



Forest Carbon · Inventory · Data Systems

To: California Air Resources Board
Re: Proposed Amendments to the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms Regulation (Cap-and-Invest Program)
Date: March 9, 2026
Comment Period: January 23 – March 9, 2026
Reference: Appendix A-2 (nc_app a-2)

Introduction

Arbos is a forestry and carbon consulting practice based in Northern California, specializing in forest carbon inventory, growth and yield modeling, and data systems for compliance offset projects under California's Cap-and-Invest Program. I have worked directly on the development, monitoring, and verification of forest offset projects registered under the Program, including projects utilizing both traditional plot-based inventories and CARB-approved LiDAR alternate methods. I have also contributed to open-source tools for forest carbon quantification, including the Forest Vegetation Simulator (FVS) and biomass traceability systems.

I have direct, firsthand experience developing and defending the only remote sensing-based forest carbon inventory to have completed CARB's full verification process, including site visit verification with unpaired sequential sampling, under the Compliance Offset Protocol. That project — a large Improved Forest Management project in Northern California — provides an empirical basis for many of the comments that follow.

These comments focus on provisions within the Proposed Amendments that affect forest offset project implementation, with particular attention to (1) the removal of remote sensing from alternate monitoring and measurement methods, (2) the treatment of forestry offset reversals, and (3) verifier capacity as a systemic constraint on program implementation.

Removal of Remote Sensing from Alternate Methods (§95976(g))

The Proposed Change

The Proposed Amendments remove remote sensing from the alternate monitoring and measurement methods framework in §95976(g). The Initial Statement of Reasons states that "CARB staff have determined such methods to currently be infeasible," while also noting that "[w]hen CARB identifies feasible methods to implement remote sensing for forestry, it will clarify the procedures for doing so." Arbos appreciates the signal that this pathway is not permanently closed. However, we believe the interim removal is premature, runs counter to the direction of the broader carbon market, and is unnecessary given that CARB's existing verification framework already provides a robust mechanism for validating remote sensing inventories.

Notably, the same Proposed Amendments expand the alternate methods framework to accommodate "otherwise unapproved" growth and yield models under §95976(g), demonstrating CARB's willingness

to use the alternate methods process for methodological flexibility. Removing remote sensing while expanding alternate methods for modeling creates an inconsistency in the regulatory approach to emerging technologies.

Voluntary Market Precedent

In 2025, the leading voluntary market standards bodies moved to integrate, not eliminate, remote sensing in forest carbon methodologies:

- *Verra VM0047* (Afforestation, Reforestation, and Revegetation) became the first nature-based methodology to use remote sensing for dynamic performance benchmarks. It was approved by the Integrity Council for the Voluntary Carbon Market (ICVCM) for Core Carbon Principles labeling in October 2025.
- *Verra VM0045* (Improved Forest Management Using Dynamic Matched Baselines) received ICVCM CCP approval and issued its first credits in December 2025 through the Family Forest Carbon Program, specifically enabling small-acreage family forest owners who had been excluded by the cost of traditional inventory approaches.
- *ACRIFM v2.1* was updated to explicitly allow remote sensing tools, including LiDAR, for common practice silviculture assessments and baseline validation, while maintaining field-based calibration requirements.
- The *ICVCM* approved remote sensing classification standards for REDD+ methodologies in September 2025, including minimum mapping unit requirements.

These developments reflect a growing international consensus that remote sensing, when appropriately validated and paired with field measurements, enhances rather than compromises the integrity of forest carbon quantification. CARB's proposed removal moves in the opposite direction from the standards bodies that collectively govern approximately 98% of recent voluntary market credit retirements.

Internal Regulatory Contradiction

The Proposed Amendments simultaneously rely on remote sensing data to establish the "date of discovery" for unintentional reversals under §95983, treating remote sensing as sufficiently reliable to trigger compliance obligations and enforcement timelines. If remote sensing is reliable enough to determine when a reversal has occurred and to start a compliance clock, it is difficult to maintain that the same class of technology is categorically unsuitable for measuring forest carbon stocks, particularly when combined with field-based calibration and validation.

Cost and Access Implications

Forest inventory and remeasurement represent one of the largest recurring costs for forest offset projects. For small and mid-sized landowners — including family forest owners, tribal nations, and community-based organizations — these costs can be prohibitive and represent a significant barrier to participation in the Program.

Remote sensing approaches, when combined with targeted field verification, have demonstrated the ability to reduce per-acre inventory costs by 40–60% while maintaining or improving measurement precision through wall-to-wall coverage and optimized plot allocation. LiDAR-derived forest inventories, paired with field plot calibration, now achieve measurement precision comparable to or better than traditional approaches while enabling stratification and variance reduction that can improve confidence in carbon stock estimates beyond what is achievable through conventional plot sampling alone.

Removing the regulatory pathway for these approaches will disproportionately affect the landowners least able to absorb traditional inventory costs, and may reduce participation and geographic diversity within the Program.

Treatment of Existing LiDAR Projects

The Proposed Amendments do not address the treatment of existing forest offset projects that relied on CARB-approved LiDAR methodologies to establish baseline inventories or monitoring frameworks. The absence of transition language creates uncertainty regarding whether: (i) previously approved LiDAR-based inventories may continue to be used for future reporting periods; (ii) hybrid inventory approaches that incorporate both field plots and remote sensing remain acceptable; or (iii) projects will be required to reconcile LiDAR-derived baselines with protocol-standard plot inventories.

Empirical Evidence: Verification of a Remote Sensing Inventory Under the Current Protocol

The discussion above is not hypothetical. I led the development and defense of the only CARB-approved LiDAR alternate method inventory to have completed full site visit verification under the Compliance Offset Protocol. The project — a large IFM project in Northern California — combined field plots with wall-to-wall LiDAR (≥ 8 pulses/ m^2) and 20-cm multispectral imagery to produce a spatially explicit 10-meter carbon map covering the entire project area.

During the site visit verification, CARB-accredited verifiers conducted unpaired sequential sampling across all three verification strata. All three strata passed. This outcome is significant not only because it demonstrates that the alternate method's estimates are statistically consistent with independent field measurements, but because of what the unpaired test actually validates.

Unpaired vs. Paired Sequential Sampling: A Critical Distinction

The Compliance Offset Protocol (§8.1.1) provides two sequential sampling approaches for verification: paired and unpaired. This distinction is not merely procedural — it reflects fundamentally different levels of assurance about the quality of a project's inventory.

Paired sequential sampling (§8.1.1.1) compares the verifier's re-measurement of the project operator's own monumented plots against the operator's recorded values for those same plots. The null hypothesis is that the verifier's and operator's measurements of the same plots are equal. This is a verification of the *sample* — it confirms that the operator measured its own plots correctly. It says nothing about whether those plots are representative of the broader forest, whether the sampling design adequately captured the population, or whether the extrapolation from plots to project-level carbon stocks is sound.

Unpaired sequential sampling (§8.1.1.2) compares the verifier's independently located plots against the project's *stratum-level average* estimates. The null hypothesis is that the verifier's independent measurements and the project's population estimates are statistically equivalent. This is a verification of the *population estimate* — it tests whether the project's reported carbon stocks for each stratum are consistent with what an independent observer would measure at randomly selected locations throughout the project area.

When wall-to-wall inventory data is available — as it is with a properly calibrated remote sensing inventory — the unpaired test becomes a particularly powerful validation tool. Because the project's stratum averages are derived from a spatially exhaustive inventory (every 10-meter pixel), the verifier is testing against a near-census estimate rather than an extrapolation from a sparse sample. The unpaired test in this context provides stronger assurance of inventory accuracy than paired testing of a conventional plot-based inventory, where the stratum averages themselves are subject to sampling variability.

In the project described above, the verifier’s independent field plots confirmed agreement with the LiDAR-derived stratum estimates across all three strata. The cost implications are significant: unmonumented, variable-radius verification plots can be completed at a fraction of the cost of fixed-radius inventory plots, and the wall-to-wall nature of the remote sensing inventory means the verification is testing against more robust population estimates.

Implications for §95976(g)

The successful verification of this project demonstrates that:

1. Remote sensing inventories, when properly calibrated with field plots, can pass CARB’s own verification standards — including the more rigorous unpaired sequential sampling test.
2. The unpaired sequential sampling framework already provides CARB with a robust, protocol-compliant mechanism for verifying remote sensing inventories to a reasonable level of assurance.
3. Removing remote sensing from the alternate methods framework eliminates a pathway that has been empirically demonstrated to work within the existing regulatory structure, using CARB’s own verification tools.
4. The combination of wall-to-wall remote sensing inventory with unpaired sequential sampling verification provides *stronger* assurance of inventory accuracy than the conventional approach of paired testing against a plot-based sample — because it validates the population estimate, not merely the sample measurements.

Recommendation

Arbos recommends that CARB:

1. Retain a technology-neutral alternate methods pathway within §95976(g) that allows for the consideration and approval of remote sensing and other emerging technologies, subject to appropriate validation requirements.
2. Establish standardized evaluation criteria for alternate method applications, including minimum accuracy thresholds, required field calibration protocols, and peer review or technical panel review processes, to ensure consistency and reduce agency burden.
3. Provide explicit transition language confirming that forest offset projects with previously CARB-approved LiDAR-based inventories may continue to rely on those inventories for ongoing reporting and verification purposes.
4. Consider a structured pilot program for alternate methods that would allow controlled evaluation of emerging technologies without requiring blanket regulatory approval.

Forestry Offset Reversals (§95983)

Discovery Date Construct

The proposed “discovery date” construct relies on disturbance end dates “reported or implied” by external sources, which may not reflect conditions on the ground, may not be consistently defined across events, and may start compliance timelines before safe site access is feasible. Multi-stage disturbance events — such as multi-year drought, bark beetle outbreaks, or repeated fire entries — further complicate the application of a single discovery date.

Mixed Disturbance Classification

The Proposed Amendments add new provisions under §95983(d) for reporting periods in which both intentional and unintentional disturbances occur simultaneously. This addition appropriately recog-

nizes that disturbance classification in real forest systems is not binary. However, the same recognition should extend to the discovery date construct: if CARB acknowledges that multiple disturbance types can co-occur within a single reporting period, it follows that external data sources may not be able to cleanly attribute timing to a specific disturbance type, further supporting the need for operator-presented evidence and on-the-ground assessment.

Natural Forest Dynamics

The proposed reversal provisions do not explicitly address whether routine natural forest dynamics — including background mortality, self-thinning, small-scale wind events, endemic insect activity, and age-related senescence — fall within or outside the scope of reportable reversals. These processes are inherent to forest ecosystems and are already accounted for within the growth and yield models and baseline projections required by the U.S. Forest Projects Protocol. They do not represent a loss of credited greenhouse gas benefits relative to baseline; rather, they are part of the modeled trajectory against which project performance is measured.

If the proposed language is not intended to capture routine ecological variation as reversals, explicit clarification would prevent misapplication and avoid creating perverse incentives for projects to overstate baseline mortality assumptions in order to avoid future reversal determinations.

Recommendation

Arbos recommends that CARB:

1. Clarify the hierarchy of acceptable evidence sources for establishing the date of discovery, with preference given to on-the-ground assessments where feasible.
2. Provide explicit guidance on how multi-stage or prolonged disturbance events are treated for discovery date purposes.
3. Establish a process by which project operators may present evidence of a different discovery date where externally reported dates are incomplete, inconsistent, or do not reflect actual site conditions.
4. Confirm that background levels of tree mortality and natural forest dynamics, as modeled within protocol-required growth and yield projections, do not constitute unintentional reversals.

Verifier Capacity as a Systemic Constraint

Across sections 95977, 95978, 95983, and 95985, the Proposed Amendments place increased reliance on timely, repeated, and sometimes sequential engagement by CARB-accredited verification bodies. While Arbos supports CARB's objective of strengthening oversight and environmental integrity, it is important to recognize that the availability and capacity of qualified verification bodies — particularly for forest offset projects — is already a significant constraint within the Program.

The current pool of CARB-accredited forest offset verifiers is severely limited, and verifier availability is often constrained during periods of heightened demand, including following large disturbance events or during overlapping verification cycles. The Proposed Amendments add further constraints: §95985(b)(2) now requires that the second verification (for reduced invalidation period eligibility) be performed not merely by a different accredited verification body, but by entirely different individual team members. In a small and specialized verifier pool, this requirement further narrows the available options for project operators seeking timely verification.

Regulatory changes that add procedural complexity, narrow verifier roles, or impose rigid timelines without accounting for this reality risk creating compliance and invalidation exposure driven by verifier

scarcity rather than by substantive project deficiencies.

Recommendation

Arbos recommends that CARB take a coordinated, program-wide view of verifier capacity when finalizing amendments across these sections, ensuring that timelines, evidentiary requirements, and enforcement backstops are calibrated to practical verifier availability.

Monitoring Period (§95976(h))

Arbos recognizes the 100-year permanence obligation as a foundational element of the Compliance Offset Program. We note that the Proposed Amendments appropriately distinguish between the active crediting phase and the post-crediting monitoring phase with respect to verification frequency — §95977(d) allows deferral of verification for up to 12 years during the monitoring period, which represents a reasonable graduated approach.

However, the annual Offset Project Data Report (OPDR) requirement persists throughout the full monitoring period, including during years when verification is deferred. For a 100-year post-crediting obligation, this creates a substantial cumulative reporting burden. The proposed termination provisions — project termination after 15 consecutive reporting periods without an approved positive verification statement — compound this concern. A project that has completed its crediting period, maintained its permanence obligations, and experienced no reversal events could face termination due to administrative lapses in annual reporting over a multi-generational time horizon.

Recent international experience underscores this tension. In late 2025, the Article 6.4 Supervisory Body initially proposed a 100-year monitoring period with annual monitoring requirements for land-based activities but subsequently deferred that approach following substantial feedback regarding the impracticality of annual reporting over such a long time horizon.

Recommendation

Arbos recommends that CARB:

1. Reduce the frequency of OPDR submissions during the post-crediting monitoring phase to align with the graduated verification schedule (e.g., requiring OPDRs only in years when verification is scheduled or triggered by a reversal event).
2. Distinguish between administrative non-compliance (missed reports in the absence of a reversal) and substantive non-compliance (failure to address an actual reversal or permanence violation) when applying termination provisions.
3. Consider whether the 15-period termination trigger is appropriately calibrated for the monitoring phase, where projects are no longer generating credits and the primary obligation is permanence maintenance.

Conclusion

The Proposed Amendments represent an important step in ensuring the long-term viability of the Cap-and-Invest Program. The provisions affecting forest offsets would benefit from targeted revisions that preserve environmental integrity while maintaining practical implementability, supporting broad participation, and enabling the Program to adapt to technological and methodological advances in forest carbon quantification.

Arbos appreciates the opportunity to comment and welcomes further dialogue on these issues.

Respectfully submitted,



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