.

This study found wide variation in estimates, but generally lower than would have been implied by JEEM. Indeed the Land Economics paper even used the JEEM article as the point of departure and found leakage from avoided deforestation in the Pacific Northwest is likely much lower (less than 10%) than the JEEM estimates (more than 80%). The leakage effects from avoided deforestation in the South are in the 20-30% range. Avoided deforestation, though could be high in the Lake States in the Midwest or the Northeast if projects originate from there, but I do not know if those are common origins of offsets for California.

Another study that I contributed to at around the same time showed even lower leakage levels than those implied in the Land Economics study, but that study focused on national programs, both forest

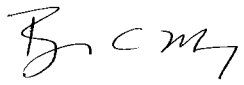
and agriculture, not regional ones focused on forests, and thus is not as appropriate a source for the California forest offsets program

- Murray, B.C., B.L. Sohngen, A.J. Sommer, B.M. Depro, K.M. Jones, B.A. McCarl, D. Gillig, B. DeAngelo, and K. Andrasko. 2005. EPA-R-05-006. "*Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*." Washington, D.C: U.S. Environmental Protection Agency, Office of Atmospheric Programs.

I believe leakage is an important issue in forest carbon programs and I devoted a substantial amount of my professional effort in the early 2000s exploring its nature and empirical magnitude. I think California is absolutely right to adjust offset quantities to account for leakage as this will give a more proper accounting of the net benefits of the transactions. The empirical work is not easy and I do not pretend that the estimates from my work with others, generated more than ten years ago, focused on hypothetical programs are precise estimates of what happens today with real programs. But to my knowledge, they are the only (or perhaps one of a few) peer-reviewed estimates of carbon leakage in US regional programs out there. As such, I encourage California to fund more work in this area using a range of methods and tapping other researchers to give a more contemporary view and policy guidance for today.

I will also point out that leakage exists in the other sectors affected directly by the California cap and trade program. While the state has taken great efforts to address this in the electric power sector through resource shuffling provisions, and these effects have likely reduced leakage, it has probably not eliminated it. Moreover the program may also be diverting activity and emissions to other states through the interaction of inter-regional and global markets for industrial goods. This is the unfortunate fact of any emissions control program that is regionally confined. This does not mean that the program should not be undertaken, just that it is not as effective as a comprehensive global (or even national) program. California cannot create that outcome but understand the shortcomings of what it does create, a program that will have leakage effects for all sectors, including via forest offsets.

Sincerely,



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