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10-11-1 & 10-11-2



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December 15, 2010

Mary D. Nichols, Chairman
California Air Resources Board
1101 I Street - P.O. Box 2815
Sacramento, CA 95812

**Re: Technical Adjustments for Proposed AB 32 Cap and Trade Regulation and
Compliance-Grade Forest Project Protocol**

Dear Chairman Nichols and Board Members,

We are writing as a follow-up to our December 9th letter, submitting additional comments with more detail about some highly technical translation inconsistencies from CAR (v 3.2) to the combined protocol and regulation language.

As you know, the Calif. Air Resources Board of Directors adopted their revised Forest Project Protocol (FPP 3.2) at their meeting on August 30th after a nearly three-year multi-stakeholder public-input process of creating this protocol. This process and adoption became the basis for your current proposed FPP, which we fully support. These technical improvements can be addressed in a clean-up rulemaking action without delaying adoption of the current package in front of you.

We believe the Air Resources Board's proposed FPP is fully consistent with your objective to achieve conservative, high-quality offsets that are additional, consistent with CEQA, and which create significant environmental co-benefits and we strongly support its adoption. Thank you for consideration of our suggested technical improvements.

Best regards,

David A. Bischel
President

Attachment

Comments on the Cap & Trade Regulation, U.S. Forest Projects Compliance Offset Protocol and the Initial Statement of Reasons

Note: For clarity sake in these comments any time a section of the Protocol, Regulation or ISOR is shown it will be enclosed in a box.

1. ARB has eliminated the requirement for a deed restriction and the project implementation agreement from CAR's version 3.2. Permanence is still 100 years past your last offset sold. Some of the buffer pool risk rating values will need to be adjusted now that a "Qualified Deed Restriction" has been removed; the default financial risk is now 5% of all offset credits issued, which is way too high. There is no evidence of a 5% rate of financial failure for forest owners. The work group assumed that most projects would also include the deed restriction as well, and received the 1% default financial risk, which is a much more realistic value. Small non-capitalized projects may have slightly elevated risk, but still less than 2%. We would recommend that ARB correct table replacing 5% with 2% and allow verifier to consider forest owner capitalization and allow reduction even without a Qualified Conservation Easement to use 1%.

D.1 Financial Risk

Financial failure of an organization resulting in bankruptcy can lead to dissolution of agreements and forest management activities to recover losses that result in reversals. Projects that employ a Qualified Conservation Easement, or that occur on public lands, have lower risk.

Table D.2. Financial Risk Identification

Applies to all projects		
Identification of Risk	Contribution to Reversal Risk Rating	
Default Financial Risk	Forest Project not on public lands or without a Qualified Conservation Easement	Forest Project on public lands or with a Qualified Conservation Easement
	5%	1%

2. Another error also found in CAR 3.2 is the setting of a default for other Episodic Catastrophic Events. This category was added for places predominately outside of California, where hurricanes, tornado or extreme high wind events occur, so setting this to default at 3% is unfair to California projects and should allow for verifier to review and accept much lower values for lands not found in these types of high wind event areas. Similarly especially unique areas, say in the blast zone of volcanoes should allow the verifier to add a risk factor in this catch all unique category.

Natural Disturbance Risk III - Other Episodic Catastrophic Events

A major wind-throw event (hurricane, tornado, high wind event) has the potential to cause a reversal, especially in certain carbon pools.

Table D.9. Natural Disturbance Risk III – Other Episodic Catastrophic Events.

Applies to all projects	
Identification of Risk	Contribution to Reversal Risk Rating
Default Risk Contribution from Other Catastrophic Events	3%

3. The summary of the Risk Analysis still refers to the Project Implementation Agreement, which will no longer be required.

Table D.10. Project Contribution to the Buffer Account Based on Risk.

Risk Category	Contribution from Risk Descriptions Above		
	Source	Forest Project without a Qualified Conservation Easement and/or Public Ownership	Forest Projects with a Qualified Conservation Easement and/or Public Ownership
Financial Failure	Default Risk -Remedies for reversals addressed in PIA	5%	1%
Illegal Forest Biomass Removal	Default Risk	0%	0%
Conversion	Default Risk - Remedies for reversals addressed in PIA	2%	0%
Over-Harvesting	Default Risk - Remedies for reversals addressed in PIA	2%	0%
Social	Default Risk	2%	2%
Wildfire	Calculated Risk from worksheet	X%	X%
Disease or Insect Outbreak	Calculated Risk from worksheet	3%	3%
Other Catastrophic Events	Calculated Risk from worksheet	3%	3%

4. After 12/31/2014 CAR projects must be re-verified and be brought up to ARB protocol standards. There is an inconsistency with this requirement and Early Action Projects, especially around the limits on Commencement Date in the regulations which could prevent early action projects from being re-verified. This is found in the regulation at:

§ 95973. Requirements for Offset Projects Using ARB Compliance Offset Protocols

...

- (2) meet the following additionality requirements as of the date of Offset Project Commencement:

...

- (B) the Offset Project commencement date occurs after December 31, 2006; and

and in the Protocol at page 10:

Programmatic changes to align with cap-and-trade program requirements:

A number of programmatic changes were necessary to align the protocol text with the processes and requirements in the cap-and-trade regulation. These relate both to the transition from a voluntary to a regulatory program generally, and specifically the transition from a program administered by CAR to one administered by ARB. These modifications included modifying references to ARB's program and regulatory text, eliminating some forms not required by ARB, and aligning start date eligibility and project commencement requirements with the regulation. Sections containing quantification methodologies were clearly identified, as these are exempt from the APA process. References to CAR's website were changed to reference ARB's website where protocol related documents will be housed. A requirement was also added that projects must fulfill all applicable local, regional, and national requirements on environmental impact assessments to be eligible.

And at page 11:

Examples of other terminology changes include:

- 'Project Developers' changed to 'Offset Project Operators' or 'Authorized Project Designees';
- 'Avoidable' and 'Unavoidable' were changed to 'Intentional' and 'Unintentional';
- 'Buffer Pool' changed to 'Forest Buffer Account';
- 'GHG Assessment Boundary' changed to 'Offset Project Boundary';
- 'Project Start Date' changed to 'Offset Project Commencement';
- 'Annual Monitoring Report' changed to 'Offset Project Data Report', and the 'Project Design Document' requirements were incorporated into the initial offset project data report.

There are numerous uses of the term "Commencement date in the protocol, all of which make sense if the Regulation is modified to recognize early action projects that meet ARB qualifications can have earlier commencement dates governed by the start date limitations as set forth in the ARB approved early action protocols. An example of this problem is: All ARB offset projects must have a "Commencement Date" of 1/1/2007 or later. This is a significant problem for early action CAR reforestation projects which were allowed to have "Start Dates" back to 1/1/2001. ARB should not be overly concerned about this Reforestation start date issue as this is the same commencement issue and these projects do not accrue significant offset credits during this 4 year period between 2001 and 2005 (the earliest early action offset credit that can qualify as a compliance grade offset under ARB). Also both CAR v 3.2 and the ARB protocol say that Reforestation projects can't receive credits until after the 2nd verification which in almost all cases has not happened yet.

5. The requirement calling for a site visit for every forest protocol offset verification report to receive credits is cost prohibitive and really unnecessary when you consider the required re-measurement of all inventory plots every 12 years. In many cases the only change will be modeled growth which certainly doesn't require a site visit as long as there are required visit every 6 years. As CAR v. 3.2 allowed an office review should suffice for annual offset verification especially with the required site visits every six years and required new inventory every 12 years. Section 9.3.2.1 of the Protocol seems to indicate that site visits are only required every 6 years .

9.3.2.1 Minimum Required Verification Schedule

Except as allowed for the second verification of Reforestation Projects, ARB requires that an ARB-accredited third-party verification body review and assess all reported data and information for a Forest Project and conduct a site visit at least once every six years. Verification is also required anytime new confidence deductions and/or reversal risk ratings are established.

Yet the regulation at Section 95977(e)(C)(iv) sets that back to annual.

(iv) **Site Visits for Offset Projects.** For a non-sequestration offset project, at least one accredited offset verifier in the offset verification team, including the project specialist, must make at least one site visit every year to each offset project location for which an Offset Project Data Report is submitted. For a forest or urban forest offset project, at least one accredited offset verifier in the offset verification team, including the project specialist, must make a site visit every year that offset verification services are provided. A site visit is also required after the first full calendar year of operations of an offset project. During the site visit, the offset

6. *There is a requirement that in the forest projects the verifier must re-measure a minimum number of plots or 5% whichever is greater. The 5% requirement of larger projects is many times over that which is necessary to check the quality of the project inventory effort as long as the plots that are re-measured are randomly chosen. This 5% re-measurement cost alone will prevent many landowners from participating. A better approach is the approach (developed by the stakeholder work group) taken in CAR 3.2 where the verifier goes through a thorough review and establishes a minimum number of plots based upon project characteristics. Recall since these re-measurements are taken randomly the verifier is able to very reasonably assess accuracy of reported inventory. This methodology for determining the required number of plots to be re-measured is found in Section 10.3.5 of the CAR v. 3.2 approved protocol and is attached as a separate document to these comments.*

10.2 Additional Verification Requirements

In addition to the offset project verification requirements in § 95977, verification of Offset Project Data Reports for Forest Projects must include:

During the initial verification:

1. A detailed review of all required Listing Information during the initial verification.

During every verification:

2. A detailed review of the forest carbon inventory, including:
 - a. Inventory methodology and sampling design;
 - b. Inventory update processes;
 - c. Measurement of sample plots and sample plot locations;
 - d. Lifetime and updating of sample plots, as applicable;
 - e. Stratification methods, if applicable;
 - f. Biomass equations and calculations;
 - g. Incorporation of growth and harvest modeling and data;
 - h. Documentation of inventory methods and procedures, including procedures for data quality assurance and quality control.
3. Identification and re-measurement of a selection of sample plots, along with a comparison with inventory data to have reasonable assurance that sample plots are measured accurately. A minimum of 8 sample plots or 5% of the total sample plots used to develop the forest carbon inventory, whichever is greater, must be measured by the verification body. A paired t-test must be conducted to determine whether the verifier sample plot measurements are within the same population as the inventory submitted by the Offset Project Operator or Authorized Project Designee to a reasonable degree of confidence.

7. Verification issues in the regulation at Section 95977 (d) include a very strict delivery date for offset verification reports. The penalty for being late is denial of eligibility of the offset credits reported in that Offset Project Data Report. This seems highly punitive especially given that many projects will have multiple years of data verified in the first report and if necessary to avoid this penalty just wait another year and submit this first Offset Project Data Report without any penalty. Especially in the first few years such deadlines should be more flexible to allow verifiers to get up to speed and ARB to have a steady flow of offsets arriving to keep Cap & Trade economic impacts down.

(d) **Timing for Submittal of Offset Verification Statements to ARB or an Offset Project Registry.** Any Offset Verification Statement must be received by ARB or an Offset Project Registry by October 1 of the year in which the Offset Project Data Report was submitted. If the Offset Verification Statement is not submitted to ARB or an Offset Project Registry by the verification deadline, the GHG reductions or GHG removal enhancements quantified and reported in the Offset Project Data Report are not eligible to be issued offset credits.

Section 95976 has a similar deadline and penalty for Offset Project Data Reports, which should be addressed.

- (6) **All Offset Project Data Reports for the previous year's reported data are due April 1.**
- (7) **If an Offset Project Data Report is not submitted to ARB or an Offset Project Registry by the applicable reporting deadline, the GHG reductions or GHG removal enhancements quantified and reported in the Offset Project Data Report are not eligible to receive offset credits.**

8. Verification issues in the regulation at Section 95977 (e) includes a limit of six consecutive years of offset project data verification. This six year limit needs to be adjusted for the first verification on early action projects and for reforestation projects. This is problematic in the first few years due to availability of verifiers and first verification may cover 2007 through 2011 vintages (5 consecutive years) thus a verifier will need replacement in one additional year of verification (after only two years of actual work), this is costly and there may be limited numbers of verifiers. Initial or first verification regardless of offset credit vintage years generated should only count as one year towards this verifier year limit.

Another drawback to this limit is that a verifier who is familiar with the project and conducts the first site visit (and the entity most likely to recognize issues) is prevented from doing the second required site visit at the 6 year interval. A more reasonable solution relative to Forest Projects is to have the ARB do random reviews of projects for the purpose of testing the verifiers and thus obviate this verifier replacement requirement. This would be more effective for ARB to assure verifier quality and be much more cost effective for projects, eventually leading to more cost effective offsets to encourage AB 32 implementation.

(e) Requirements for Offset Verification Services.

- (1) Rotation of Verification Bodies.** An offset project shall not have more than six consecutive years of offset project data verified by the same verification body or verifier(s). An Offset Project Operator or Authorized Project Designee may contract with a previous verification body or verifier(s) only after three years of offset project data have been verified by a different verification body or verifier(s).

9. Under Section 9.1.1.1 of the Forest Protocol, item #27 requires reporting of projections of baseline and actual harvests from the project area over 100 year. The Board of Forestry and CalFire recognize that such actual harvest projections need to be treated as confidential trade secret information as such estimates can impact a forest owner's competitiveness. Also this requirement while it must be shown to the verifier can be handled confidentially in that process, but the actual timing of harvest while generally predictable will invariably vary over time, due to market conditions. The actual harvest in any one year must be reported to complete annual offset credit verification and would be released to the public in that report, but must be protected in the 100 year projection form.

27. *Projections of baseline and actual harvesting volumes from the Project Area over 100 years.

An alternative would be to mark such data as "confidential" according to Section 96021 of the regulation. This would require the Executive Officer to treat all such requests according to the procedures specified in CCR Title 17 sections 91000 to 91022. This can be fixed by removing this item from this list since it is already required in the required Annual Offset Project Report, at which time it will also be real and known from measured actual harvest.

Item 20 from that list also needs hectare to be replaced with acre, for US based projects.

20. *A description of the calculation methodologies for determining metric tons per hectare for each of the carbon pools included in the project report.

10. Under Section 9.1 the word "is" in the second paragraph needs to be struck.

All reports that reference carbon stocks must be submitted with the oversight of a Professional Forester. If the project is located in a jurisdiction without a Professional Forester law or regulation, then a Professional Forester is must either have the Certified Forester credentials managed by the Society of American Foresters, or other valid professional forester license or credential approved by a government agency in a different jurisdiction.

11. Under Section 6.2.1.1 of the Forest Protocol in the requirements for a Logical Management Unit that says:

A "logical management unit" or "LMU" is defined as all land that the Forest Owner and its affiliate(s) (as defined below) either own in fee or hold timber rights on, and which it or they manage as an explicitly defined planning subunit. LMUs are generally characterized by unique biological, geographical, and/or geological conditions, are generally delimited by watershed boundaries and/or elevational zones, and contain unique road networks. In addition, an LMU must:

- Be a sustainable planning subunit as demonstrated by inventory reports and growth and harvest projections for the LMU.
- Where even aged management is utilized, have a uniform distribution (by area) of 10-year age classes that extend to the normal rotation age (variation of any 10-year age class not to exceed 20%).
- Where uneven aged management is utilized, have between 33% and 66% of the forested stands exceeding the retention standards identified in the growth and harvest projections by a minimum of 25% (basal area).

This is an impossible test as most areas have histories which prevent this uniform distribution by age class, and if there is any necessary test on age class distribution it is already included in the project requirements for Natural Forest Management under Section 3.8.2 and shown in Table 3.2.

12. Section 3.8.3 of the Forest Project Protocol requires live carbon stock must be maintained and/or increased during the project life.

3.8.3 Promotion of the Onsite Standing Live Carbon Stocks

In an effort to promote and maintain the environmental benefits of Forest Projects, the standing live carbon stocks within the Project Area must be maintained and/or increased during the Project Life. Therefore, except as specified below, Offset Credits will not be issued for quantified GHG reductions and removals achieved by a Forest Project if a Forest Project's Offset Project Data Reports – over any 10-year consecutive period – indicate a decrease in the standing live carbon stocks.

Exceptions are allowed where reductions in standing live carbon stocks are important for maintaining and enhancing forest health, environmental co-benefits, or the long-term security of all carbon stocks; where reductions are due to non-harvest disturbances; or where reductions are required by law. Note that these exceptions in no way change or affect the requirements related to compensating for reversals, as detailed in Section 7.3.

This provision needs to be revised to state that this is required for the crediting period and that after such period standing live carbon stock may increase and decrease as long as it does not fall below that level to support all registered tonnes. This could easily be clarified by adding a 5th exception to the requirement in Section 3.8.3 which states as follows:

5. The decrease in standing live carbon stocks occurs after the crediting period and the residual stocking is above the level that assures all verified credits will be permanent.
13. The above discussion leads to another discussion, that is the annual reporting and six year site visits as well as full inventory every 12 years should only be required for the crediting period, and that ARB will develop required monitoring period requirements that recognize the 100 year permanence and the need being of lower resolution, and an investment and detail level that demonstrates that the level of onsite carbon stocks must be maintained at or above that amount needed to assure all registered tonnes. For example a satellite monitoring of change detection could be more than reasonable for monitoring period needs and cost effective.
14. In Section 3.2 of the Forest Protocol in the second full paragraph (top of page 14) there is a double period typo.

An Improved Forest Management project's offset project commencement date must be linked to a discrete, verifiable action that delineates a change in practice relative to the project's baseline..One of the following actions denote an Improved Forest Management project's commencement date:

15. In Section 6.1.1 Estimating Baseline Onsite Carbon Stocks there is a requirement for a pre-site prep inventory for pools that maybe affected by the site prep.

6.1.1 Estimating Baseline Onsite Carbon Stocks

Quantification Methodology

To estimate baseline carbon stocks for a Reforestation Project:

1. Provide a qualitative characterization of the likely vegetative conditions and activities that would have occurred without the project, taking into consideration any laws, statutes, regulations, or other legal mandates that would encourage or require reforestation on the Project Area. The qualitative assessment shall include an assessment of the commercial value of trees within the Project Area over the next 30 years. The qualitative assessment must be used as the basis for modeling baseline carbon stocks (Step 3).
2. Inventory the carbon stocks in each of the project's required carbon pools, following the requirements in Appendix A of this protocol.⁶ For carbon pools that will be affected by site preparation, the inventory must be conducted prior to any site preparation activities. For those carbon pools that are affected by site preparation, provide an estimate of initial carbon stocks using one of the following alternatives:
 - Measuring carbon stocks using 20 sample plots located in the portion of the Project Area containing the greatest amount of biomass in the pool that will be affected.
 - Stratifying (classifying) the Project Area into similar densities and measuring stocks within the affected carbon pools using 20 sample plots per density class.
 - Measuring the affected carbon stocks based on a grid system across the Project Area.

While very few pools would be affected by site prep, for early action projects this pre-site prep inventory cannot be measured. Suggest adding a professional estimate by an RPF based upon non reforested areas nearby and including a specific requirement for verifier to check this estimate for reasonableness.

16. For future changes and clarity sake over a 100 year period, ARB should adopt a numbering system for the protocol versions as surely they will be updated and since they would apply for at least one crediting period there will be need to identify which specific protocol applies to a particular project.
17. Since the ARB Forest Offset Protocol Resources website is not yet available, it was impossible to check some of the required values for species composition and common practice values, which will require further comment when they become available.
18. There has been a lot of public comment over the lying dead wood pool and the decision to not make it a required pool. In forests as the stakeholder workgroup correctly determined, such a pool is very expensive and they recognized that the source of lying dead wood is preponderantly from standing dead wood, a pool that is required to be measured and certain minimums must necessarily be maintained for the natural forest management definition, there is no need to change this decision.
19. It is also important that the same workgroup with almost 2 years of efforts developed the standard for when it would be necessary to actually measure soil carbon, another extremely expensive pool to estimate. That process recognized that this pool is virtually not affected by most management activities and only when a site is very drastically disturbed is there any likelihood of loss from this carbon pool, again the 25% disturbance standard is a reasonable and conservative standard that balances cost without compromising the protocol carbon additionality.
20. Section 6.2.6 for quantifying secondary effects of projects that reduce harvesting, fails to account for differences in timing for baseline estimates and actual project real harvesting.

6.2.6 Quantifying Secondary Effects

Quantification Methodology

For Improved Forest Management Projects, significant Secondary Effects can occur if a project reduces harvesting in the Project Area, resulting in an increase in harvesting on other properties. Equation 6.10 must be used to estimate Secondary Effects for Improved Forest Management projects:

This calculation is done annually and does not take into account timing of harvest and would require secondary effects contributions from projects that over time increase harvest above average baseline carbon harvests and thus have no reduced harvesting secondary effects. Since a project that increases onsite carbon additionality and increases offsite storage of carbon in wood products is sequestering the maximum CO₂ such a result (project) shouldn't be discouraged. This methodology also applies the 20% multiplier to total onsite carbon harvested when the leakage effect is only applicable to the harvested wood products, since all other pools are required to be stable or increasing this over-estimates the leakage effect. The required onsite stock maintenance or increase takes care of the carbon in the non product portions of harvested trees at issue. An identical over estimate occurs in the contribution to landfills for those projects that harvest more than baseline. See Appendix C in Section C.4. This calculation requires landfill deductions even though the project increases wood product production as compared to the baseline.

C.4 Estimate the Average Carbon Storage Over 100 Years for Wood Products in Landfills

Wood product carbon in landfills is only calculated for years in which a Forest Project's actual harvesting volumes are below estimated baseline harvesting levels, as determined in Section 6. To determine the appropriate value for average landfill carbon storage, perform the following steps:

In both these cases, the verifier could evaluate the project and determine if the project will actually harvest more than the baseline over the crediting period and correctly calculate these contributions. This decision can be re-evaluated at each 6 year site visit and if need be corrected in the inventory true-up process.

21. Section 95976 of the regulation sets out record retention requirements.

- | | |
|-----|--|
| (2) | Documents shall be retained in paper, electronic, or other usable format for five years after the end of the crediting period for non-sequestration offset projects or, for sequestration offset projects, the length of time that the offset project is issued offset credits plus 100 years. |
|-----|--|

Clearly a sequestration project could be allowed to establish a final crediting period baseline plus all offsets credits registered and then enter a monitoring process that would not require maintenance of all the preceding decades of documents. Of course during the active crediting period these records are necessary, but once in the monitoring period, with no additional revenue cost is an important issue.



California Clearcuts – A Unique Approach to Evenaged Management

Existing Mandatory Protections Associated with California Clearcuts

In California, timber harvesting is subject to preparation of a CEQA compliant discretionary environmental permit that must be prepared by a licensed professional forester (RPF), conducted by a licensed timber operator (LTO), reviewed by a multi-disciplinary team of resource professionals and requires public comment prior to approval by the California Department of Forestry and Fire Protection (CAL FIRE).

In addition, timber stands harvested under any even-aged method (including clearcutting) must meet the following standards:

- **Sustained Yield Mandatory** - To assure the "continuous growing and harvesting of commercial forest tree species," each Timber Harvesting Plan (THP) must show that total harvest will not exceed total growth over the next 100 years.
- **Minimum Harvest Age of 50-80 Years** - Forests may not be harvested by clearcutting if stand age is less than 50 years (highly productive sites), 60 years (moderately productive), or 80 years (least productive sites).
- **Size Limited to 20-30 Acres** - Clearcuts with tractor operations are limited to 20 acres and helicopter/cable operations limited to 30 acres. Some limited exceptions are allowed up to 40 acres where environmental benefit can be shown. (By comparison, most states do not limit size - where there are limits, Oregon/Washington have 120 acres, with exceptions to 240 acres.)
- **Mandatory Forest Retention Adjacent To Clearcuts** - Forest areas adjacent to clearcuts must be at least as large as the clearcut being harvested. In addition, these adjacent areas may not be harvested until/unless trees planted after the original clearcut are at least 5 feet tall and/or 5 years of age, and total harvest levels must be sustainable across the landscape over 100 years.
- **300 Ft. Stream Protection Zones** - No clearcuts within 150 feet of each side of any fish-bearing stream (300 feet total protection zone).
- **Replanting 300 Trees Per Acre** - Clearcuts must be replanted, and harvest areas must contain at least 300 healthy seedlings/acre (minimum two years old) within 5 years after harvest. (Statewide, this means more than 5 trees are planted for each tree harvested.)
- **Full CEQA Analysis & Impact Mitigation** – All timber harvest activities must undergo a full environmental analysis of site specific impacts and cumulative impacts equivalent to an Environmental Impact Report (EIR) and each THP is reviewed by a multi-disciplinary team that includes CAL FIRE, Dept. of Fish & Game and State Water Quality Control Board staff. All significant environmental impacts must be avoided or mitigated to a level of insignificance.

Source: California Forest Practice Rules 2003. Title 14, California Code of Regulations, Chapters 4, 4.5, and 10.

MANAGING CALIFORNIA'S FORESTS – THE ROLE OF SCIENTIFIC SILVICULTURE

California's forests are dynamic and always changing. Natural forces such as fires, windstorms, insects and disease, as well as human impact, have all influenced the structure and development of the forests we see today.

Foresters have studied these natural forces and learned to imitate them. Management treatments are designed to maintain a healthy and productive forest that provides for the needs of Californians today and for future generations. This is called the science of **Silviculture**.

California's **Registered Professional Foresters (RPF)** evaluate a forest area or "stand" to determine the appropriate silvicultural treatment to maintain forest health and to provide sustainable forest products and environmental values for the long term.



Figure 1- Uneven-Age Forest Structure



Figure 2 – Even-Age Forest Structure



Figure 3- Replanted Clearcut with Variable Retention for Wildlife Habitat



Figure 4- Shelterwood Even-Age Regeneration

Many natural forests have stands of trees with relatively **Even-Age** structure. This could have been the result of a natural event such as a fire or windstorm, or from a man-made disturbance such as logging or brush clearing. The full sunlight in the resulting opening is the favored environment for many tree species such as ponderosa pine and Douglas fir to thrive. The young trees that grow after the disturbance are either planted or "seeded in" from adjacent seed trees, thus resulting in a forest with trees of approximately the same age. The young trees grow and eventually begin to compete with each other for the limited light, water and nutrients in their environment. The trees will eventually be naturally thinned from insect attack, disease or wildfires, or RPFs can design a harvest to commercially thin the forest and use the trees for lumber, plywood, or paper and energy chips.

Some of California's forests have trees that grow well in the shade of larger trees, resulting in **Uneven-Age** structure. White fir and some hardwoods are examples. These trees often grow in forests with clumpy or uneven aged groups. They prefer full sunlight for optimum growth, but can wait in the shadows until an opening appears from the death of a larger tree by insects, disease, fire or a planned harvest. RPFs can design a harvest to create small opening that encourage trees to seed in and maintain this uneven structure over time. Frequent harvests are needed to maintain this structure and keep the forest thinned to maintain growth and health.

Conifer trees in California can live for hundreds of years, but as they age they become prone to disease and insects, and the forest stand's growth slows. Foresters plan **Thinnings** to maintain growth and health, but eventually the trees become mature and the decision to restart the cycle of growth must be made. The RPF must consider the potential for future disease, wildfire, harvest methods, and the impacts to wildlife, water quality and quantity and aesthetics when a regeneration harvest is planned. The RPF

evaluates the existing age structure, either even-aged or uneven-aged, the mix of tree and brush species, wildlife and fisheries resources, present and future forest product needs, and the ownership objectives of the forest owner before choosing a regeneration strategy.

Even-age regeneration harvest such as **Clearcutting**, **Shelterwood** and **Variable Retention** provide rapid reforestation by replanting the desired species or mix of tree species adapted to the location. By harvesting all or most of the trees at one time, repeated disturbance in the forest is reduced, diseases can be treated, and slash (limbs and tops) from the harvested trees can be treated to reduce fuel for wildfire. The abrupt change from large trees to small trees is good for some wildlife, but others must move

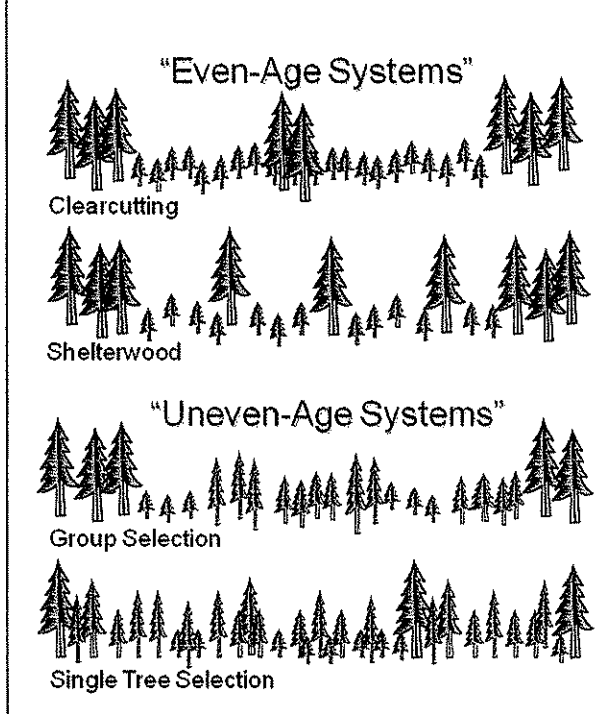
or adapt. This change can also be aesthetically displeasing to some people who view it as destructive rather than a part of the natural cycle of forest regeneration.

Uneven-age regeneration harvest such as **Individual Tree** or **Small Group** selection provide small openings where young trees are encouraged to reseed. Species mix and disease can be difficult to regulate, but this method requires less investment since planting is not required. The forest structure is more uniform over a large area which is good for some wildlife, but excludes others, especially those that require open conditions. Forest fire fuels

are harder to control and "ladder fuels" develop which can allow a fire to travel from the ground to the tops of the trees. Uneven-aged forests are generally aesthetically acceptable but are difficult to establish in some forest types.

California's RPFs are entrusted with protecting all of the valuable products and values that we expect from our forests. Scientific silviculture is a key tool used to maintain forest health so that we can have healthy, sustainable forests for today and for the future.

EXAMPLES OF SILVICULTURAL METHODS



To Manage or Not to Manage: The Role of Silviculture in Sequestering Carbon in the Specter of Climate Change

Jianwei Zhang¹, Robert F. Powers², and Carl N. Skinner³

Abstract—Forests and the soils beneath them are a major sink for atmospheric CO₂ and play a significant role in offsetting CO₂ emissions by converting CO₂ into wood through photosynthesis and storing it for an extended period. However, forest fires counter carbon sequestration because pyrolysis converts organic C to CO and CO₂, releasing decades or centuries of bound C to the atmosphere as a pulse, exacerbating the greenhouse gas effect. With global warming, the probability of fire has increased. Silviculture is an important tool for reducing wildfire risk and enhancing long-term carbon sequestration and—through this—mitigating the effect of climate change. Using the data collected from three studies over the last several decades, we compared treatment effects (density manipulation, fertilization, vegetation control, and interactions among some of them) on tree growth and subsequently carbon accumulation, fire risks predicted with fire behavior simulations, and responses of stand to future climate changes modeled by a process-based model (3-PG). With these case studies, we found that (1) intensive management (vegetation control and fertilization) increased C sequestration 400 percent and decreased fire caused tree mortality 50 percent compared to control at age 21 (Whitmore Garden of Eden study). (2) Density manipulation and vegetation control increased C sequestration 30 percent and decreased fire caused tree mortality 50 percent compared to control at age 40 (Challenge Initial Spacing study). (3) Density manipulation increased C sequestration 9 percent and decreased fire caused tree mortality 40 percent compared to control at age 55 (Elliot Ranch LOGS study). In addition, bark beetles killed significantly more trees in the control (high density plots) than in the lower density plots. (4) The 3-PG model predicts that global warming impacts carbon sequestration more in unmanaged than managed stands. These findings suggest that if carbon sequestration and storage are goals, our forests should be managed more aggressively in the future.

Introduction

Global climate is changing at an unprecedented rate. The latest assessment from the Intergovernmental Panel on Climate Change (IPCC 2007) states that the global average surface temperature has increased 0.74 °C from 1906 to 2005. By 2100, increases of 1.1–6.4 °C are projected over the 1990 level using different models with various scenarios. Warming trends are believed to be due to the anthropogenic increase of greenhouse gases (GHG), with an increase of 70 percent between 1970 and 2004. Carbon dioxide (CO₂) is one of the most important anthropogenic GHGs. Annual emissions grew by about 80 percent between 1970 and 2004. Not only have CO₂ and GHG concentration increased greatly since 1750, but the rate of increase far exceeds pre-industrial values determined from ice cores spanning many thousands of years (IPCC 2007).

Forests play a significant role in offsetting CO₂ emissions by converting CO₂ into organic C through photosynthesis. Much of the product of photosynthesis

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