

FiniteCarbon

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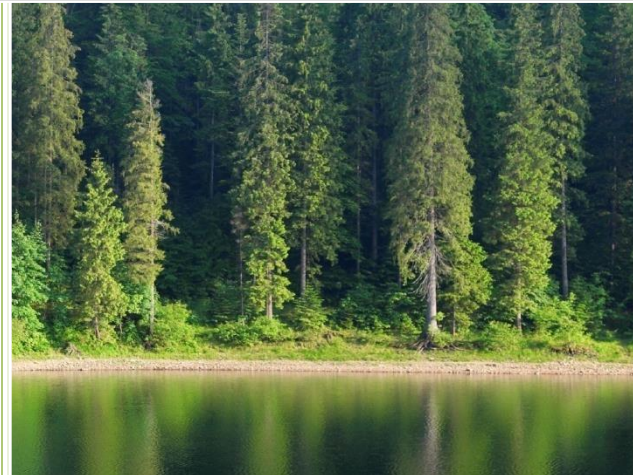
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Appendix A. CAR1391 CAFR6391 Inventory and Modeling Methodology “Finite Carbon – Lyme Wisconsin IFM” CA EPA Air Resources Board Compliance Offset Protocol U.S. Forests Projects: Improved Forest Management

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Introduction

California’s Cap and Trade Regulation (“Regulation”) took effect on January 1, 2012, with amendments to the Regulation effective September 1, 2012. The enforceable compliance obligation began on January 1, 2013. The Air Resources Board (ARB) has developed and implemented a compliance offset program as part of the State’s Cap and Trade Program. Covered entities may use a limited number of ARB offset credits to fulfill up to 8% of their compliance obligation. Offset credits are tradable compliance instruments that represent verified greenhouse gas (GHG) emission reductions or removal enhancements made in sectors and sources not covered by the Cap and Trade Program.

The ARB U.S. Forest Projects Compliance Offset Protocol adopted on October 20, 2011 (“Forest Offset Protocol”; “Protocol”; COP; or FOP) provides requirements and methods for quantifying the net climate benefits of activities that sequester carbon on forestland. The protocol provides offset project eligibility rules; methods to calculate an offset project’s net effects on GHG emissions and removals of CO₂ from the atmosphere (removals); procedures for assessing the risk that carbon sequestered by a project may be reversed (i.e. released back to the atmosphere); and approaches for long term project monitoring and reporting. The goal of this protocol is to ensure that the net GHG reductions and GHG removal enhancements caused by an offset project are accounted for in a complete, consistent, transparent, accurate, and conservative manner and may therefore be reported as the basis for issuing ARB or registry offset credits. The protocol is built from The Climate Action Reserve’s Forest Project Protocol Version 3.2. This project was developed under the updated version of the FOP adopted on June 25, 2015, and in compliance with the Regulation adopted April 1, 2019.

Finite Carbon is a forest carbon project developer specializing in the creation and monetization of forest carbon offsets. Combining unparalleled project development experience with extensive carbon market knowledge, Finite Carbon offers the most comprehensive forest carbon project development and commercialization service in the United States. With an in-house team of forest carbon experts, Finite Carbon provides all the expertise and resources for successful implementation of forest carbon inventories, project design, verification management and monetization of carbon offset.

This document is the primary appendix to the Offset Project Data Report (OPDR) for *Finite Carbon – Lyme Wisconsin IFM* (“Lyme Wisconsin”), assigned by the Climate Action Reserve, which is an ARB approved Offset Project Registry (OPR), as Project ID: CAR1391. Since this project is located in Wisconsin which does not have a professional forester regulation, the OPDR and all other project documentation and reports that reference carbon stocks have been prepared and submitted with review by an SAF certified forester (Stephen Dettman of Finite Carbon – SAF certification number #4019, and Brian Sharer – SAF certification number #53906) to satisfy the professional forester requirements outlined in the FOP, section 7.2.

Project Area Background

The Lyme Wisconsin Timberlands have been managed in the past for timber production and outdoor recreation such as hunting and fishing with limited agricultural activities. The land is owned by a limited liability corporation (Lyme Wisconsin Timberlands LLC) established by the Lyme Timber Company to manage the land on behalf of a group of investors. The Project Area is comprised of several large blocks of multiple-use forestland in northeastern Wisconsin. The species composition is primarily sugar maple, red maple, northern white cedar, yellow birch, and balsam fir. The forest is mature with approximately 96% of the forest older than 20 years of age. The forest project lies in the 4a climate zone as shown of the USDA Plant Hardiness Zone mapping for the region.

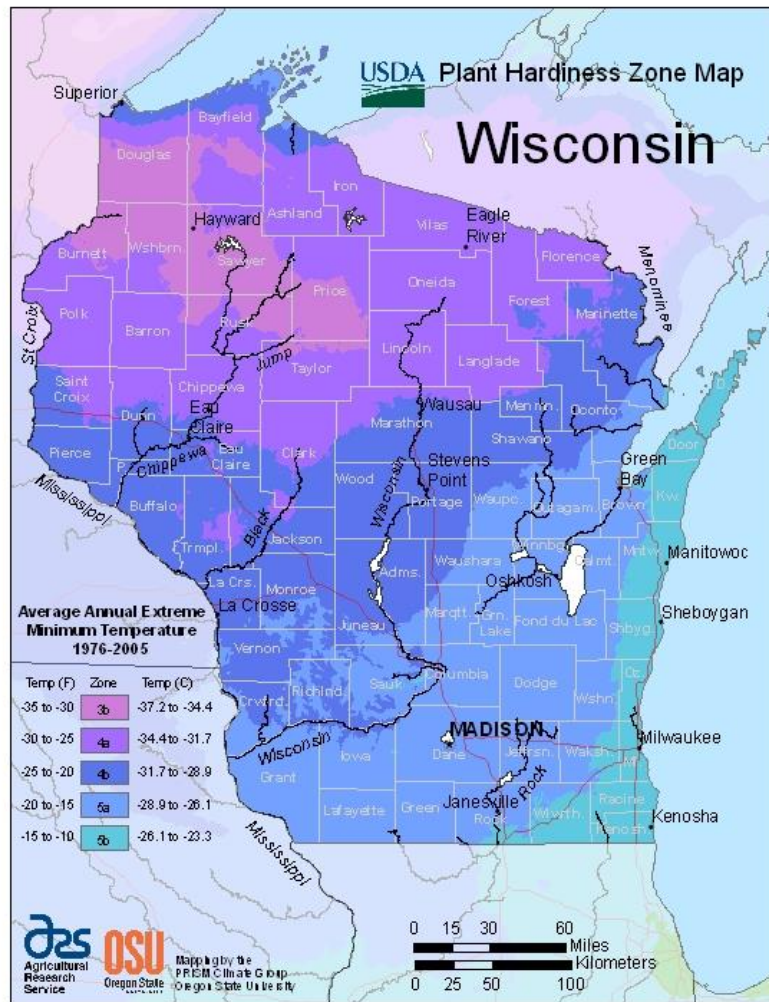


Figure 1. Plant Hardiness Zones (source: planthardiness.ars.usda.gov)

Further review of a series of publicly available aerial imagery taken over time indicates that land use change pressure in this region is moderately low with limited residential development and little changes to other land uses from forest. The topography of the area ranges in elevation from 900 feet to 1600 feet above sea level.

The primary purpose of the inventory is to accurately quantify the onsite forest stocks of the standing living and dead tree carbon pools in the project area for registration and approval as a forest carbon offset project with the California Air Resources Board compliance offset program. This inventory was conducted in a manner that can be verified, facilitates growth and yield modeling, and is replicable. The following inventory procedures will be the guiding requirements for future inventory work done on this site to comply with the offset program, including updates of sample data done as forests are affected by management annually and periodically.

Inventory data collected has been independently and/or jointly audited by the contractor and Finite Carbon for accuracy. As all carbon claims for this project site will also be independently verified by an ARB accredited verifier, the accuracy and precision of the data collection for this project is paramount to project success for the landowner.

Description of the Offset Project's GHG Assessment Boundary

Table 1. GHG Sources, Sinks, and Reservoirs

SSR	Description	Type	Gas	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
IFM-1	Standing live carbon (carbon in all portions of living trees)	Reservoir / Pool	CO2	Baseline: Modeled based on initial field inventory measurements Project: Measured by field measurements and updating forest carbon inventory	Increases in standing live carbon stocks are likely to be the largest primary effect of Improved Forest Management Projects.
IFM-3	Standing dead carbon (carbon in all portions of dead, standing trees)	Reservoir / Pool	CO2	Baseline: Modeled based on initial field inventory measurements Project: Measured by updating forest carbon inventory	Improved Forest Management Projects may significantly increase standing dead carbon stocks over time.
IFM-7	Carbon in in-use forest products	Reservoir / Pool	CO2	Baseline: Estimated from modeled harvesting volumes Project: Estimated from measured harvesting volumes	Included because many Improved Forest Management Projects may significantly change carbon storage in in-use forest products relative to baseline levels. Treated as a "source/sink" because forest product carbon is quantified according to the change in harvesting volumes, relative to baseline levels, in each year. Of this change (increase or decrease), only the average amount of carbon expected to remain stored for 100 years is included in the final quantification of annual net GHG removals/emissions. This approach accounts for CO2 emissions from decomposition or disposal of wood products (see SSR #IFM-17).
IFM-8	Forest product carbon in landfills	Reservoir / Pool	CO2	Baseline: Estimated from modeled harvesting volumes Project: Estimated from measured harvesting volumes	Because of significant uncertainties associated with forecasting the quantity of forest product carbon that will remain stored in landfills, landfill carbon is excluded from quantification in years when project harvesting volumes exceed baseline volumes. Landfill carbon is included, however, in years when project harvesting volumes are below baseline levels. This case-dependent exclusion or inclusion is necessary to ensure that total GHG reductions and removals caused by the Forest Project are not overestimated.

Secondary Effect Sources, Sinks, and Reservoirs					
IFM-9	Biological emissions from site preparation activities	Source	CO2	Baseline: N/A Project: Quantified based on measured carbon stock changes in included reservoirs (SSR #IFM-6, where applicable)	Biological emissions from site preparation are not quantified separately, but rather are captured by measuring changes in included carbon reservoirs (soil carbon, where applicable). For other carbon reservoirs, changes are unlikely to have a significant effect on total quantified GHG reductions/removals.
IFM-14	Biological emissions/removals from changes in harvesting on forestland outside the Project Area	Source / Sink	CO2	Baseline: N/A Project: Estimated using a default 20% “leakage” factor applied to the difference in harvest volume relative to baseline	Improved Forest Management Projects may either increase or decrease harvesting relative to baseline levels. If harvesting is reduced in the Project Area, harvesting on other lands may increase to compensate for the lost production. This “leakage” effect is included in the GHG Assessment Boundary. If harvesting is increased in the Project Area, harvesting on other lands may decrease in response to the increased production. The reduction in harvesting may lead to increased carbon stocks on other lands. Carbon stock increases on other lands are excluded from the GHG Assessment Boundary, however, because it is not possible to ensure their permanence.
IFM-17	Biological emissions from decomposition of forest products	Source	CO2	Baseline: Quantified as a component of calculating carbon stored for 100 years in wood products (SSR #IFM-7) and landfills (SSR #IFM-8) Project: Quantified as a component of calculating carbon stored for 100 years in wood products (SSR #IFM-7) and landfills (SSR #IFM-8)	CO2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years.

Inventory Overview

This section describes the inventory data collection specifications and is one part of the comprehensive forest carbon inventory methodology used for the project. Additional footnotes have been inserted to provide clarifications and supplementary information as needed for this OPDR appendix.

The OPO, Lyme Wisconsin Timberlands LLC, in collaboration with Finite Carbon commissioned the following forest inventory for this project totaling approximately 26,794 forested acres in northeastern Wisconsin. The project boundary is defined by the shape files provided with this specification document.

The purpose of this forest inventory was to quantify the forest carbon stocks of the standing living and dead tree carbon pools in the project area for enrollment as an improved forest management carbon offset project. The procedures described herein shall also be the guiding basis for the collection of future inventory data annually and/or periodically throughout the project life. This inventory was conducted in a manner that is verifiable, facilitates modeling, and is replicable. All inventory data collected was audited for accuracy both by the primary contractor, Finite Carbon, and a third-party auditor.

Sampling Methodology

The project inventory design is based on the requirements for volume and biomass calculation as listed in the volume and biomass equations approved for use by the California ARB U.S. Forests Compliance Offset Protocol. Finite Carbon developed the following sampling design to be implemented by the inventory to reduce overall sampling error and optimize the carbon results for the forest owner. In all cases the inventory protocol was implemented as written.

Inventory Design

In order to ensure sufficient plots to achieve our statistical confidence targets and ensure randomly distributed set of inventory plots, Finite Carbon overlaid a square grid of points separated by approximately 1,980 feet north to south and east to west with a random starting point. This grid resulted in a total of 281 plots to be measured within the project area.

Sampling method of this inventory consisted of a nested sample approach including a 20th acre (1/20 acre) fixed radius plot (26.3 feet) for all stems 5.0 inches DBH and larger, with a 150th acre (1/150 acre) fixed radius plot (9.6 feet) at the same location for stems 1.0 to 4.9 inches in diameter. All eligible standing living and standing dead trees were tallied. Eligibility was defined for living trees as either standing or downed provided they still have foliage/buds/or living cambium. Dead trees were eligible provided they were attached to the stump and not supported by other downed dead material that was on the ground. All borderline trees were measured to the geometric center of the base of the tree using approved devices, including slope adjustments for all slopes in accordance with the USFS procedures laid out in the forest management field book 2014 edition. Slope percentage was measured by either measuring the angle between points of equivalent height at plot center and the tree center or applying a clinometer to the tape as it extended between the base of the tree and the point at equivalent height above the plot center pin.

- **Sampling Intensity** was determined to be 281 total nested samples across the project area allocated to each forest inventory strata and systematically located in a grid across the Project Area. The total number of plots included in the final inventory data was determined by the intersection of grid locations with stands listed as forested. Any plot that fell in a non-forested area was not considered within the sampling frame and was not tallied. All sample locations were pre-determined using field maps and were assigned GPS coordinates.
- **Statistical Standards** of Inventory were a minimum of +/- 5% of total carbon (tCO₂e) expressed at the 90% confidence interval for forest stratum on the project.
- **Edge Plots** were collected using the “walk-through” procedure. Obvious potentials locations for walk-through plots were labeled on the plot map for cruisers in advance of field activities.

In order to be eligible for this procedure, the hard edge must have fallen within two plot radii of the edge. If a plot fell wholly within the sample frame but within two plot radii of a hard edge, the walk-through method was used and denoted as such in the notes. Cruisers were directed to implement the walk-through technique on hard edges such as mapped non forest areas, strata boundaries where the timber type change is abrupt (i.e. pine plantation to hardwood, etc.), marked property boundary lines, etc. In some cases, cruisers were given a bearing and distance to the edge in advance of field activities. If the actual bearing and distance to the edge differed in the field, it should have been noted in the tally with the new metrics.

On every plot, when a hard edge is encountered, this method was followed for any “in” tree along the edge:

- The distance was measured from the sample point (plot center) to the geometric center of the point of origin of the tree. Then, this distance was duplicated in a straight line through the other side of the tree. If the doubled distance intersected the hard edge, then the tree was recorded twice.
- The trees were recorded with two identical sets of measurements but two separate tree numbers.
- If the measured distance to a tree crossed a narrow hard edge or double edge (such as a truck road, swamp, or wide non forest stream), the full doubled distance was measured from plot center and the following rules were applied:
 - If the location of the end point was **in the narrow non forest area** (in the road) **the tree was counted twice.**
 - If the location of the end point crossed the feature and ended up back in the sample frame within the same stratum as the plot center, **the tree was not counted twice.**
 - If the location of the end point crossed the feature and ended up back in the sample frame within a different stratum as the plot center, **the tree was counted twice.**

Guidance: Every hard edge was considered an absolute boundary of the sample frame, just as if the edge were a property boundary line. Trees within the plot radius that fell across the hard edge but within the sampling frame were NOT eligible and thus, not tallied. Also, the plot radius itself did not have to be intersected by the hard edge. The key measurements of the walk-through procedure included: defining where the hard edge was located, measuring the distance from plot center to the tree of interest, and measuring the distance beyond the tree in a straight line to determine whether the walk-through distance crosses the hard edge.

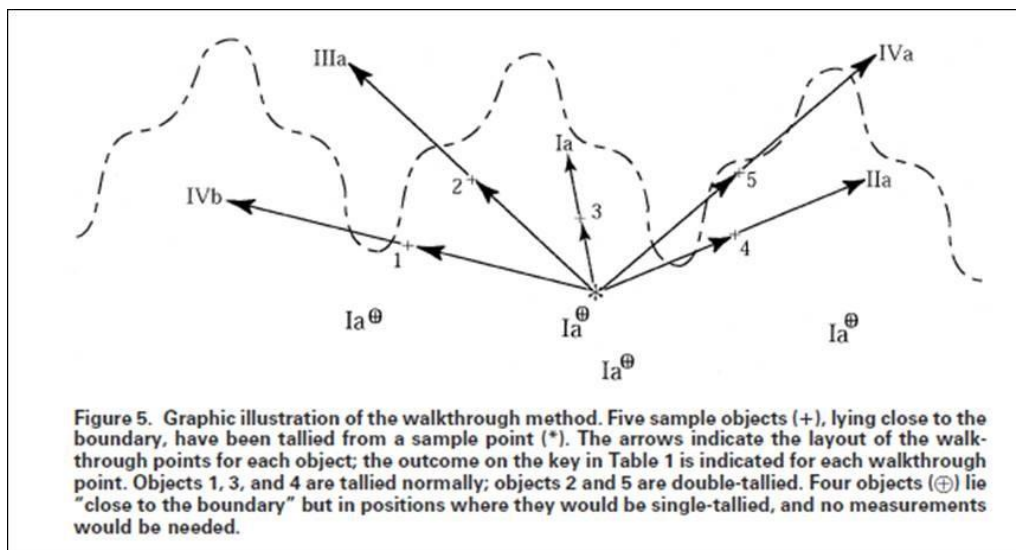


Table 1. A decision key for field implementation of the walk-through method. The key is entered whenever a tallied object appears close to the boundary.	
I.	Is it possible that the tallied object is closer to the boundary, than to the sample point?
Ia.	NO—No action needed. Tally the object normally.
Ib.	YES—Proceed to II.
II.	Measure the distance from the sample point to the object—call this distance x . Now measure the distance from the object to the boundary, continuing on the same bearing. Call this distance y . Is y less than x ?
IIa.	NO—No action needed. Tally the object normally.
IIb.	YES—Proceed to III.
III.	Does the boundary curve back across the walkthrough line?
IIIa.	NO—Walkthrough point must be outside the tract. Double-tally the object.
IIIb.	YES—Proceed to IV.
IV.	Move to the walkthrough point, so that the distance to the object equals the previously measured distance x along the same bearing, or to a point where that location can be clearly identified. Is the walkthrough point inside the tract?
IVa.	NO—Double-tally the object.
IVb.	YES—Tally the object normally.

Figure 2: Walk Through Examples (Ducey *et al.*, 2004)

Monumentation of walk-through plots included a flagged and or painted line (at least three marked points) where the edge was declared.

When declaring an edge location, cruisers looked for obvious physical features like the top of the ditch line on a road, edge of a river bank or lake shore, or in cases where the edge was forest to forest, the drip line or edge of the canopy for the polygon the plot center fell in. It was impossible to escape the subjective determination of edges on the part of the cruiser as edges take many configurations. In some instances, the edge location may be an estimate based on these principles. Any trees double tallied using the attached procedures received two tree numbers painted above DBH. The tree data was entered twice in the final inventory data in accordance with the assigned tree numbers.

Guidance: Cruisers also may have run into plot locations where non forest area or strata edges were not expected since they were not previously designated through GIS analysis. If a cruiser questions whether to install a walk-through plot at any location they cruised, monumented, and tallied the plot normally, flagged the potential edge, and designated any potential double count trees in the notes section of the tally only. All plots executed in this manner were brought to the attention of Finite Carbon at the completion of the inventory. On any plot where a walk-through procedure was used, the cruiser was asked to provide a bearing and distance to the shortest point to the declared edge as a note for the plot.

Some edge plots may be located next to marked property lines. In this instance, trees bisected by the line as evidenced by fence, blazes, or signage were considered out of the sample frame. Trees bisected by the line were considered the property of both landowners and not in the direct control of the project owner, therefore they were not cruised.

Field Procedures

Tools/materials used in the field included: a WAAS enabled GPS unit, laser hypsometer, and/or relaskop, diameter tape, calipers, increment borer, calculator, hammer, paint, surveyors' ribbon, grease pencils or permanent markers, "fat max" 20-foot tape, and metal tree tags. Tools selected for height and diameter measurements were

determined prior to field data collection and were consistent for all trees and plots unless a device failure was experienced. All tree heights were measured with a laser hypsometer and/or relaskop and diameters were measured with steel logger's tape.

All tally files were labeled with the following information; cruise line and/or plot ID, date, stand and/or strata ID, cruiser name or initials. Each plot had a stand identifier reflecting the stand or strata where the sample was taken (included in all tally files submitted).

Cruisers navigated to all sample plots using a 3 to 5-meter accuracy GPS unit (WAAS enabled). Cruisers not able to use their GPS due to reception or other reasons could locate and collect data using compass and pacing. For these plots, the declination, bearing, and distance from a key starting point (i.e. road intersection, other data samples located with GPS, etc.) was noted in the notes section of the tally file. Appropriate declination for the subject tract was pre-determined by the contractor and provided to all parties collecting data, including Finite Carbon foresters at the beginning of the project. When using GPS for plot location, the cruiser was instructed to establish the plot at the first indication from the GPS receiver that they reached the target location at a minimum range of 30 feet. This requirement was meant to ensure no bias in sample location.

Monumentation of sample locations was critical to project success.

- **Plot center** was monumented with a 2 to 3-foot-long highly visible survey ribbon hung at or above eye level as close to point center as possible and a painted metal stake placed at plot center leaving 4 to 6 inches of the stake visible above ground level. Highly visible ribbon was tied around the head of the metal stake prior to being driven into the ground to help locate plot center. The survey ribbon was labeled with the following information: Plot #, Cruiser's initials, and Date. Cruisers did their best to place the steel pin in the ground at each sample. If the site precluded the placement of the pin, a heavily painted X was painted on the sample center (a small pile of rocks could be useful for this purpose as well) with the pin placed in an area nearby. Cruisers recorded the offset of the pin in feet along with the bearing and distance to the sample center along with witness tree data as specified below (witness tree data should always be referenced to the plot center location, not the offset pin).
- **Witness trees.** At each sample two witness trees were selected. The witness trees were living and large diameter trees easily seen from plot center. All witness trees had a prominent W and the plot number painted on the tree at eye level facing plot center or with a metal tree tag at eye level and stump level with the plot number etched on it. Witness trees had a highly visible painted ring around the stem at eye level and a painted plot number. The species and size of the witness trees was recorded in the notes section of the tally, along with the azimuth (from plot center to middle face of tree) and distance (in feet and tenths of feet) to plot center from the middle of the witness tree face. Ideal witness tree selection considered the angle created from each witness tree to the plot center. Ideally an angle near 90 degrees was created facilitating accurate plot center replacement if the center pin be disturbed in the future.
- **Measured trees** had a horizontal paint mark at the DBH measurement location and trees in the larger overstory plot had a painted tree number facing plot center.
- **Walk through plots** were marked as described earlier.

Borderline trees. The most sensitive part of the plot measurements are borderline trees. Cruisers were very diligent in their measurement and assessment of these trees to avoid failed plots. Any tree that was not definitively determined to be in or out was measured for horizontal Limiting Distance (see the end of this appendix for limiting distance calculations and tables). DBH was measured to the nearest 0.1" for the calculation and distance was measured with a steel tape. If a borderline tree was found to be out, the tree received an "X" marked through the DBH line. The critical measurement point on borderline trees is the point of origin or stump of the tree. It is possible that a leaning tree could have a point of origin inside the plot while outside the plot at DBH. Best

practices would include a paint mark at the geometric center of the tree where the measurement was taken, use the DBH staff and DBH mark on the tree to measure slope, and trim out the line of sight for accurate results.

Tally Measurements

Species were recorded for all eligible living and dead stems in accordance with the USDA FS FIA numerical three-digit species codes. Trees smaller than 1" DBH, whether alive or dead were not eligible for this inventory. All species were measured, commercial and non-commercial species. If the tree had no bark or other identifiable features, the cruiser made a best guess as to the species based on surrounding trees and site evidence. No miscellaneous species or species group codes were used. Cruisers made their best assessment of species possible, even for dead stems. If a tree species did not have the natural ability to grow to a minimum of 5" DBH and 15' in height, it was not tallied.

Tree Status was recorded for every tallied tree. All standing live trees greater or equal to 1" DBH had their tree status recorded as "live". Standing dead trees greater than or equal to 1.0" DBH were tallied if they were a minimum 15 feet in total height. Standing dead trees that were leaning at more than a 45-degree angle from vertical were not tallied. All tallied standing dead trees were evaluated and categorized in one of the following decay classes status categories listed below in the tree status field:

Standing Dead Tree Decay Class

1. All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact, with minimal decay; heartwood is sound and hard.
2. There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.
3. Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base.
4. Few or no limb stubs remain; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay at the base and is sloughing in the upper bole.
5. No evidence of branches remains; the top is broken; <20 percent of the bark remains; sapwood is gone; heartwood is sloughing throughout.

Note: Cruisers should start with Class 5 with every standing dead tree. If the tree does not meet all qualities of that class, they should move upward in the scale until the most accurate designation is reached.

Diameter at breast height (4.5') on the high side of the stump, measured with a diameter tape to the 0.1 inch. Cruisers were encouraged to use guide sticks 4.5 feet long or a measuring tape to ensure that DBH was measured at the correct height consistently. DBH locations were measured to the 4.5-foot height or alternative as noted below and in the USDA FIA Field Guide provided at the end of this document.

All trees were measured to the nearest 0.1-inch diameter class using standard rounding rules (≤ 0.04 rounds down, ≥ 0.05 rounds up). The only exceptions to this rule were trees less than 1.00 inches (Table 2).

Table 2. DBH Rounding Examples

Cruiser DBH Measurement	Recorded Diameter Class	Plot Eligibility
0.97 inches	None, as it is less than 1.00 inches.	Not eligible
1.05 inches	1.0 inches	1/150 th fixed radius plot
4.94 inches	4.9 inches	1/150 th fixed radius plot
4.95 inches	5.0 inches	1/25 th fixed radius plot

Alternative DBH locations:

All trees were measured with a steel diameter tape at DBH (4.5 feet above the ground on the high side of the stump), unless as noted below:

- There were swells, branches or other abnormalities at the required location. In this case, the tree was measured just above the abnormality.
- The tree forked below 4.5 feet. In this case each fork was measured 3.5 feet above the estimated junction of the piths. In this case each fork was recorded as a separate tree. Trees that are joined within a foot of the ground level could be measured at 4.5 feet.
- The tree had a distinct butt swell. In this case, the tree was measured 1.5 feet above the swell. Measurement tools included a relaskop, laser calipers, or equivalent.
- For leaning trees, cruisers measured the DBH location (4.5 feet) from the underside of the lean or the face of the tree closest to the ground. A tree was designated as leaning when the angle of the tree to the ground in the direction of the lean was less than 90 degrees. The lean should be obvious, with a safe guideline that a tree with 5% or more of lean should be considered. Stilted trees were measured at 4.5 feet above the root collar on the high side of the tree.
- For oddly shaped trees cruisers referenced the USFS FIA diameter location document and tree diagrams included with this specification. Interference at DBH by other plants or features was considered by the cruiser. Moss, vines or abnormal large bark ridges was removed or otherwise accounted for in the measurement of diameter. For stilt rooted trees, a bottom measurement location from which the 4.5 feet is measured was marked with paint. This bottom location was above where the roots converge as per the attached tree diagrams.

Best Practices: Cruisers are always to refer to the USFS booklet on DBH location for guidance. It was recommended to remove or compress the moss at the base of the tree, make a paint mark on bottom measurement location on pistol butt, forked, or stilted trees, watch for butt swell carefully, and use the relaskop to measure DBH on trees where the diameter location cannot be reached with the tape (averaging two measurements at 90 degrees).

Height of each stem was measured with a laser hypsometer, relaskop, or clinometer in one-foot increments for all height measurements. Small trees could be directly measured with a tape.

Note: for leaning trees, the total tree length was the measurement objective, not height from the ground. Leaning tree height could be calculated using the $A^2 + B^2 = C^2$ formula. When this method was used, it was noted in the comments section of the tally. Cruisers were cautioned to be sure they get back a sufficient distance (one tree height or more) from the stem to get an accurate height measurement.

Cruisers recorded total height in one-foot increments for all standing live trees $\geq 1"$ DBH and for all standing dead trees $\geq 1"$ DBH and $\geq 15'$ in total height.

- Total height was recorded to the most vertical tip of the living stem or crown. Note, on some trees with large broad crowns, this entailed shooting through the crown to measure the top at the middle of the crown. Total heights were recorded for every tallied tree regardless of species or size.
- If the top of the tree was dead or missing, total height was measured at the point it was broken or died unless a new leader had developed, in which case the height of the new leader was measured. Cruisers did not deduct dead tree top volume, instead they measured the total height of the living crown. The highest top of any lateral branch that had assumed the highest portion of the living crown would be the correct height for a "top of the living crown" measurement. This was common on trees with dead tops.

- For dead trees that are close to 15 feet total height, use of a guide stick or measuring tape was encouraged to ensure the snag is in fact at least 15 feet total height.

Best Practices: Tie a flag at the location you take large tree heights so that it can be replicated. Always strive to be up hill or on the same elevation as the tree to be measured and about 1 tree length away at 90 degrees to the lean of the tree. Also, due to the difficulty seeing the base of the tree in this forest, shoot to the DBH mark and add 4.5 feet to your measurement.

Soundness was evaluated in the field for both standing live and standing dead trees. For most regions outside of California, Washington, Oregon, and Alaska, deductions were based on the percentage of missing or rotten volume estimated or directly measured in the field during the inventory. However, for projects such as this one located in the Midwest (IA, IL, IN, KS, MI, MO, MN, ND, NE, SD AND WI), deductions are based on assigning a tree class code ("treeclcd") to each inventory tree based on definitions from the FIA database user's guide as follows in Table 3 below:

Table 3: Tree Class Codes (USFS FIA database description, p. 3-16)

Code	Description
2	Growing-stock - All live trees of commercial species that meet minimum merchantability standards. In general, these trees have at least one solid 8-foot section, are reasonably free of form defect on the merchantable bole, and at least 34 percent or more of the volume is merchantable.
3	Rough cull - All live trees that do not now, or prospectively, have at least one solid 8-foot section, reasonably free of form defect on the merchantable bole, or have 67 percent or more of the merchantable volume cull; and more than half of this cull is due to sound dead wood cubic-foot loss or severe form defect volume loss. This class also contains all trees of noncommercial species, or those species where SPGRPCD equals 23 (woodland softwoods), 43 (eastern noncommercial hardwoods), or 48 (woodland hardwoods). Refer to appendix F to find the species that have these SPGRPCD codes. For dead trees, this code indicates that the tree is salvable (sound).
4	Rotten cull - All live trees with 67 percent or more of the merchantable volume cull, and more than half of this cull is due to rotten or missing cubic-foot volume loss. For dead trees, this code indicates that the tree is nonsalvable (not sound).

General observations were made during the timber cruise that may impact project development. As field data collection took place, cruisers were asked to note any clear and obvious examples of significant disturbance (>20 acres), incorrect non-forest designation and errors in forest strata or vegetation typing. Examples of natural disturbance include (but are not limited to) ice damage, wind throw, insect infestation, disease, and timber theft.

Inventory Audit (QA/QC)

Finite Carbon jointly and independently audited the project cooperatively to ensure that the data quality met the standards of the CA ARB program and Finite Carbon expectations. (Note, if a contractor enlisted the services of additional sub-contractors, the quality of data collection should not be left to this audit procedure alone. It was the contractor's responsibility to ensure the quality of work done by sub-contractors they employ).

The joint audit consisted of a minimum of 7% of the samples collected. Initially, audits addressed all cruisers equally. If, however, individual cruisers were found to be consistently out of compliance, the auditor or audit team may have focused on individuals in order to verify compliance with the specifications. Additional audits may have been conducted by Finite Carbon or their assigns at any time and at any intensity.

Audit report summaries were generated for Finite Carbon by the contracted auditor periodically throughout the inventory project and were submitted with per cruiser audit totals and results. A final audit results summary was provided to Finite Carbon at the completion of the project which included audit dates, number of audited samples

per cruiser including sample location identifiers, total audited samples vs. total samples as a percent, corrective actions per cruiser, any plots re-done due to noncompliance, and overall auditor's comments.

Audit results were based on a per cruiser assessment of plot tally on a percent error basis. Error was expressed as the number of errors (as noted below) divided by the number of trees sampled on a minimum of 6 randomly selected sample plots. The maximum acceptable error threshold for accuracy is 1 error in 10 trees or 10%.

Table 4. Check Cruise Error Calculations

Incorrect Species	1 error
Incorrect Diameter (tolerance +/- 0.2")	1 error
Incorrect Height (tolerance of +/-8 feet on trees 139 feet and lower, +/- 10 feet on trees 140 feet and higher) on THT only	1 error
Incorrect tree status designation	1 error
"In" tree marked "Out" (tolerance 0.2 foot)	2 errors
"Out" tree marked "In" (tolerance 0.2 foot)	2 errors
Plot location (greater than 1.5 chains from map location/coordinates)	1 error
Incomplete tally file label	0.5 error
Incorrect or poor monumentation	1 error

When an audit of a cruiser was completed, the total number of errors was divided by the total number of trees included in the audit plots and expressed as a percent. Error ratings at or below 10 percent required no further action. Error ratings above 10% could have resulted in further investigation and corrective actions. If the error rate was close to 10% and no trend in errors was evident (i.e. consistent height problems) the auditor may have chosen to select another 2 to 4 samples for the non-compliant cruiser to fully assess the errors before determining corrective action.

Corrective actions: Re-training non-compliant cruisers and correcting erroneous samples were the minimum corrective actions implemented. Based on the results of audits, if a cruiser repeatedly cannot or did not meet the quality standards (fails two consecutive audits) for allowable error, all plots for that cruiser were re-done at the expense of the contractor by a cruiser that can consistently meet quality thresholds.

Inventory Deliverables:

- Electronic data files for both the raw field tally and screened tally with an edit log summarizing changes to the data set in the screening process. These files were submitted in Excel, or Access formats providing the full tally and notes. All electronic files were screened for obvious errors such as missing data, and data outside of normal parameters for forests of the region. If paper tally was done, scanned copies of the tally cards were submitted.
- Any joint audit field files, notes, and summary report.
- Summary report of all cruiser comments, including field maps with noted plot relocations and natural disturbances noted.
- A description of the methods used to screen completed data files and otherwise ensure data quality and integrity.

Review and Approval:

Once received, Finite Carbon representatives screened and edited the data files for approval to the written requirements. Following the screening process, the work was deemed acceptable. Contractors were provided with feedback on any omissions, missing data or deficiencies in the product and were granted the opportunity to

correct any issues in a timely fashion. Pending final approval of the data, all outstanding fees were paid to the contractor as per the terms of the Services Agreement.

Stratification

The project area was stratified for inventory and assessment area purposes. The goal of the project area stratification was to provide an unbiased stratification of the project area's vegetative communities and to remove non-forested areas. Finite Carbon used a combination of forest owner data, on-the-ground observations, historical forest typing data, imagery, and experience with regional forest cover types.

Prior to sampling the project area, Finite Carbon assessed the overall quality and integrity of the mapped boundaries and underlying spatial data. Ancillary spatial data was taken from a variety of sources including publicly available data, landowner shapefiles, and files created from site visit field work. In all cases, GIS shapefiles are projected to the proper coordinate system, checked against publicly available shapefiles for ownership and boundary issues, ground-truthed using GPS and other field equipment, and then stored in geodatabases to ensure compatibility with outside data and data integrity. Tools used include ESRI ArcMap and Geodatabase, GPS devices, acquired orthorectified aerial photography.

The forested area consists of two classes, commercial timberland and non-commercial forestland. The non-commercial forestland class represents marginally productive forested areas containing levels of stocking unable to support commercial timber management. Areas that were identified as non-commercial forestlands were excluded from project area eligibility leaving only commercial timberland in the project area. The process was completed using publicly available and privately acquired orthorectified aerial imagery at "eye elevation" or approximately 3,500'.

Stratification Process

For the Lyme Wisconsin project, an initial project area shapefile was provided by the OPO that identified ownership boundaries and stands. This property is an investment grade property that has been subjected to numerous real estate transactions and the boundary layer has a high-level accuracy and confidence. Project boundaries were reviewed utilizing the provided data and ESRI ArcMap tools, as well as through on the ground reconnaissance during the inventory process.

Finite Carbon relied on local experience and expert opinion more than quantitative evidence such as remote sensing classification to determine assessment areas, strata, and forest type. There is a long history of subjective evaluation of forest types as noted in the Existing Vegetation Classification, Mapping and Inventory Technical Guide relied upon by the US Forest Service to define forest types and species groups.

Finite Carbon also prioritizes a divisive approach to the forest stratification of the project area. This type of hierarchical classification generally uses few classification criteria and was therefore suited for large areas such as this project. Compared to an agglomerative approach or "bottom up" where relationships and patterns are not known, relationships are set forth in the Appendix F assessment area data file. Table 5 below outlines the two approaches to hierarchical classification as outlined in the Existing Vegetation Classification & Mapping Technical guide published by the USDA Forest Service.

Table 5. Hierarchical Classification Approaches (source: Existing Vegetation Classification & Mapping Technical Guide, USDA Forest Service)

Divisive approach (top-down)	Agglomerative approach (bottom-up)
Subdivides a group of objects to create types.	Groups individual objects together to create types.
Focuses on differences.	Focuses on similarities.
Generally uses one or few classification criteria.	Often uses many classification criteria.
Usually requires little observation of objects.	Often requires detailed observation of the objects.
Usually based on a simple dataset.	Usually based on a complex dataset.
Best suited for large sets of objects.	Best suited for small sets of objects.
Works best over large areas; is less useful for small areas.	Works best in small areas; often breaks down for large areas.
Upper level units are usually more clearly defined than lower level units.	Lower level units are usually more clearly defined than upper level units.
Often used to express and clarify known relationships and patterns.	Usually used to detect unknown relationships and patterns, or to quantify known relationships.
Resulting classification tends to be conceptual and <i>a priori</i> .	Resulting classification tends to be empirical and <i>a posteriori</i> .

Finite carbon utilized the landowners' forest typing as the primary basis of stratification. Each stand had a forest type, size class, density, and secondary forest type listed. The forest typing was cross walked to the ARB-defined Assessment Area by relying on primary species listed.

Inventory stratification of the defined project area utilized stand outlines based on general forest types that were dominated by conifers, a mix of hardwoods and softwoods, sugar maple, and northern hardwoods (Conifer, Mixed, Northern Hardwoods, Sugar Maple). Physiognomic characteristics observed from aerial imagery at a typed plot's location was also used to delineate unique stratum polygons and define strata polygons in areas proximal to the observed plot conditions. Multiple years of imagery contribute additional physiognomic information when assigning delineated areas to a stratum.

Step 1: Delineation of Forested and Non-Forested Areas

A simplified physiognomic unit classification system was used to identify forested and non-forested areas that appeared to be ~5 acres or greater within the project area. Forest and non-forest classes were simplified units for the iterative top down classification approach. Physiognomy refers to the overall appearance of a kind of vegetation, i.e. forest, meadow. Non-forested areas are comprised of several classes typically separated by the USDA into individual subclasses. Examples of non-forested areas included roads, clearings or fields, structures, open and flowing water, and scrub lands with minimal tree cover.

Roads included in the non-forested areas were limited to service roads and timber haul roads while skid roads were not included in this delineation. Road areas were created through heads-up digitizing of visible road boundaries as seen in aerial imagery. The OPO revises and refines the roads polygons in their overall ownership shapefile as part of their timber harvest planning. In addition, they check each compartment for any inconsistencies or missing road polygons against the latest aerial imagery. This is a subjective process and results in polygons defined as "roads" which we have removed from the project area.

Step 2: Plot Classification- Strata and Assessment Areas

Stratification of the defined project area utilized the project inventory data to check the floristic composition of areas based on Appendix F floristic associations. There were two distinct forest typing exercises completed during

the project development, 1) assessment area evaluation to correlate the forest typing with the two major and one minor Assessment Areas found in the project area, and 2) forest typing linked more directly to the forest type categories established by Lyme Wisconsin Timberland to define different areas of management and summary inventory totals.

Each assessment area contains species that are unique to that assessment area as well as species that occur in multiple assessment areas. Finite Carbon utilized the OPO stand maps and forest type data from the individual plots to help define consistent inventory strata polygons defined by broad forest type. The results were four different strata labeled: Conifer, Mixed, Northern Hardwood, Sugar Maple. The imagery utilized in the stratification represents several different years and was sourced from publicly available data sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Evident changes in timber type, ground features, and topo lines were all used to manually interpret and define breaks in strata consistent with the image interpretation section (3-21) set forth in the Existing Vegetation Classification, Mapping and Inventory Technical Guide.

Inventory Stratification Results

Conifer Stratum

This stratum consists of a mix of all major conifer types found across the property. Species mixes here are dominated by balsam fir, white and black spruce, northern white cedar, and tamarack.

Mixed Stratum

This stratum is defined by a mix of conifers and hardwoods found in other strata, but with no single species or pair of species dominating total basal area to the same degree as in the conifer and northern hardwood/sugar maple strata. Most prevalent species include northern white cedar, eastern hemlock, red maple, sugar maple, and aspen.

Northern Hardwoods Stratum

This stratum is marked by the predominance of sugar maple, white ash, basswood, yellow birch, beech, and other hardwoods common for the region. This stratum is like the Sugar Maple stratum but is less dominated by sugar maple and generally contains less than 60% of total basal area in that species.

Sugar Maple Stratum

This stratum is dominated by typical hardwoods listed in the northern hardwoods stratum but has a higher estimated percentage of sugar maple per acre than the Northern Hardwoods stratum.

Table 6: Inventory Strata acreage

Strata	Acres
Conifer	4,080.4
Mixed	6,249.7
Northern Hardwoods	9,060.9
Sugar Maple	7,403.2
Total:	26,794.3

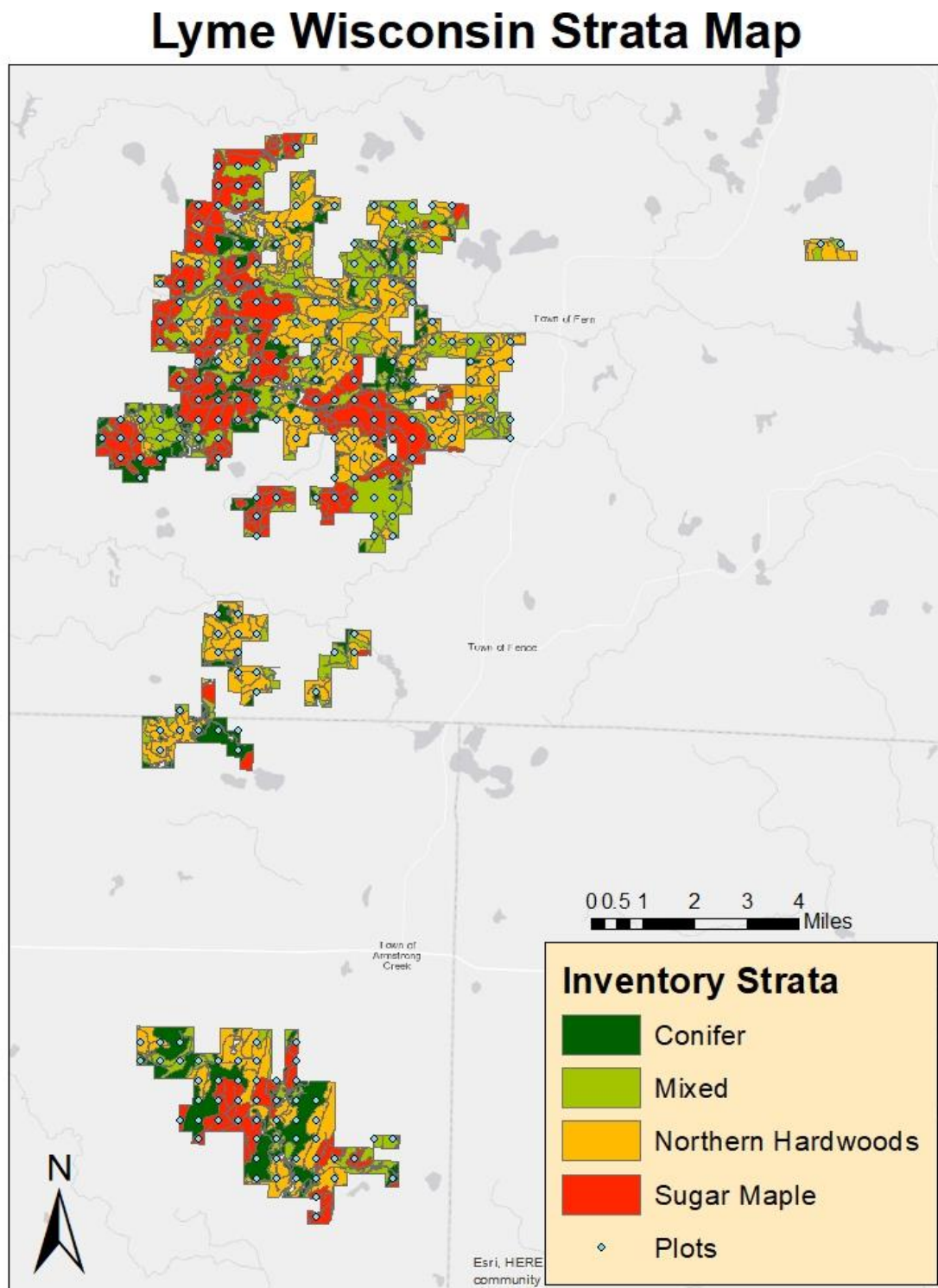


Figure 3. Cruise Plots and Inventory Stratification

Assessment Areas

The secondary evaluation and mapping of ARB assessment areas relied on the initial inventory strata definitions above with additional refinements that reflected inventory plot data and other observations from the field. Since the ARB defined assessment areas are not traditional recognized forest cover types, such as those published by the Society of American Foresters, their species composition and assumed location within the landscape are loosely correlated to SAF forest cover types by diagnostic species and their associated habitat.

ARB assessment areas, and the species that occurred within them, were compared to the Forest Cover Types of the United States located in that region of northeastern Wisconsin. They were assessed and assigned a general position within the landscape in which they have the potential to occur consistent with the associated species/cover types. These generalized locations were the basis of assessment area delineation for the project and are detailed in the typing considerations for strata section.

Table 7: Assessment Area acreage

Assessment Area	Acres
Laurentian Mixed Forest Northern Highlands Conifer Bog	3,875.9
Laurentian Mixed Forest Northern Highlands Mixed Northern Hardwoods	22,904.5
Laurentian Mixed Forest Northern Highlands Mixed Pine-Oak	13.9
	26,794.3

Data Management & Analytical Systems

This section describes the data management and analytical systems used to estimate the baseline and project carbon stocks of selected carbon pools within the Project Area.

Data Creation

Finite Carbon, in coordination with the inventory contractor, implemented a continuous forest inventory (CFI) from October 2019 – January 2020 on behalf of the Forest Owner. These plots will be re-measured over time per the specification outlined in the inventory specifications document. Once field measurements have been collected, the raw inventory data will be compiled by the inventory contractor. A database is then transferred to Finite Carbon in an MS Excel worksheet and/or MS Access database. The database contains multiple tables with the plot and individual tree measurements recorded by the cruisers.

Spatial data is provided to Finite Carbon from the Forest Owner's GIS department while the forest inventory data in tabular form is provided to Finite Carbon from the inventory contractor. The two most relevant spatial files are the forest area polygons and the inventory points; they are provided in either ESRI shapefiles or feature classes. All GIS files are then input into the project geodatabase which is the underlying foundation of the Project's Monitoring, Reporting and Verification System (MRVS) and will serve as the central carbon data spatial repository.

Converting Data Formats

After receiving the data, Finite Carbon reviews it and executes a quality control/assurance process for validation. Keys are also setup to standardize relations between spatial and tabular data. Once the raw data has been assured for quality, it is formatted into a MS Access database for input to FVS. The FVS input database tables are read by the FVS program using the Database Extension of FVS (Crookston 2003).

Forest Vegetation Simulator (FVS)

General Overview

Finite Carbon uses the Forest Vegetation Simulator (FVS) model to accept processed inventory data from the Preparatory Module and to output tree lists for the current inventory year so that carbon can be calculated in the Carbon Modules. The growth functions of FVS are applied, if necessary, to grow carbon stocks forward to the current reporting period end date.

The Forest Vegetation Simulator (FVS) is a family of forest growth simulation models supported and maintained by a special unit of the USDA Forest Service (www.fs.fed.us/fmfc/fvs/). Since its initial development in 1973, it has become a system of highly integrated analytical tools. These tools are based upon a body of scientific knowledge developed from decades of natural resources research. The FVS growth model is an approved ARB FOP growth model (FOP, Appendix B, Section B (a)).

The FVS is an individual-tree, distance-independent growth and yield model (Dixon 2002). It has been calibrated for specific geographic areas (variants) of the United States. FVS can simulate a wide range of silvicultural treatments for most major forest tree species, forest types, and stand conditions. The Lake States (LS) Variant has been used for this project (Keyser 2008).



Figure 4. FVS Variants

The following summarizes basic FVS operation and the major model execution steps. Specific operation details will vary for different variants.

1. Process keywords and input data - FVS begins by reading keywords to establish location, environment, and stand parameters; then reads the tree record file.

2. Compute initial stand characteristics - FVS computes stand characteristics for the initial year (cycle 0). This is typically the inventory date or the stand regeneration date. Input tree records with missing heights or crown ratios have these dubbed in.
3. Backdate densities and compute calibration statistics - If sufficient large tree diameter increment data is contained in the input tree data (and/or small tree height increment data), FVS back-dates the stand one default cycle length. FVS then “grows” the stand back to the inventory date, compares the values from the actual inventory date with simulated values, and computes scale factor adjustments to account for differences in actual and model values.
4. Check event monitor (pre-treatment) - FVS continues with the steps it repeats every cycle. FVS checks the Event Monitor keywords and functions to see if the user scheduled any activities based on existing stand conditions at the start of the cycle. Event Monitor capabilities are powerful and very useful for modeling situations and creating variables not covered in standard FVS output. Crookston (1990) describes Event Monitor functions and processes along with several good examples.
5. Perform treatment - Almost any silvicultural operation imaginable can be structured using one or more treatment keywords in a direct or conditional (If..Then) context.
6. Check event monitor (post-treatment) - FVS Event Monitor checks for conditions and scheduled operations that are based on post-treatment activity conditions within the same cycle.
7. Grow large trees - If “large” trees exist in the tree-list, FVS estimates their new diameter (first) and height (second) one growth cycle into the future. The user can specify a different time interval length.
8. Grow small trees - FVS estimates small tree height (first) and diameter (second) one growth cycle into the future. FVS uses a weighting procedure to compute tree height increment to obtain a smooth height-growth transition from small to large tree models.
9. Mortality - Following growth estimation, FVS estimates mortality based on individual tree variables such as diameter and crown ratio, and on stand variables such as maximum stand density index or basal area (“BA”).
10. Insect and disease impacts - If the variant has available extensions to cover specific disease or insect agents, and if the user calls for these, FVS estimates and incorporates these effects.
11. Regeneration - FVS adds new seedlings to FVS tree-lists in the regeneration step. Some FVS variants have natural regeneration routines, but most variants depend on the user to specify the species and number of trees to plant. Some variants have a stump sprouting algorithm, whereby certain species will sprout after a harvest.
12. Crown change - FVS estimates crown ratio change for all trees based on stand density and the trees position in the density distribution.
13. Update stand characteristics and compute volume - After projecting the stand for the growth cycle, FVS computes, summarizes, and records the stand attributes, including volume. Volume is computed using corporate equations from the National Volume Estimation Library.

14. Test for more cycles to be projected - FVS repeats the sequence from the initial "Check Event Monitor", per Figure 2, to this point for each cycle until the specified number of cycles is completed.
15. Final FVS Output file reports and post-processor files - After FVS completes the scheduled cycles, it prints final output file reports and generates files specified by the user for running post-processors, including SVS.

Functions

The FVS growth model is used in this project to estimate growth and mortality based on field measurements and management activities over time.

Data and FVS Settings

FVS Input Data

The FVS input database is comprised of three tables: FVS_GroupAddFilesAndKeywords; FVS_StandInit; and FVS_Treelnit.

Table 8. FVS Input Data

Table Name	Field Name	Description	
FVS_GroupAddFilesAndKeywords	Groups	Used to assign keywords to all strata or a specific stratum	
	AddFiles	Not used	
	FVSKeywords	A list of FVS Keywords which define the FVS run (described further below)	
FVS_StandInit	Stand_CN	Stand Control Number: Used for the FVS yield curve ID number	
	Stand_ID	Stratum	
	Variant	“LS” Lake States Variant	
	Inv_Year	“2019” - The inventory year of the plots associated with the Stand_CN.	
	Location	“913” – Chequamegon-Nicolet National Forest. Indicates the closest National Forest Region and Forest Number to the project area.	
	PV_Code	This is the native plant community (NPV) code. In the LS variant, it is used in the fuel model selection logic in the Fire and Fuels extension. The codes below were used for each inventory stratum in the project. Codes were based on qualitatively matching inventory strata, based on vegetation and location, to native plant community types based on the classification schemes for NPV codes referenced in the FVS Lake States Variant guide (Keyser 2008; Minnesota Department of Natural Resources 2003; Minnesota Department of Natural Resources 2005).	
		<u>Inventory Stratum</u>	<u>PV Code</u>
		Conifer	WFn53
Mixed		MHn45	
Northern Hardwood		MHn45	
Sugar Maple	MHn45		

	Basal_Area_Factor	“-20” - The inverse of the fixed plot size in acres (1/20 acre) using negative value to indicate fixed radius rather than Basal Area Factor.
	Inv_Plot_Size	“150” - The inverse of the fixed plot size in acres (1/150 acre fixed radius plot) – used for subplots, in this case to measure trees less than 5.0” DBH.
	Brk_DBH	“5.0” – indicates that all tree records ≥ 5.0 ” DBH are processed using the Basal Area Factor (1/15-acre plot in this design), all trees less than 5.0” DBH are processed using the subplot.
	Num_Plots	Total number of plots associated with Stand_CN.
	NonStk_Plots	Number of non-stockable plots associated with Stand_CN (not used because total number of plots used).
	Site_Species	Not used. See section “Site Index, Site Class, and Growth Determination” below for further details.
	Site_Index	Not used. See section “Site Index, Site Class, and Growth Determination” below for further details.
FVS_Treelnit	Stand_CN	Stand Control Number: Used for the FVS yield curve ID number
	Stand_ID	Stratum
	Tree_ID	Tree identification code for plot
	Plot_ID	Plot identification code
	Tree_Count	The number of trees on plot with the exact same measurements (always 1, no repetition counts used).
	History	Tree history code, e.g. alive, recent mortality, “older” mortality
	Species	Tree species
	DBH	Diameter at breast height
	Ht	Total height in feet
	HtTopK	Height to top kill in feet
	Damage1	“25” - Percent defect of tree’s merchantable cubic foot volume
	Severity1	“1-99” (99 = 100%) – percent defect
	Damage 2	“55” – Custom code
	Severity 2	Product code (if dead tree then dead tree decay class)
	TreeValue	Tree value class, in this case it is used to distinguish live cull trees (using a code value of “3”). “8” is used to indicate a no-tally plot. All other values indicate a live tree or dead tree, e.g. “1”.

FVS Settings

The FVS model has many program options to control the inputs and variables which affect growth and yield. These options are typically set using “FVS Keywords.” They are programmed in the FVS input tables or selected in Suppose¹. The following keywords are used for this project:

NOTRIPLE (No tripling) – Random effects are incorporated in the Forest Vegetation Simulator in the manner originally described by Stage (1973), and subsequently updated to reflect changes in program control variables. The program assigns all random effects to the distribution of errors associated with the prediction of the logarithm of basal area increment. Basal area increment was selected to reflect the stochastic variation because the effects of differing diameter growth rates extend in highly nonlinear ways through most of the remaining components of the model. This distribution of errors is assumed to be Normal, with a mean of zero. The variance of this Normal distribution is computed as a weighted average of two estimates; the first estimate is derived from the regression analysis that developed the prediction function, and the second estimate is the standard deviation of the differences between the recorded growth for the sample trees in the population (transformed to the logarithm of basal area increment) and their corresponding regression estimates. The weights assigned to these two estimates are (1) the number of observations by species and/or habitat type in the database for the model for the prior component of error, and (2) the number of growth-sample trees in the stand for the second component of error (Mehta 1972).

The random component of change in tree diameter is treated in two ways, depending on how many tree records make up the stand being projected. When there are many tree records, the effects of any one random deviation on the growth rate of one tree would be blended with many other trees, and the stand totals should be quite stable estimates. Accordingly, a random deviate from the specified distribution is added to the logarithm of basal area increment.

When relatively few sample trees represent the stand, however, a different strategy is used. In order to increase the number of replications of the random effects, two additional records augment each tree record. These new records duplicate all characteristics of the tree except the predicted change in diameter and the number of trees per acre represented by the source tree record. The trees per acre value of the original tree record are reduced to 60 percent of its current value. The two new records are given 15 and 25 percent of the original value; thus, the three records together still represent the same number of trees per acre. This process is known as tripling.

Because each stratum in the project area contains an adequate number of tree observations, tripling is not used in this modeling; it is turned off with the NOTRIPLE keyword.

SPGROUP - Defines a group of species that can be referenced by a single name, or FVS sequence number, and will be treated as a group in management actions or event monitor functions. Users may define up to 10 species groups with each group containing up to 50 species codes. If the species group name is entered in the species field of a keyword, the keyword action will apply to all species in the group. One or more supplemental records are required that contain the FVS species codes or FVS species sequence numbers.

The SPGROUP keyword was used to define 1 species group: CONIFER, which included all coniferous species in the inventory. By default, all other species were hardwood species. The CONIFER species group was used in the calculation of naturally seeding conifers following certain harvest events.

MINHARV (Minimum Harvest) - Specifies minimum acceptable harvest standards for board-foot volume, merchantable cubic-foot volume, basal area per acre, or total cubic foot volume. The accumulated removals across all thinnings in a cycle must exceed the standards for all the units of measure (fields 2, 3, 4, and 5), or none of the thinnings in that cycle will be implemented.

¹ Suppose v2.02 is the FVS graphic user interface (GUI).

This keyword was used in thinning treatments to ensure that a silvicultural treatment (harvest) satisfies a minimum harvest level for financial and operational feasibility. The minimum harvest volume was set to 600 merchantable cubic feet per acre, corresponding to roughly 8 cords per acre, based on consultation with the current property manager.

THINABA (Thin from Above to Basal Area target)- Schedules a thinning from above to a basal-area-per-acre target. Only trees with DBH's and heights within the user-defined ranges are considered for removal. The tree record with the largest diameter within the specified range is considered for removal first, and the proportion of that tree record specified in field 3 is removed. The tree record with the next largest diameter is considered next, then the next largest and so on until the residual basal area target is met or all records in the specified range have been considered. The residual target basal area is specified only for the user-defined range of DBH and height and does not represent the total residual unless the range of DBH's and heights includes all trees in the stand.

This keyword was used in baseline commercial thinning simulations representing the removal of higher value sawlog and veneer trees to a target residual BA of 60 sq. ft. per acre as follows:

```
THINABA  0.  PARMS(70,1.0,0.0,999,0.0,999)
```

THINBBA(Thin from Below to Basal Area target): Schedules a thinning from below to a basal-area-per-acre target. Only trees with DBH's and heights within the user-defined ranges are considered for removal. The tree record with the smallest diameter within the specified range is considered for removal first, and the proportion of that tree record specified in field 3 is removed. The tree record with the next smallest diameter is considered next, then the next smallest and so on until the residual basal area target is met or all records in the specified range have been considered. The residual target basal area is specified only for the user-defined range of DBH and height, and does not represent the total residual unless the range of DBH's and heights includes all trees in the stand.

This keyword was used in baseline shelterwood harvest simulations to represent a shelterwood cut to 50 square feet of BA as follows:

```
THINBBA  0.  PARMS(50.0,1.0,0.0,999,0.0,999)
```

THINBTA(Thin from Below to Trees per Acre target): Schedules a thinning from below to a trees-per-acre target. Only trees with DBH's and heights within the user-defined ranges are considered for removal. The tree record with the smallest diameter within the specified range is considered for removal first, and the proportion of that tree record specified in field 3 is removed. The tree record with the next smallest diameter is considered next, then the next smallest and so on until the residual trees-per-acre target is met or all records in the specified range have been considered. The residual target trees per acre is specified only for the user-defined range of DBH and height, and does not represent the total residual unless the range of DBH's and heights includes all trees in the stand.

This keyword was also used to simulate a seed tree cut to a 100' spacing (approximately 4 trees per acre) in the conifer stratum as follows:

```
THINBTA  0.  PARMS(4,1.0,0.0,999,0.0,999)
```

THINDBH (Thin from a DBH range) – Schedules a thinning from throughout a specified DBH range for any or all species to a basal area per acre or trees per acre target. If the target trees per acre or target basal area is nonzero, thinning occurs uniformly throughout the specified DBH range until the target is met (cutting efficiency is ignored). In other words, a calculated proportion of each of the eligible tree records is removed such that the target trees per acre or target basal area is exactly met. If both residual targets are 0 (zero), the cutting efficiency determines the proportion of trees represented by each eligible tree record that will be removed (residual targets are ignored). Only trees of the user-specified species that are within the user-defined DBH range are considered for removal. The residual target basal area per acre or trees per acre is specified only for that species and DBH range and does not represent the total residual unless the DBH range includes all trees of all species in the stand.

THINDBH was used to simulate clearcuts and overstory removal harvests following either a shelterwood or seed tree cut. For clearcut regimes, the THINDBH keyword parameters were set to remove all trees as follows:

```
THINDBH  0.  PARMS(0.0,999.0,1.0,ALL,0,0)
```

For overstory removal harvests, the THINDBH keyword was set to ensure that all trees past the seedling / sapling stage (e.g. any remaining overstory) were removed as follows:

```
THINDBH  0.  PARMS(5.0,999.0,1.0,ALL,0,0)
```

ESTAB (Establishment Model) – signifies the beginning of keywords for the Regeneration Establishment extension. The ESTAB keyword sequence must be terminated with an END keyword. All keywords between ESTAB and END are considered Establishment extension keywords.

The LS variant contains a partial establishment model which may be used to input regeneration and ingrowth into simulations. Sprouts are automatically added to the simulation following harvest for sprouting hardwood species, which applies for all hardwood trees sampled in the inventory. Regeneration of conifer seedlings however must be simulated following the ESTAB keyword with additional keywords as described next.

NATURAL (Natural regeneration) – Specifies natural regeneration that will be added to the stand.

This keyword was used to simulate natural regeneration of conifer following thinning treatments based on FVS-predicted hardwood sprouting and to simulate natural regeneration of all species following clearcut, shelterwood cuts, and seed tree cuts. Natural regeneration was invoked in the cycle immediately after the treatments occurred with a species-specific distribution in each stratum and with a specific total trees per acre for each treatment. Details of how natural regeneration was quantified are described below in the Baseline Silviculture section and in the description of the COMPUTE keyword that follows.

In all treatments, seedlings have an 100% expected survival rate, an average seedling age of 2 (default) in years for the year specified in Field 1, and a shade code of 0 (seedlings occur more uniformly on plots throughout the strata). The average seedling height in feet five years from the time of seedling appearance or at the end of the cycle, whichever is earlier is estimated by the average seedling age set in Field 5 of the keyword parameters. Thus, an average seedling height was not entered.

SPROUT - Requests the automatic scheduling of root and stump sprouts after a thinning and allows users to change the number of regenerated sprouts and initial sprout heights. A value of less than 1.0 decreases the number and/or height of sprouts, and a value greater than 1.0 increases the number and/or height of sprouts. Only those species that are prone to stump or root sprouting will have this type of regeneration scheduled. This keyword has no effect on species that do not sprout. For most sprouting species this keyword is on by default.

NOSPROUT - Suppresses the automatic scheduling of root and stump sprouting following thinning

The SPROUT and NOSPROUT keywords were used to turn sprouting on following commercial thins, and to turn sprouting off following the TSI cut in the CCHT regimes (see baseline silviculture section below)

SPMCDBH - returns the trees, basal area, total cubic volume, merchantable cubic foot volume, total board foot volume, quadratic mean diameter, average height, percent cover, average mistletoe rating, stand density index, or average diameter growth per acre for a given species or species group, tree-value class, tree status, and range of diameter and height. These metrics can be obtained for live trees, cut trees, dead trees, live trees after thinning, or mistletoe infected trees. For more information on how SPMCDHB is used, please refer to Dixon (2002).

COMPUTE - allows the user to define variables expressed as mathematical expressions containing constants, Event Monitor variables, Event Monitor functions, and variables previously defined using the COMPUTE keyword. Variables are defined using mathematical equations in supplemental records, which are up to 80 characters long. The Event Monitor feature of FVS allows users to specify a set of conditions that must occur, or thresholds that

must be reached in order for FVS to simulate a management activity or set of management activities. The COMPUTE keyword is used to define variables that are evaluated by the Event Monitor to determine if necessary conditions or thresholds have been met.

The COMPUTE keyword was primarily used, in conjunction with FVS Keyword SPMCDDBH to define the amount of naturally regenerating conifer seedlings following thinning harvests, depending on the amount of sprouting that FVS predicted. The following variables were defined:

Table 9. Variables calculated using COMPUTE keywords in FVS simulations.

Variable	Definition	Usage
CONTPALT1	Total conifer trees, defined by the CONIFER species group (SPGROUP), less than 1" per acre present in the FVS simulation	Used to detect the total amount of conifer trees present to calculate the number of conifer seedlings to be added to the simulation one cycle after thinning.
TPALT1	Total trees less than 1" per acre present in the FVS simulation.	Used calculate the number of conifer seedlings to be added to the simulation one cycle after thinning.
HWTPTALT1	= TPALT1-CONTPALT1	Used to calculate the number of hardwood sprouts in the FVS simulation following a clearcut
CONWCTPA	=1.9578*HWTPTALT1	Number of northern white-cedar (WC) seedlings predicted, based on number of hardwood sprouts (HWTPTALT1) following thinnings, 195.78%, based on analysis of prevalence of WC BA in project inventory relative to total hardwood BA for the Conifer strata. Similarly for balsam fir (BF), eastern hemlock (EH), tamarack (TA), black spruce (BS), white spruce (WS), and white pine (WP)
CONBFTPA	=0.5046*HWTPTALT1	
CONEHCTPA	=0.4259*HWTPTALT1	
CONATCTPA	=0.3266*HWTPTALT1	
CONBSTPA	=0.2596*HWTPTALT1	
CONWSTPA	=0.1564*HWTPTALT1	
CONWPTPA	=0.0191*HWTPTALT1	
MIXWCTPA	=0.5863*HWTPTALT1	Number of northern white-cedar (WC) seedlings predicted, based on number of hardwood sprouts (HWTPTALT1) following thinnings, 58.63%, based on analysis of prevalence of WC BA in project inventory relative to total hardwood BA for the Mixed strata. Similarly for balsam fir (BF), eastern hemlock (EH), tamarack (TA), black spruce (BS), white spruce (WS), and white pine (WP)
MIXBFTPA	=0.0789*HWTPTALT1	
MIXEHCTPA	=0.2828*HWTPTALT1	
MIXATCTPA	=0.0559*HWTPTALT1	
MIXBSTPA	=0.0902*HWTPTALT1	
MIXWSTPA	=0.0216*HWTPTALT1	
MIXWPTPA	=0.0008*HWTPTALT1	
NHWCTPA	=0.0508*HWTPTALT1	Number of northern white-cedar (WC) seedlings predicted, based on number of hardwood sprouts
NHBFTPA	=0.0013*HWTPTALT1	

NHEHTPA NHWSTPA	=0.2259*HWTPALT1 =0.0062*HWTPALT1	(HWTPALT1) following thinnings, 5.08%, based on analysis of prevalence of WC BA in project inventory relative to total hardwood BA for the Northern Hardwood strata. Similarly for balsam fir (BF), eastern hemlock (EH), tamarack (TA), and white spruce (WS)
SMWCTPA SMBFTPA SMEHTPA SMWPPTA	=0.0339*HWTPALT1 =0.0033*HWTPALT1 =0.1365*HWTPALT1 =0.0022*HWTPALT1	Number of northern white-cedar (WC) seedlings predicted, based on number of hardwood sprouts (HWTPALT1) following thinnings, 3.39%, based on analysis of prevalence of WC BA in project inventory relative to total hardwood BA for the Sugar Maple strata. Similarly for balsam fir (BF), eastern hemlock (EH), tamarack (TA), and white spruce (WS)

IF-THEN-END IF - also known as scheduling by condition, the IF-THEN-END IF code block is used to execute FVS actions once certain conditions are met. The Event Monitor keyword sequence must begin with an IF keyword. The next record must be a condition statement that evaluates to true or false. The next record is a THEN keyword. The sequence ends with an ENDIF keyword. All keywords contained between the THEN and ENDIF keywords will be executed whenever the condition is true. The condition is checked every cycle, unless that cycle falls within the minimum waiting time since the last time the condition was true.

A record of how all keywords were used in the modeling can be found in the FVS input databases delivered as part of the baseline modeling package with this project.

NUMCYCLE - Specifies the number of cycles to run the projection. A cycle is the period of time for which tree characteristics are predicted, and for which inventories are reported (see TIMEINT).

TIMEINT - Specifies the length, in years, of any or all projection cycles. This keyword is used to ensure that an action can be implemented in the same year that it is scheduled rather than the FVS default, which is the first year of a cycle. The default projection cycle for the LS variant of FVS is 10 years. TIMEINT was used in conjunction with NUMCYCLE and IF-THEN-END IF code blocks to offer different timing possibilities of silvicultural actions throughout the 100-year planning horizon for each stand type. Having multiple prescriptions available for each stand in which different sequences and timing of harvest events and other silvicultural events occur ensures that property-level constraints, such as upper or lower limits on harvest volumes, can be met in the baseline planning model described below.

RESETAGE - Sets the stand age to zero to make FVS model output correspond to the actual age of the stand. Age is strictly for reporting purposes and has no effect on growth or survival prediction. Its only effect is on the calculation of mean annual increment. This keyword is useful when average stand age has changed due to thinnings and plantings.

This keyword was used to reset stand age after certain harvest types so that the timing of subsequent harvests could be calculated and controlled programmatically as necessary. A record of how all keywords were used in the modeling can be found in the FVS input databases delivered as part of the baseline modeling package with this project.

SITECODE - Sets species-specific site index values. If a SITECODE keyword is present, all species for which site index values were not explicitly set will be assigned site index values derived from the site index of the specified site species. If no SITECODE keyword is present, default site index values are assigned. Site index can be described for the site species of an entire stand, which is equivalent to entering a species code in the "Site_Species" field in the

FVS_StandInit table, and for all other species in the stand. This keyword was used to assign site index values derived from the site index estimation procedures described below.

A record of how all keywords were used in the modeling can be found in the FVS input databases.

Site Productivity Class, and Growth Determination

Site Productivity Class

Some ARB Assessment Areas are distinguished by site class. The ARB FOP defines high site classes as USDA Forest Service Sites I, II, III and IV; low site classes are Forest Service Sites V – VII. The Forest Service separates site classes by potential yield, or mean annual increment expressed as merchantable cubic feet per acre (see USDA Forest Service Forestland Productivity Classes table below). Using this type of classification to determine site quality is known as the Yield Method (Avery and Burkhart 2002).

Table 10. USDA Forest Service Forestland Productivity Classes

Code	Potential Yield, Mean Annual Increment
1	225 or more cubic feet per acre
2	165 to 225 cubic feet per acre
3	120 to 165 cubic feet per acre
4	85 to 120 cubic feet per acre
5	50 to 85 cubic feet per acre
6	20 to 50 cubic feet per acre
7	Less than 20 cubic feet per acre

In the subject Supersection, the Mixed Northern Hardwoods and Pine-Oak Assessment Areas of the Laurentian Mixed Forest Northern Highlands Supersection are separated into site classes (i.e. High and Low). The Project Area site classes for these Assessment Areas were determined by using the “Yield - Soils Overlay method”.

The Yield - Soils Overlay method determines the potential productivity of each Assessment Area (MAI in Cubic Feet per Acre per Year) within the Project Area from soil survey data obtained from the USDA Natural Resources Conservation Service (NRCS). These results are then compared to the Forest Service site classes to assign “High” or “Low.”

The NRCS provides soil survey data at no cost from their *Web Soil Survey (WSS)* platform for almost all the contiguous United States. The data can be delivered in SSURGO format, which has spatial and tabular components allowing users to group and report soils data for a focus area.

The steps to perform the Yield Method using NRCS SSURGO soils overlay data are as follows:

1. Download soil dataset and coverage for Project Area (<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>).
2. Use ArcGIS Overlay Identity Analysis Tool to attribute Project Area with soil survey Mapping Unit Key (mukey).

3. Relate soil mapping units with soil series components.
4. Relate soil series components with forestland productivity values and determine the average MAI for all suggested species.
5. Aggregate forestland productivity by strata and soil mapping unit weighted by component representative percent (i.e. weighted average method).

The results of the Soils Overlay – Yield Method show that only 34.2% of the subject area contained mapping units with soil productivity data. Of the acres with data, 99.4% of the acres were located on Low site class mapping units. In the Mixed Northern Hardwoods and Pine-Oak Assessment Areas, the Low site class carries a higher common practice statistic than the High site class. Therefore, for all “No Data” acres, we conservatively assigned a low site class status to acres in the Mixed Northern Hardwoods and Pine-Oak Assessment Areas with no soils data. All acres falling in the Conifer Bog Assessment Area carry the same common practice statistic, so there was no need to assign acres with no soils data.

Table 11: Assessment Area Acreages

Supersection	Assessment Area	Site Class	Project Area (Acres)	CP Stock	Area Weight	Weight CP (per acre)
Laurentian Mixed Forest Northern Highlands	Laurentian Mixed Forest Northern Highlands	All	3,875.9	32.31	14.47%	4.67
	Conifer Bog					
	Laurentian Mixed Forest Northern Highlands	High	56.5	55.10	0.21%	0.12
	Mixed Northern Hardwoods	Low or No Data*	22,848.0	56.65	85.27%	48.31
	Laurentian Mixed Forest Northern Highlands	High	0.0	72.90	0.00%	0.00
	Mixed Pine-Oak	Low or No Data*	13.9	73.08	0.05%	0.04
TOTAL			26,794.3			53.13

*Areas in the Mixed Northern Hardwoods and Pine Oak strata with no available soil productivity data were assigned to the site class with the highest common practice value (Low, in both strata)

Site Index

Site index across the project area was determined through the same essential process as the Soils – Yield Overlay Method described above for Site Productivity Class. Soils series components with site index values (Carmean et al 1989) were aggregated by strata and soil mapping units weighted by component representative percent (i.e. weighted average method). Although, as was the case with Site Class, only approximately 1/3 of the project area had site index values using this method, visual inspection of the subject property’s GIS area overlaid with the soils data showed site index coverage well distributed across the project area, so the Yield-Overlay was judged adequate for determining site indices by inventory stratum across the property.

The results of the site index analysis are shown below. The site species for each stratum was determined by ranking the basal area percentage of each species.

Table 12. Site Index by Inventory Strata

Inventory Strata	Species	FVS Code	Acre-weighted Average Site Index	Site Species
Conifer	American basswood	BW	66.5	Y
Conifer	balsam fir	BF	53.9	
Conifer	bigtooth aspen	BT	78.0	
Conifer	black spruce	BS	15.0	
Conifer	eastern white pine	WP	57.0	
Conifer	jack pine	JP	65.9	
Conifer	northern red oak	RO	66.4	
Conifer	northern white cedar	WC	28.0	
Conifer	quaking aspen	QA	69.8	
Conifer	red maple	RM	48.7	
Conifer	red pine	RP	59.6	
Conifer	sugar maple	SM	63.6	
Conifer	tamarack	TA	55.0	

Inventory Strata	Species	FVS Code	Acre-weighted Average Site Index	Site Species
Mixed	American basswood	BW	66.2	Y
Mixed	balsam fir	BF	54.1	
Mixed	bigtooth aspen	BT	77.8	
Mixed	black spruce	BS	38.1	
Mixed	eastern white pine	WP	57.0	
Mixed	jack pine	JP	67.3	
Mixed	northern red oak	RO	68.0	
Mixed	northern white cedar	WC	28.0	
Mixed	paper birch	PB	54.0	
Mixed	quaking aspen	QA	71.7	
Mixed	red maple	RM	52.2	
Mixed	red pine	RP	60.5	
Mixed	sugar maple	SM	62.9	

Inventory	Species	FVS	Acre-	Site
NH	American basswood	BW	66.6	Y
NH	balsam fir	BF	55.0	
NH	bigtooth aspen	BT	78.0	
NH	black spruce	BS	43.0	
NH	eastern white pine	WP	57.0	
NH	jack pine	JP	66.4	
NH	northern red oak	RO	66.6	
NH	northern white cedar	WC	28.0	
NH	paper birch	PB	54.0	
NH	quaking aspen	QA	70.3	
NH	red maple	RM	47.6	
NH	red pine	RP	59.8	
NH	sugar maple	SM	64.5	
NH	tamarack	TA	54.7	

Inventory	Species	FVS	Acre-	Site
SM	American basswood	BW	67.1	Y
SM	balsam fir	BF	59.3	
SM	bigtooth aspen	BT	78.0	
SM	black spruce	BS	43.0	
SM	eastern white pine	WP	57.0	
SM	jack pine	JP	70.2	
SM	northern red oak	RO	68.2	
SM	northern white cedar	WC	28.0	
SM	quaking aspen	QA	73.9	
SM	red maple	RM	50.6	
SM	red pine	RP	61.3	
SM	sugar maple	SM	65.2	
SM	tamarack	TA	53.5	
SW1	red pine	RP	71.0	

Annual Growth and the Initial Project Inventory

The initial project inventory was conducted October 2019 through early January 2020, or effectively year-end 2019. The initial reporting period end date is June 17, 2020. According to maps provided by the University of Wisconsin Horticulture Extension program², the last killing frost day of the spring each year averages around May 27 each year, while the first killing frost day in the fall of each year occurs around September 16, yielding an effective growing season of 112 days. June 17 represents 21, or 18.75%, of those days.

One year of growth in FVS was applied by linearly interpolating 1 FVS cycle of growth (through year-end 2027) to add $(1/10^{\text{th}} \times 18.75\%)$ of the growth on to the original inventory results, representing 18.75% of 1 full year's worth of growth, to calculate the carbon stocks at the end of the initial reporting period.

Carbon Modules

This section describes the steps to process the FVS output data subject to the ARB volume and biomass equations for projects outside of California, Washington and Oregon using the *carbon modules*. The carbon modules are a set of proprietary MS Access relational databases setup primarily to calculate carbon stocks from the FVS_TreeList and FVS_CutList. The carbon modules are based on a series of queries that select data and perform the calculations necessary to summarize onsite and harvested carbon stocks by stratum in a fashion that is compliant with the Forest Offset Protocol.

² <https://hort.extension.wisc.edu/maps/>

Step 1: Run FVS and create tables for FVS module.

Inventory data is processed in the FVS to obtain modeled data. This includes growth (accretion and in-growth), mortality, and harvesting. FVS output tables are maintained in output databases (e.g. ForestCarbon_FVS_OUT.mdb) and include the following tables: FVS_Cases; FVS_Summary (or FVS_SummaryEast for eastern variants); FVS_TreeList; and FVS_CutList.

Step 2: Run the Central Module.

The purpose of this module is to calculate the cubic foot volume, biomass by component ratio method, and ultimately carbons stocks by stratum and year, from the tree list and cut list output from FVS. The database is programmed to relate each tree by species to the appropriate volume equation and biomass coefficients associated with the project. The database includes a form with instructions and buttons to execute commands.

Step 2a: Calculate cubic foot volumes (VOLCFGRS & VOLCFSND) using “Gross Cubic Foot Volume Equation Coefficients.xls” and “Sound Cubic Foot Volume Equation Coefficients.xls” as published by ARB on their website.

- a. Open the CRM_Central_Module.mdb database.
- b. Follow instructions in tab 1 of the form (Setup) to make the Strata-Species-Site Index table (StrataSppSI) for species that require site index as a volume equation input.
- c. Follow instructions in tab 2 of the form (Component Ratio Method) to make the CRM Species Table to create a crosswalk table for cubic foot volume equations and biomass coefficients for the component ratio method.
- d. Follow instructions in tab 2 of the form (Component Ratio Method) to calculate cubic foot volumes which will apply the appropriate ARB cubic foot volume equations as indicated by Supersection in the species look up table.
- e. **Quality Control Note:** After making these tables, open them up and sort the ‘VOLCFGRS’ column in descending order. Observe the highest value. If the value equals 5,000,000 then an error occurred because the species was not recognized, i.e. a species code or equation reference was not related correctly.

Step 2b: Calculate biomass using the Component Ratio Method and the volumes calculated in the previous step.

- a. Still within the CRM_Central_Module.mdb database.
- b. Follow instructions in tab 2 of the form (Component Ratio Method) to calculate biomass with the CRM which will apply the CRM biomass coefficients and equations as indicated by Supersection in the species look up table by species.

Step 2c: Create Final Stand Summary

- a. Still within the CRM_Central_Module.mdb database.
- b. Follow instructions in tab 3 of the form (Summary) to create a Final Stand Summary. This will execute several sub-queries to convert biomass to carbon and then aggregate volumes and carbon stocks by strata by year.

Further description of Carbon Pool Calculation Assumptions**Allometric Equations used**

The Forest Protocol requires estimates of total above-ground and below-ground biomass. OPOs/APDs with projects located in all approved states except Alaska, California, Oregon, and Washington (lower 45 states) should

use these instructions³ to estimate volume and convert biomass to tons of CO₂e emissions or removal enhancements. The Protocol requires use of specific volume equations found in "Methods and Equations for Estimating Aboveground Volume, Biomass, and Carbon for Trees in the U.S. Forest Inventory, 2010" (Woodall, *et al.* 2010). Coefficients are found in the regional Coefficients Database associated with the Woodall document. The OPOs/APDs will estimate biomass using the Component Ratio Method (CRM); the CRM is applicable to all states except California, Oregon, and Washington.

IFM-1: Standing Live Carbon (carbon in all portions of living trees)

1. Live trees were inventoried. Rotten material was measured by percent of the main bole and deducted from gross volume to determine sound volume.
2. Growth data (diameter and total height increment) is processed in the FVS-LS Variant.
 - a. Species with a volume equation that required total height used the FVS output estimated total height. The total heights of each tree from the inventory were input to FVS; FVS projects total height increment in subsequent years. The height to top kill was used if this type of height was present for a tree.
 - b. Volume equations that require bole height to a 4" top diameter use an adjusted merchantable height calculated by the FVS regression based on the actual measured DBH, merchantable height, and total height of the tree record in the inventory. FVS-calculated merchantable heights are adjusted up or down during the compilation of the original field inventory within the carbon modules based on actual merchantable height data. The difference between FVS-calculated merchantable height and field-collected merchantable height is maintained throughout growth projections within the carbon modules by applying this difference throughout subsequent growth cycles.
3. FVS is only being used for DBH and height data – the FVS_TreeList cubic foot volumes are not used in carbon calculations. Carbon calculations are based on the ARB Cubic Foot Volume Equations for gross cubic volume (VOLCFGRS) in the United States outside of California, Washington, Oregon, Alaska and Hawaii instructions. Gross cubic foot equation references and coefficients used for this project are shown below in Table 13
4. Protocol instructions page. The central module stores a species table that relates the FVS_TreeList.SpeciesFIA field to the Species_LU_step2.SpeciesFIA field to match the equation reference numbers, specific gravities, and bark as a percentage of wood volume.
5. The query that applies the Component Ratio Method (CRM) by Heath and others (2009) is "003_Compute_CRM_Biomass_TreeList_MT." The SQL has also been saved in a text document.
 - a. Calculates: DRYBIO_BOLE, DRYBIO_TOP, DRYBIO_STUMP, DRYBIO_BG, and DRYBIO_SAPLING. Calculations follow the example detailed in Heath and others (2009). The query is applied to only trees where DBH>=1. The units are pounds dry biomass.
 - b. No "Woodland" species were measured.
 - c. The query results are made into a table: Tree_CRM_biomass.
6. The FVS_TreeList, CRM_CFVolume, and CRM_biomass tables are then related to each other and tree records are summed by stratum to calculate standing live trees per acre, basal area, merchantable cubic feet, and forest carbon.

³ https://www.arb.ca.gov/cc/capandtrade/protocols/usforest/2014/instructions_45states_2014v3.htm

*Note: Coefficients B₁₂ through B₁₉ were not used to predict bole length. Adjusted FVS-Calculated merchantable height to 4" DOB was used to calculate bole length as an input into the Hahn volume equation (B₀ through B₁₁).

7. Sound volume (VOLCFSD) is calculated for both standing live and standing dead trees by deducting the volume of wood that is rotten or missing from the VOLCFGRS. For most regions outside of California, Washington, Oregon, and Alaska, deductions are based on the percentage of missing or rotten volume estimated or directly measured in the field during the inventory.

For projects, such as this one, located in IA, IL, IN, KS, MI, MO, MN, ND, NE, SD AND WI, VOLCFSD equations incorporate standard volume deduction coefficients that are obtained from the “Sound Cubic Foot Volume Equation Coefficients” spreadsheet on the ARB website. These deductions are based on assigning a tree class code (“treeclcd”) to each inventory tree based on its current or future condition:

Table 14. Tree class codes and descriptions used in sound volume calculation.

Code	Description
2	Growing-stock - All live trees of commercial species that meet minimum merchantability standards. In general, these trees have at least one solid 8-foot section, are reasonably free of form defect on the merchantable bole, and at least 34 percent or more of the volume is merchantable.
3	Rough cull - All live trees that do not now, or prospectively, have at least one solid 8-foot section, reasonably free of form defect on the merchantable bole, or have 67 percent or more of the merchantable volume cull; and more than half of this cull is due to sound dead wood cubic-foot loss or severe form defect volume loss. This class also contains all trees of noncommercial species, or those species where SPGRPCD equals 23 (woodland softwoods), 43 (eastern noncommercial hardwoods), or 48 (woodland hardwoods). Refer to appendix F to find the species that have these SPGRPCD codes. For dead trees, this code indicates that the tree is salvable (sound).
4	Rotten cull - All live trees with 67 percent or more of the merchantable volume cull, and more than half of this cull is due to rotten or missing cubic-foot volume loss. For dead trees, this code indicates that the tree is nonsalvable (not sound).

Sound cubic foot equation references and coefficients used for this project are shown below in Table 15.

Table 15. Sound Cubic Foot Volume Coefficients by Species

Name	FIA	Treeclcd		Values			
		2		3		31	
		B1	B2	B1	B2	B1	B2
American Basswood	951	4.4	0.1	14	0.15	14	0.15
American Elm	972	6.3	0.1	13.2	0.15	13.2	0.15
Balsam Fir	12	2.1	0.1	11.1	0.15	11.1	0.15
Balsam Poplar	741	4.5	0.1	19	0.15	19	0.15
Black Ash	543	5.3	0.1	20.2	0.15	20.2	0.15
Black Cherry	762	6.8	0.1	15.5	0.15	15.5	0.15
Black Spruce	95	1.4	0.1	12.1	0.15	12.1	0.15
Chokecherry	763	8.7	0.1	16.8	0.15	16.8	0.15
E. Hophornbeam	701	8.7	0.1	16.8	0.15	16.8	0.15
Eastern Hemlock	261	5.4	0.1	24.9	0.15	24.9	0.15
Eastern White Pine	129	3.2	0.1	16.6	0.15	16.6	0.15
Northern White-Cedar	241	3.8	0.1	17.2	0.15	17.2	0.15
Paper Birch	375	4.5	0.1	14.3	0.15	14.3	0.15
Quaking Aspen	746	5.2	0.1	21.8	0.15	21.8	0.15
Red Maple	316	5.8	0.1	16.8	0.15	16.8	0.15
Sugar Maple	318	6.3	0.1	17.7	0.15	17.7	0.15
Tamarack	71	2.7	0.1	16.8	0.15	16.8	0.15
White Ash	541	4.6	0.1	17.8	0.15	17.8	0.15
White Spruce	94	1.6	0.1	11.7	0.15	11.7	0.15
Yellow Birch	371	8.9	0.1	19.7	0.15	19.7	0.15

IFM-3: Standing Dead Carbon (carbon in all portions of standing dead trees or snags)

Standing dead trees (i.e., snags) were inventoried using the same sampling methodology as live standing trees. Dead tree decay status was classified using the classes and density reduction factors described by Harmon, *et al.* (2011) for inventoried standing dead trees. The five decay classes (Table 16) are qualitative, based on the physical characteristics of the standing dead tree. The decay class is indicated in the inventory data in the FVS_TreeList.SSCD column. The dead tree decay status codes are concatenated with a 3 for programmatic reasons (e.g. 23 = “There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.”; 33 = “Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base”).

Table 16. Decay Class Definition

Decay Class	Description
1	All limbs and branches are present, the top of the crown is still present, all bark remains, sapwood is intact with minimal decay, heartwood is still sound and hard.
2	There are few limbs or fine branches, the top may be broken, a variable amount of bark remains, sapwood is sloughing, heartwood has advanced decay in upper bole and is beginning at the base.
3	Only limb stubs exist, the top is broken, variable bark remains, sapwood is sloughing, heartwood has advanced decay at the base and is sloughing in the upper bole.
4	Few or no limb stubs remain, top is broken, variable bark remains, sapwood is sloughing, heartwood has advanced decay at the base and is sloughing throughout.
5	No evidence of branches remains, the top is broken, less than 20 percent of the bark remains, sapwood is gone, heartwood is sloughing throughout.

Applying density reduction factors (DRF) and Structural Loss Adjustments (SLA):

This process was developed in accordance with the Domke guidance document “Adjusting Standing Dead Tree Carbon Pool for Structural Loss and Density” released by ARB on February 17, 2015, and which is available on their website. Density Reduction Factors can be found in Harmon, *et al.* (2011) Appendix B and D. Specific gravity values for bole and bark, as well as bark as a percentage of wood volume, for each species can be found in the REF_SPECIES workbook, also available from ARB. Structural Loss Adjustment factors are listed in Table 2 of Domke, *et al.* (2011) and are included in Table 17 below.

This step is performed in the same “003_Compute_CRM_Biomass_TreeList_MT” query in the CRM Central Module database as was described in the IFM-1 section above. The central module stores a species table that relates the FVS_TreeList.SpeciesFIA field to the Species_LU_step2.SpeciesFIA field to match the equation reference numbers, specific gravities and bark as a percentage of wood volume. It also matches the FVS_TreeList.SSCD code (described at the beginning of this section) to the same look-up table which also contains the Harmon DRF values for each species. The appropriate SLA factors are also applied based on the SSCD code in this query. Following the CRM approach, the components are summed and converted from biomass to carbon. Saplings (i.e. trees < 5 “DBH) are not expanded using a CRM adjustment factor. Therefore, the DRF is applied straight to the DRYBIO_SAPLING value by Harmon decay class and species. The SLA for carbon in the Bole for saplings is 1.0, resulting in no structural loss for DRYBIO_SAPLING.

Note: For trees greater than or equal to 5” DBH, the reductions and adjustments described above are made to the sound volume (VOLCFSND), which is calculated for each record using the steps outlined for IFM-1 above.

Table 17. Structural Loss Adjustment Factors

Decay Class	Top	Bark	Bole	Stump	Roots
1	1	0.92	1	1	1
2	0.5	0.66	1	1	0.95
3	0.2	0.39	1	1	0.8
4	0.1	0.21	1	1	0.65
5	0	0	1	1	0.5

Assessment Areas

The project area was stratified by Finite Carbon as described in the Stratification Rules section of the Sampling Methodology with the following results.

Table 18: Assessment Area and Associated Species

Supersection	Assessment Area	Associated Species
Laurentian Mixed Forest Northern Highlands	Laurentian Mixed Forest Northern Highlands Conifer Bog	Black spruce, northern white cedar, tamarack
	Laurentian Mixed Forest Northern Highlands Mixed Northern Hardwoods	Aspen, birch, balsam fir, black ash, American elm, red maple, black cherry, cherry, white ash, yellow poplar, eastern hemlock, elm, ash, black locust, cottonwood, hard maple, basswood, maple, beech, paper birch, pin cherry, river birch, sycamore, silver maple, sugar maple, yellow birch, sugarberry, hackberry, green ash, white spruce, willow
	Laurentian Mixed Forest Northern Highlands Mixed Pine-Oak	Bur oak, eastern white pine, eastern hemlock, jack pine, red pine, pine, scotch pine, northern red oak, white ash, oak, hickory, red maple, white oak

Site Class

Site class acres by Assessment Area were determined using the methods described previously in the Site Index, Site Class, and Growth Determination section. The Northern Hardwoods and Pine-Oak Assessment Areas have common practice values which differ by site class.

The final dispensation of the project inventory by inventory strata and assessment area was shown above in Table 6 and Table 7 along with the calculation of the common practice statistic for this project in Table 11. The common practice carbon stocking for the Project Area is calculated to be 53.13 tons per acre.

Baseline Model Constraints

In modeling the baseline for standing live and dead carbon stocks, the forest owner has considered and incorporated all operational, legal, and financial constraints that could affect baseline growth and harvesting scenarios.

The baseline scenario models timber harvesting over 100 years, as a function of what it is legally allowable, financially feasible and physically possible, while at the same time adhering to the minimum baseline level (MBL). In the baseline model, forest development was projected using a combination of regeneration harvest, selection thinning, and grow-only regimes. Forest stands were eligible for treatment types based primarily on their forest structure, site attributes, and baseline model constraints.

Constraints that affect land-use specific to forest management activities have been incorporated into the baseline carbon modeling, as described in detail below.

Legal Constraints

Wisconsin Best Management Practices

These voluntary site-level forest management guidelines provide valuable decision-making tools for landowners, resource managers and loggers throughout Wisconsin, who share an ongoing responsibility to make balanced, informed decisions about forest use, forest management and forest sustainability.

Activity-Specific Guidelines that are applicable to forest management activities include:

- Forest road construction and maintenance
- Timber harvest planning
- Riparian Management Zones
- Forest Roads
- Stream Crossings
- Forest operations
- Site preparation
- Reforestation

Riparian Areas

Riparian areas are areas that transition from aquatic to terrestrial ecosystems along streams, lakes, and open water wetlands. Riparian areas are important for many forest resources including plant and animal diversity, habitat, water quality, and forest recreation. Timber harvesting in or near riparian areas has the potential to impact these resources if proper care is not taken to minimize negative effects.

A Riparian Management Zone (RMZ) is the defined portion of the riparian area adjacent to a stream, lake, or open water wetland where RMZ guidelines apply. RMZ area is dependent on the recommended RMZ width which varies according to stream, lake, or open water wetland characteristics.

Wisconsin's standard RMZ minimum width is 100 feet as measured horizontally from the top of the bank of the lake, stream, pond, other open water bodies (e.g. open water wetlands), or the ordinary high-water mark. These RMZ widths were determined using the spatial data developed by the USGS. Since these shapefiles did not contain information on the stream width or slopes in adjacent areas, the buffer size was figured conservatively at 100 feet from the center line of the stream.

Timber Management in RMZ

Where harvesting is planned within an RMZ, cutting specifications should be modified to retain a sufficient number of trees (60 ft² basal area per acre is used as the benchmark) to maintain shading of streams and to leave a relatively stable and undisturbed forest floor (less than 10% bare soil exposure).

Baseline Model Considerations: The baseline model considers the management guidelines of the Wisconsin BMPs by allowing only thinning regimes (to a residual basal area of 60 sq. ft. per acre) in RMZs.

Endangered Species Act (ESA)

The Endangered Species Act (ESA) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The lead federal agencies for implementing ESA are the U.S. Fish and Wildlife Service (FWS) and the U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. All federally protected species are listed within the Attachment K document. The Wisconsin Department of Natural Resources manages the law locally, and a full list of all Wisconsin state protected species including birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees is listed in the Appendix to Attachment K.

Baseline Model Considerations: There are no restrictions that impact modeling. We have reviewed recovery plans and management restrictions required by law for the above species, as well as reviewed spatial locations where these species are encountered and did not find any additional modeling restrictions that would have to be put into place to ensure compliance with the ESA. It is assumed that all management activities will avoid a taking and that if additional endangered species are discovered in the property, a voluntary harvest protection plan will be developed.

Conservation Easement

A conservation easement was established on this property in 2006 and is currently held by the Wisconsin Department of Natural Resources. This easement requires adherence to a management plan which must be updated every ten years. The most recent update to this plan was completed in 2015 and the Wisconsin DNR has confirmed that the property is in compliance with the management plan. This plan outlines standard silvicultural practices as well as general land management requirements.

Baseline Model Considerations: The baseline model considers the management guidelines of the management plan drafted under the conservation easement and all modeled silvicultural activities and timber harvests comply with the requirements of that plan.

Timber Supply Agreement

There is a current timber supply agreement with Verso Corporation that is in place through 2021. Specifically, 11,500 tons is the minimum volume amount to be delivered to Verso.

Baseline Model Considerations: The baseline model maintains a minimum 11,500-ton harvest volume required to be delivered within this agreement through 2021.

Operational Constraints

Outside of the legal considerations listed above, there are few operational constraints affecting timber harvesting on the property. The terrain is extremely flat, with minimal access issues due to the prevalence of logging on frozen ground in wintertime. The OPO maintains Sustainable Forestry Initiative (SFI) certification, which imposes certain limits on clearcut sizes, green-up, and adjacency. Otherwise, primary operational considerations which affect harvesting on the project are related to sustainability, labor availability, and market saturation of stumpage sales.

Baseline Model Considerations: The baseline model sets limits on the maximum number of acres of clearcuts per year to ensure that the 120-acre size and adjacency rules can be implemented on the ground. The total acreage of

all harvest activities combined is also limited to no more than 5,000 acres per year to address contractor availability. The overall size of the property is small enough at 26,794 acres +/- that local wood markets are unlikely to be affected by large spikes or dips in harvest levels.

Baseline Silviculture

The harvest regimes developed to model baseline silviculture were designed to mimic practices detailed in the OPO's Forest Management Plan and supported by information in the Wisconsin Silvicultural Handbook (2003).

Thinning Harvest Regimes

Thinning regimes were applicable to the hardwood (NH, SM) and Mixed inventory strata in the project in both upland and RMZ areas. The objective of this treatment is to reduce stand stocking levels to maintain or increase the growth and vigor of the best quality and highest value trees in a stand. Thinning regimes featured periodic harvests to 60 sq. ft. of residual BA once a stand had grown to at least 90 sq. ft. of BA. A minimum merchantable harvest volume of 600 cubic ft. per acre, corresponding to approximately 8 cords per acre was also required for entry. The thinning was designed as a thin-from-above to capture commercial volume using the THINABA keyword as described previously.

Following thinnings, the FVS partial establishment model provided estimates of hardwood ingrowth through sprouting. The partial establishment model does not simulate natural seeding-in of conifer. The number and distribution of conifer advance regeneration stems was derived from overall inventory strata composition and the number of FVS-predicted hardwood sprouts as follows. First, the relative basal area of each conifer species in the initial inventory was determined in comparison to the total basal area of all hardwoods. For instance, if 100 square feet of basal area of hardwood trees existed in an inventory stratum while the basal area of white spruce was 20, the relative basal area factor of white spruce was 0.20 (twenty percent). Next, 10 years after a thinning event, the number of hardwood sprouts less than 1" predicted by FVS was tallied using the SPMCDDBH keyword. Then for each conifer species in the initial inventory, the number of advance regeneration conifer stems was calculated by applying the relative basal area factor calculated in the first step, *e.g.* if FVS predicted 100 total hardwood sprouts less than 1" DBH, 20 stems per acre of white spruce were added.

Predicted natural regeneration of conifer seedlings by strata in the thinning regimes is shown in Table 20 below.

Regeneration (even-age) Harvest Regimes

1. Shelterwood ("SW") regimes. The shelterwood regime was used for the hardwood (NH, SM) and Mixed inventory strata on the property in upland (non-RMZ) areas. The primary objective of this treatment is to promote the establishment, development and growth of advanced desirable regeneration. In the SW regime, a mature stand is initially thinned from below to 50-60 square feet of basal area to open up the stand and leave the best seed producing crop trees behind. Once natural regeneration is re-established, in 6-10, years, the overstory is removed.

In our implementation of this regime, the THINBBA keyword is used to thin the stand from below to 50 square feet of basal area ("BA"). Ten years later, natural regeneration is added to the stand using the ESTAB keyword sequence. The management plan references a guideline of 5,000 stems per acre 2-4" tall as an expected seeding level following SW cuts, but we were unable to find evidence of such a high quantity per acre in the carbon inventory data we collected across the property, or in sprouting simulations with FVS. Therefore, we assumed the maximum number of small stems per acre we found in the inventory per strata would be the expected number of seedlings per acre 10 years following the shelterwood cut. The distribution of the stems followed the relative basal area by species found in the initial inventory and included all species (sprouting was turned off with the NOSPROUT keyword in FVS). The number and distribution of regeneration per inventory strata following a shelterwood cut is found below in Table 20.

Following the establishment of the regeneration, the overstory is then removed in an overstory removal (“OSR”) harvest. After the understory is released, the enters into a commercial thinning regime as described previously, once minimum basal area and merchantable volume requirements are met to trigger a thin.

2. Seed Tree (“SDT”) regimes. The seed tree regime is similar to the shelterwood regime except for a much smaller number of trees is retained to serve as a seed source. In the SDT regime, the initial entry into the stand uses a thinning from below to leave approximately the 4 largest trees per acre only (100’ spacing). Ten years following the seed tree cut, the overstory trees are removed and the understory is released to grow. The SDT regime is reserved for upland(non-RMZ) areas in the Conifer strata in conjunction with strip clearcutting as described below. Following the overstory removal, the stand moves into an 80-year rotation, with the next entry being a subsequent seed tree cut.
3. Clearcut regimes. Clearcut regimes, followed by natural regeneration, apply to upland (non-RMZ) areas for all inventory strata in the following particular circumstances:

CC: In the NH and SM strata, clearcutting is modeled on a limited basis to simulate sanitation and salvage harvesting. Based on the plot data collected for this project, approximately 1% of the area in each of these strata have dead and dying timber. These areas are considered salvage harvests eligible for clearcutting on a 60-year rotation (“CC”). Regeneration is natural and consists of hardwood sprouting predicted by FVS and conifer regeneration simulated using the relative basal area method described previously.

CC40: In the Conifer and Mixed strata, approximately 5.3% and 1.5%, respectively of each type consist of balsam fir dominated (>50% BA) areas based on plot data. These areas are considered to be patches of balsam fir stands and are eligible for clearcutting on 40-year rotations (“CC40”). Regeneration is natural but sprouting is turned off with the NOSPROUT keyword, and natural regeneration is added manually at a density of 2550-3000 stems per acre, based on the inventory composition by BA in inventory plots dominated by balsam fir

CC40A: Also in the Conifer and Mixed strata, approximately 2.6% and 7.7%, respectively of each type consist of aspen dominated (>50% BA) areas based on plot data. These areas are considered to be patches of aspen stand types and are eligible for clearcutting on 40-year rotations (“CC40A”). Regeneration is natural but sprouting is turned off with the NOSPROUT keyword, and natural regeneration is added manually at a density of 2550-3000 stems per acre, based on the inventory composition by BA in inventory plots dominated by aspen.

Strip Harvesting: The remainder of the Conifer stratum is modeled using the strip-harvesting method. In the strip harvesting method, a stand is divided into strips, each strip being 2 to 3 chains in width. Strips are cut sequentially throughout the stand, and once this strip is successfully regenerated, the next can be harvested. The final strip is cut using the seed tree method.

To implement the strip harvesting method, first, inventory polygons in the conifer strata were classified by size. Assuming 2-3 chain passes through a square-shaped polygon, the number of strips necessary to harvest the entire polygon was calculated. Polygons under a certain size were too small to implement strip harvesting and were considered eligible for either a simple clearcut or seed tree regime, described previously, on an 80-year rotation. Larger polygons were classified by size according to how many entries (strips) it would take to cut the entire polygon, with the final strip being a seed tree cut. Table 19 below shows the classification of Conifer inventory polygons by number of strips necessary.

Table 19: Strip Harvest Parameters

Minimum polygon size (acres)	Years To Strip Cut
0	0
1.6	2
8.1	3
14.4	4
22.5	5

*

*Stands 22.5 acres and larger are assumed to be broken up into logical harvest units requiring 5 strips.

While beyond the scope of the modeling requirements here to explicitly spatially model each area of strip-harvesting throughout time, the sequencing and availability of areas to strip harvest are managed with constraints in the Baseline Planning Model, described below. Specifically, seed tree harvests in the Conifer strata are constrained by the total Conifer area that was cut in previous periods. For instance, the total number of seed tree acres in polygons that require 5 strips must be less than or equal to the number of clearcuts occurring 4 years ago on 5-strip polygons, and the total number of “5-strip” seed tree acres over the entire model horizon must be equal to 25% of the “5-strip” clearcut regime acres so that each area in the “5-strip” polygons is ensured 4 clearcut strips plus 1 seed tree strip.

Table 20. Regeneration keywords and prescriptions used per stratum

[illegible]

Baseline Planning Model

In compliance with the requirements of Appendix B(a) of the FOP, FVS and the carbon modules were used to create yield tables representing a variety of 100-year silvicultural regimes for each of the project strata. Over 140 regimes consisting of 100-year FVS simulations were run, and their FVS Outputs processed through the modules to create a series of yield curves based on the timing options specified by the FVS Keywords used to simulate each regime. These yield curves were then loaded into a proprietary Excel workbook in which the yield curves are interpolated to provide annual values of key carbon metrics. The final, annualized set of yield curves are next imported into Remsoft's Woodstock planning model to evaluate and allocate acres to each FVS yield table to help determine a final baseline harvest schedule that complies with the Minimum Baseline Level, legal constraints, and financial considerations. The final, optimized set of yield curves is then used to calculate 100-year averages of onsite carbon pool inventories, harvested carbon outputs, and cord volumes harvested on a per acre basis. Results of the Baseline Planning Model may be found in the ACR395 Baseline Worksheet.

ROC/ARBOC Monitoring Calculation Worksheet

After completion of the baseline modeling, the results are summarized in a MS Excel worksheet. The results are then inserted to the ROC/ARBOC Monitoring Calculation Worksheet and the Harvested Wood Products Calculation Worksheet tool for the baseline and project scenarios.

Monitoring Plan (Inventory Updates and Data Management)

This portion of the Inventory Methodology describes the Project's annual monitoring plan. The primary purpose of the project's annual monitoring plan is to ensure up-to-date estimates of project carbon stocks and provide assurance that GHG reductions or removals achieved by a project have not been reversed.

Components of the Monitoring Plan

The major components of the property's monitoring plan are:

1. Continuous forest inventory and carbon stock updates: This component focuses on updating the forest carbon inventory and includes conducting forest carbon inventories by following the *Sampling Methodology*. It also encompasses the process of recording any timber harvests or other activities that affect the overall carbon stocks. The output of this process is used to complete the Annual Forest Monitoring Report, as well as the ROC/ARBOC Monitoring Calculation Worksheet and the Harvested Wood Product Calculation Worksheet.
2. Forest carbon project verification by an ARB accredited verifier. Each year, the project is required to be verified by an accredited third-party auditor. This audit will serve to provide assurance to the ARB that the project is operating in compliance with the Forest Offset Protocol.

Forest Health

As per the requirements of the FOP Appendix A(a) this subsection of the monitoring plan identifies any known and potential insects or diseases that may affect the health of the project's inventory, specifically above-ground standing live and dead trees (<https://dnr.wi.gov/topic/ForestHealth/> and WI DNR Forest Health 2019 Annual Report).

Known insects include scattered pockets of

- 1) Emerald ash borer
- 2) Gypsy moth

- 3) Asian longhorned beetle
- 4) Hemlock Woolly Adelgid
- 5) Forest tent caterpillar
- 6) Bark beetles
- 7) Eastern larch beetle
- 8) Pine wood nematode
- 9) Spruce budworm

Common diseases that may impact stocking levels include

- 1) Oak wilt and decline
- 2) Heterobasidion root disease
- 3) Beech bark and leaf disease
- 4) Red pine pocket mortality
- 5) White pine bark scale and canker disease
- 6) Bur oak blight
- 7) Phytoplasma
- 8) Rhizosphaera needle cast

Updating Forest Carbon Stocks

There are three major inputs for updating forest carbon stocks: activity data, emissions factors, and the confidence deduction.

Activity Data

Activity data is defined as the aerial extent of a land-use category. It is the “area data” in units of acres. In this case, land-use will be stratified across the property in order to classify forest versus non-forest, and within forests, the forest type based on the dominant tree species or representative vegetative community. These strata are described in the earlier Stratification Rules section, and all changes to the activity data should follow these stratification criteria.

Activity data can change for several reasons including growth, timber harvests, natural disturbances and succession or selling property within the project area; these changes in activity data are collectively labeled as *events*. Events can affect the proportion of strata within the project area; however, the total aerial extent of the project area cannot change. For this project, activity data will be monitored and reported over time using spatially explicit datasets, also known as a Geographic Information System or GIS. On a continuous basis throughout the year, changes in activity data will be mapped, attributed and recorded by professional foresters during timber harvest operations and timber cruises. Changes will be submitted to and edited by the forest owner’s GIS controller. Edits to the activity data will be compiled and delivered to the project developer at the end of each reporting period. The project developer will store and archive all activity data by year in the project’s geodatabase in the “stands” feature class, which will also serve as the activity data change log.

Emissions Factors

Emissions factors are defined as the emissions/removals of greenhouse gases per unit area. In this case, metric tons of CO₂ equivalents (tCO₂e) will be used to express emission factors as a result of changes in forest carbon stocks. Emission factors vary based on the category of activity data (i.e. strata) and are derived from forest inventory plots.

Forest inventory plots will be conducted according to the Sampling Methodology and processed by Finite Carbon using the data management and analytical systems outlined under Analytical Methods and Biomass Equations. The forest owner will use permanent and temporary inventory plots as needed, to annually update the project’s forest carbon stocks. Measuring the same plots through time will reduce sampling variability and provide reliable estimates of actual growth through time. New temporary and/or permanent plots will be used where previous

plots or continual forest inventory (CFI) plots are not able to accurately represent a particular change in activity data. Inventory plots input to growth & yield modeling, as well as tracking harvest volumes, will be used to assess the changes in carbon stocks. No forest inventory plot data greater than 12-years old will be used.

Events

Events are activities that occur within the project area that affect activity data or emission factors. Events will require spatial and tabular updates to the carbon database. A list of events including harvest volume summaries will be submitted by the Forest Owner to Finite Carbon at the end of each reporting period for the previous year and prepared for verification by completing a monitoring report.

1. Just Growth

Just growth events are assumed to occur in all areas of the project where no other event is assumed to occur. In this event, the activity data and emissions factors are updated by projecting inventory data using FVS growth and yield software, or with new plot data, assuming that accretion and mortality are only a function of the stand's structure and condition from the previous reporting period. Furthermore, growth also occurs in other areas where other events take place, e.g. a timber harvest. In this case, the activity data and emissions factors are updated in the same fashion as just growth events, but accretion and mortality are adjusted based on the other event's effects, e.g. timber harvesting will reduce the carbon stocking, but may increase growth rates while reducing mortality because crop trees are free to grow.

Annual growth increments are determined using the method described under Data and FVS Setting. The annual height and diameter growth increments specific to each tree record are added to those records at the end of each reporting period.

2. Land Sales

Land sales activity has a tremendous bearing on every carbon project. Should all or a portion of the area committed to the carbon project be sold while under the project's commitment terms, Finite Carbon will need to be notified as soon as possible. The forest owner will be required to provide digital mapping and possibly other documentation for the area affected by the sale. Please note that any Land Sales taking place on the Project Area will remain subject to the Forest Offset Protocol and Regulations, and therefore remain part of the Project. Should any portion of the Project Area be sold and wish to terminate the Project, the whole project will be considered terminated, as there is no provision which currently allows the Project Area to be divided into multiple projects. Once the Project Area for Improved Forest Management Projects has been verified, the Project Area cannot be changed for the duration of the Project's lifetime.

3. Natural Disturbances

Natural disturbance events can include beaver dams, windstorms, tornadoes, ice storms, floods, landslides, earthquakes, insect or disease infestations, or other impacts of weather or nature on the forest carbon stocks. Finite Carbon must be notified immediately following an event of this type. The forest owner will be required to supply mapping of the damaged area, and in some cases, a re-inventory of the original sample locations affected by the event performed to the specifications attached.

4. Harvests and Land Use Conversions

IFM projects typically encounter planned timber harvests, thinning, clearing for roadways, log yards, decks, or other uses on a regular basis. When these events occur, the forest owner is required to provide Finite Carbon with a digital (GPS or GIS) polygon file of the affected area. If harvest activities affect permanent plots, a complete re-inventory of those samples affected by the action may be required. All points re-inventoried will conform to the original specifications and shall be freshly flagged and painted for relocation. Finite Carbon shall also be informed if the activity produces or is expected to produce a forest type conversion. If the conversion is to non-forest use,

such as new road construction, these areas will be mapped and the correct adjustment to the project acreage and total carbon stocks will be made. All new inventory plot data should be submitted electronically in Excel or Access formats. All areas of timber harvest will be associated with a harvest volume summary.

Harvest volume summaries will be submitted to the project developer by species group (Hardwood/Softwood) and product (Sawtimber/Pulpwood), at a minimum. All harvest volume summaries must be verifiable from mill/contractor receipts (pay-as-cut sales) and/or prospectus cruises (lump-sum sales).

Annual Inventory Updates

Carbon accounting within the project area will require accurate harvest shapefiles and volumes. The harvest polygons will be intersected with the project area shapefile to prorate the harvest volumes to the project area. This will allow for the quantification of carbon in harvested wood products from timber cut within the project area.

Post-harvest updates to project spatial data and the corresponding carbon stocks in those areas will be handled in one of two ways depending on the verification needs of the project for the current reporting period:

- For reporting periods subject to less-intensive verifications or deferring verification, updates to the project area stratification will be based on modeling. Treatments effects will be simulated based on the prescription provided by the forest owner (and following the requirements for using models to forecast carbon stocks established in Appendix B of the FOP). The end of reporting period carbon stocks in these areas will be calculated following the methodology outlined in Part VII.B. below. The resulting tCO₂e per acre will be allocated to the approximate acreage treated based on the harvest polygons to allow for accurate carbon quantification across the project area for each reporting period.
- For reporting periods subject to full site visit verifications, the stratification across the project area will be updated to reflect the changes that have occurred during the previous reported-only years and all or some of the inventory plots will be remeasured.

Additional OPO Monitoring Activities

There are several procedures the OPO currently implements to ensure that all relevant events are monitored, documented, and reported. First, the property is routinely monitored by several staff members and a hired consulting forester. These team members visually inspect the forest conditions and can report unplanned activities they were not aware of such as significant natural disturbances. For planned events, the OPO maintains a lands department consisting of staff dedicated to project coordination, deeds and records, and mapping/engineering. The lands department ensures that planned activities with respect to impact of carbon stocks are reported in a manner that conforms to the project's inventory methodology.

On-going monitoring by the forest owner and its forest managers will ensure Unintentional Reversals will be reported to ARB and where necessary, an inventory of affected portions of the forest will be inventoried to account for unintentional reversals that create a need for ARBOC replacement from the Forest Buffer Account. Inventory design to account for losses from unintentional losses will depend on the extent and intensity of the reversal should they occur.

Age Class

The Lyme Wisconsin Timberlands have been managed up until present on even-aged and selection cut harvest regimes. As part of OPO's normal record-keeping procedures, age class information is generally gathered through estimates of stocking level at the stand level. After harvesting, the remaining timber size class and stocking levels is evaluated and encoded appropriately. The age status (e.g. less than or greater than 20 years old) of these stands was verified informally by reviewing OPO-provided inventory data and current publicly available imagery during the project development process.

All OPO inventory records, including stocking class updates following harvest activities, are updated and maintained on an annual basis or more frequently as part of normal business procedures. Monitoring OPO's compliance with the COP stocking class distributions requirement will be achieved through querying OPO's inventory records combined with verification checks of imagery and field conditions.

Confidence Deduction

Offset Project Operators are required each year to apply a confidence deduction to the inventory of actual onsite carbon stocks based on field sampling (sample error based on the carbon in all carbon pools included in the forest carbon inventory calculated at the 90% confidence level). The confidence deduction must be updated each time the offset project is subject to a full, site visit verification, but must remain unchanged between verifications. If increased sampling over time results in a lower confidence deduction at the time of verification, the lower deduction must be applied to inventory estimates in the most recent reporting period subject to verification at that time. ARB or registry offset credits may be issued in the most recent reporting period for any verified increase in quantified GHG reductions and GHG removal enhancements associated with the new (lower) confidence deduction.

Conversely, if a loss of qualified sampling plots results in a higher confidence deduction, this higher deduction is applied to the inventory estimates in the most recent reporting period subject to verification at that time. Any resulting decrease in quantified GHG reductions and GHG removal enhancements from prior years as a result of the increased confidence deduction will be treated as an intentional reversal and must be compensated pursuant to the Regulation.

To determine the appropriate confidence deduction, Finite Carbon completed the following calculations:

1. Compute the standard error of the inventory estimate by strata (based on the carbon in all carbon pools included in the forest carbon inventory).
2. Multiply the standard error by 1.645.
3. Divide the result in (2) by the total inventory estimate (strata mean tCO₂e) and multiply by 100. This establishes the sampling error (expressed as a percentage of the mean inventory estimate from field sampling) for a 90-percent confidence interval.
4. Consult Table A.4 from the FOP to identify the percent confident deduction that must be applied to the inventory estimate for the purpose of calculating GHG reductions and removals.

Table A.4. Forest carbon inventory confidence deductions based on level of confidence in the estimate derived from field sampling.

Sampling Error (% of Inventory Estimate)	Confidence Deduction
0 to 5%	0%
5.1 to 19.9%	(Sampling Error – 5.0%) to the nearest 1/10 th percentage
20% or greater	100%

Monitoring Quality Control

Quality Control for this project is defined as a series of activities and documented procedures that serve to maintain an acceptable level of data quality for monitoring forest carbon stocks and demonstrating compliance with the Forest Offset Protocol. Quality control success will be measured by passing sequential sampling review by the verification body during the site visit.

Organization and Responsible Individuals

Individuals responsible for maintaining project operations have been defined in the Listing Form and listed under the forest owner's account information in both the Offset Project Registry account and the CITSS account. Any changes, including new contact information, will be updated to the account information immediately.

Document Control

Forest Owner and Finite Carbon will be responsible for maintaining critical documents and files that support forest carbon data collection and processing. All documents will be stored on company computers and back-up servers, as well as cloud-based data sharing folders, for a minimum of 15 years following the issuance of ARB Offset Credits related to each OPDR. The most critical documents and files necessary to be maintained include:

1. Offset Project Data Reports;
2. Project Inventory Methodology, including all requirements from the FOP Appendix A(b) (Appendix A);
3. Project geodatabase (GIS file geodatabase, Attachment I);
4. ROC/ARBOC Monitoring Calculation Worksheet; and
5. Harvest Wood Product Calculation Worksheets;

A change log specific to this monitoring plan to show updates made to raw inventory field data, inventory specifications, and data management and analytical systems will be recorded in the table below. When an update is made to the raw inventory field data or to the inventory methodology and calculations, it should be recorded in the Inventory File and Data Change Log. Modifications to inventory methodologies must be approved in advance by a third-party verification body and by ARB.

All edits and revisions to documents after project registration will be clearly marked and identified by placing a revision date or version number at the beginning of the document or within the name of the file. Outdated versions of documents will be archived. Other forms and documents required by ARB will be maintained and stored in the forest owner's account on the OPR software.

Central Data Repository

The ESRI personal geodatabase format will be used to store spatial and tabular project data. Built-in features of the geodatabase structure, such as domains (i.e. field value validation) and relationships, will help control data quality. Edits and updates will occur at the beginning of each reporting period to account for activities in the previous year unless an event such as a reversal occurs, in which case updates will take place and be reported to ARB in the required time frame. All results will be summarized in the Offset Project Data Reports.

Change Log

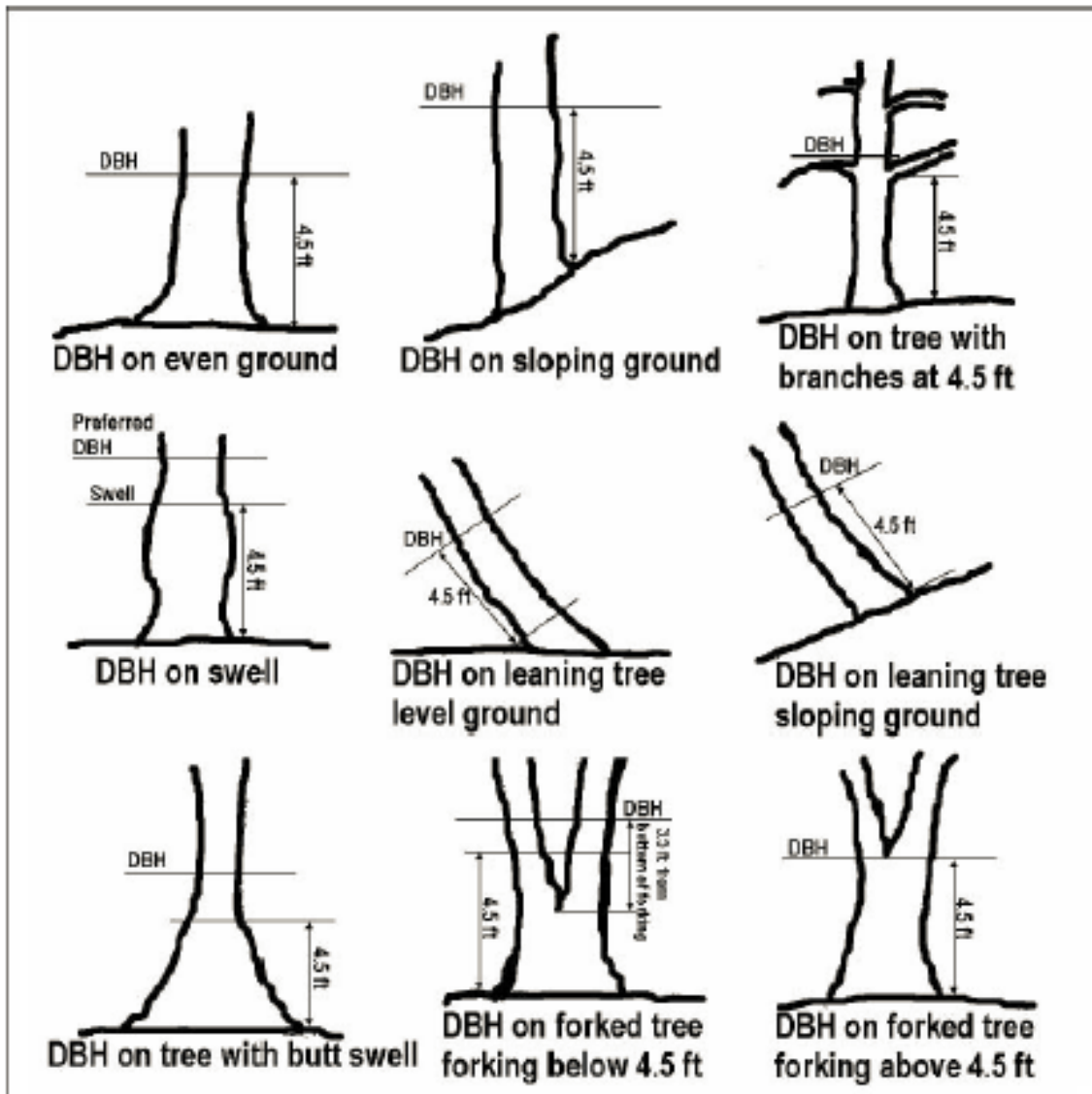
A unique number associated with change log record	Date change was made	This indicates the file that was updated	A full description of the update made
Change_ID	Change_Date	Change_Reference	Change_Description

Field Inventory References and Tables

DBH Establishment Locations

Cruisers are encouraged to use guide sticks 4.5 feet long or a measuring tape to ensure that DBH is measured at the correct height consistently. DBH locations shall be measured to the 4.5-foot height or alternative as noted below. A horizontal paint line is to be marked at the location of DBH.

DBH ESTABLISHMENT EXAMPLES



5.9.2 DIAMETER AT BREAST HEIGHT (DBH)

Unless one of the following special situations is encountered, measure DBH at 4.5 feet above the ground line on the uphill side of the tree. Round each measurement down to the last 0.1 inch. For example, a reading of 3.68 inches is recorded as 3.6 inches.

Special DBH situations:

1. **Forked tree:** In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 1.0 foot, between 1.0 and 4.5 feet, or above 4.5 feet.

- **Trees forked below 1.0 foot.** Trees forked below 1.0 foot are treated as distinctly separate trees (fig. 23). Distances and azimuths are measured individually to the center of each stem where it splits from the stump (fig. 26 A-C). DBH is measured for each stem at 4.5 feet above the ground. When stems originate from pith intersections below 1 foot, it is possible for some stems to be within the limiting distance of the microplot or subplot, and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 foot fork again between 1.0 and 4.5 feet (fig. 26-E), the rules in the next paragraph apply.

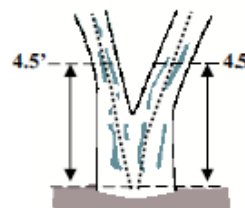


Figure 23. Forked below 1.0 ft.

- **Trees forked between 1.0 foot and 4.5 feet.** Trees forked between 1.0 foot and 4.5 feet are also counted as separate trees (fig. 24), but only one distance and azimuth (to the central stump) is recorded for each stem (fig. 26 D-F). Although a single azimuth and distance applies to all, multiple stems should be recorded as they occur in clockwise order (from front to back when one stem is directly in front of another). The DBH of each fork is measured at a point 3.5 feet above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 feet, the limiting distance is the same for all forks—they are either all on, or all off the plot.

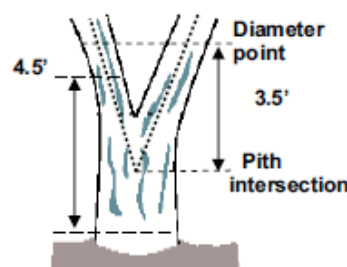


Figure 24. Forked between 1.0-4.5 ft.

Multiple forks are possible if they all originate from approximately the same point on the main stem. In such cases, measure DBH on all stems at 3.5 feet above the common pith intersection (fig. 26-F).

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 feet, do not recognize any additional forks that may occur on that stem. Measure the diameter of such stems just below the base of stem separation as shown in figure 26-E (i.e., do not move the point of diameter the entire 3.5 feet above the first fork).

- Trees forked at or above 4.5 feet. Trees forked at or above 4.5 feet count as one single tree (fig. 25). If a fork occurs at or immediately above 4.5 feet, measure diameter below the fork just beneath any swelling that would inflate DBH.

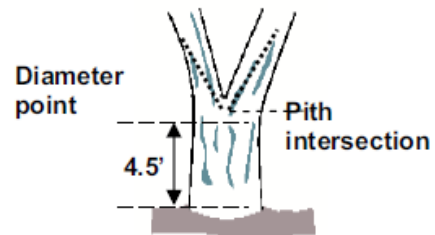


Figure 25. One tree.

2. Stump sprouts: Stump sprouts originate between ground level and 4.5 feet on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead bole. Stump sprouts originating below 1.0 foot are measured at 4.5 feet from ground line. Stump sprouts originating between 1.0 foot and 4.5 feet are measured at 3.5 feet above their point of occurrence. As with forks, rules for measuring distance and azimuth depend on whether the sprouts originate above or below 1.0 foot. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

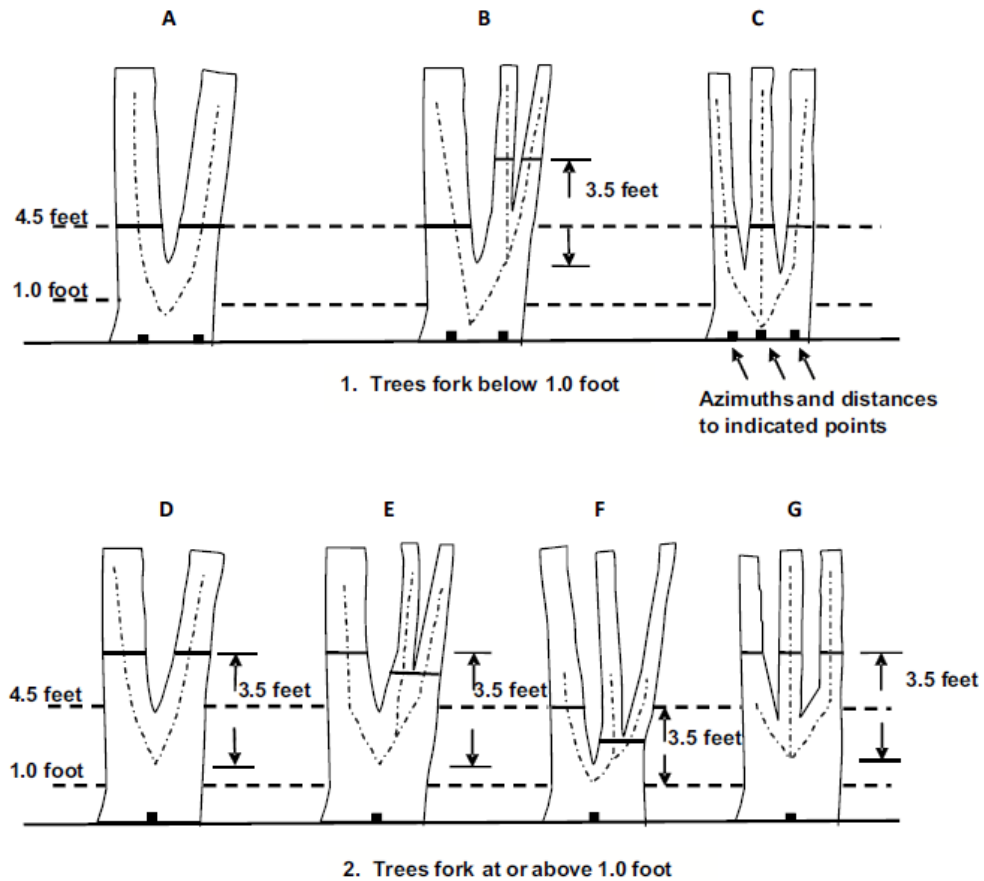


Figure 26. Summary of where to measure DBH, distance, and azimuth on forked trees.

3. Tree with butt-swell or bottleneck: Measure these trees 1.5 feet above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 feet or more above the ground (fig. 27).

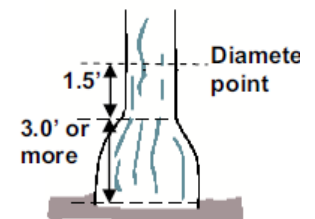


Figure 27. Bottleneck tree.

4. Tree with irregularities at DBH: On trees with swellings (fig. 28), bumps, depressions, and branches (fig. 29) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

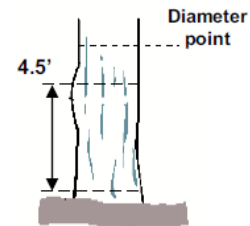


Figure 28. Tree with swelling.

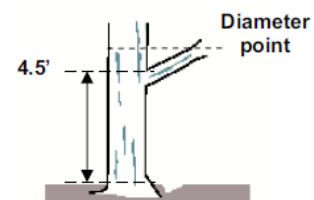


Figure 29. Tree with branch.

5. Tree on slope: Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (fig. 30).

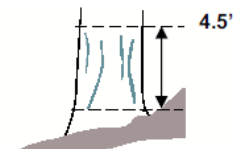


Figure 30. Tree on a slope.

6. Leaning tree: Measure diameter at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (fig. 31).

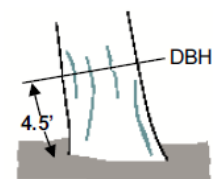


Figure 31. Leaning tree.

7. Turpentine tree: On trees with turpentine face extending above 4.5 feet, estimate the diameter at 10.0 feet above the ground and multiply by 1.1 to estimate DBH outside bark.
8. Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, set the "DIAMETER CHECK" code to 1, and explain the situation in the notes.

9. Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter, to the nearest 0.1 inch, of the wood and bark that is still attached to the tree (fig. 32). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (figs. 28 and 29).

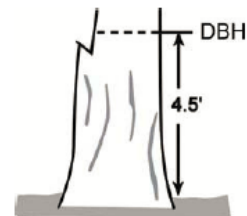


Figure 32. Tree with part of stem missing.

10. Live windthrown tree: Measure from the top of the root collar along the length to 4.5 feet (fig. 33).

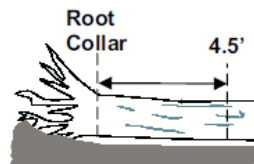


Figure 33. Tree on the ground.

11. Down live tree with tree-form branches growing vertical from main bole: When a down live tree, touching the ground, has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.
 - If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 34).
 - If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.

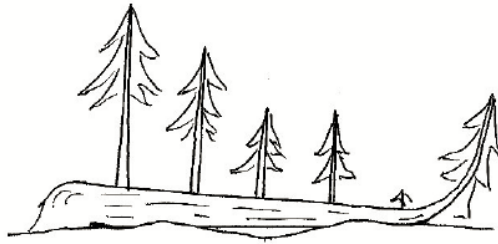


Figure 34. Down tree above duff.

- If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.
- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (fig. 35). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

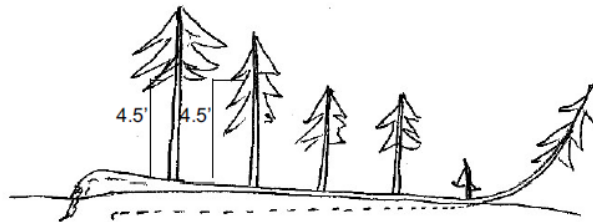
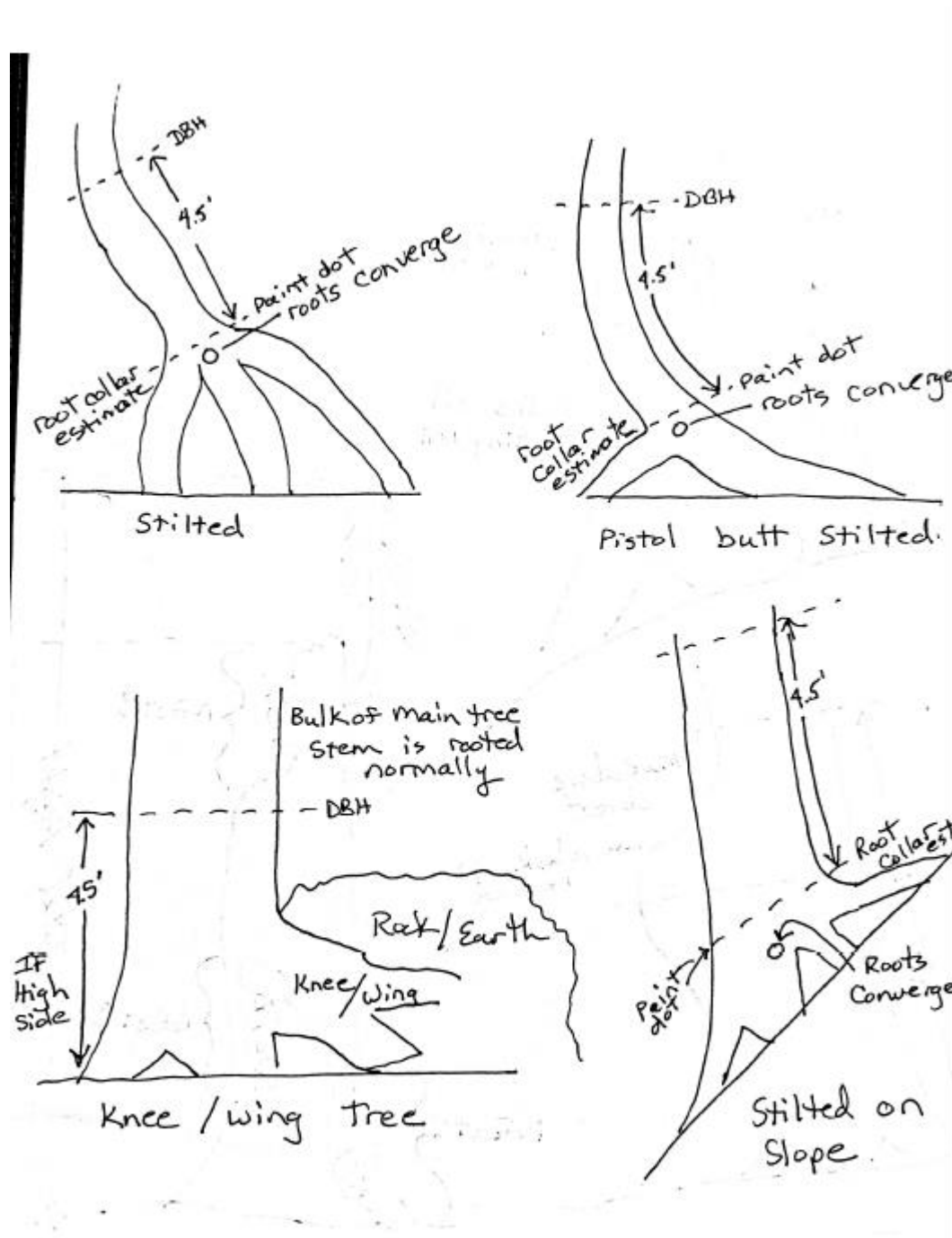
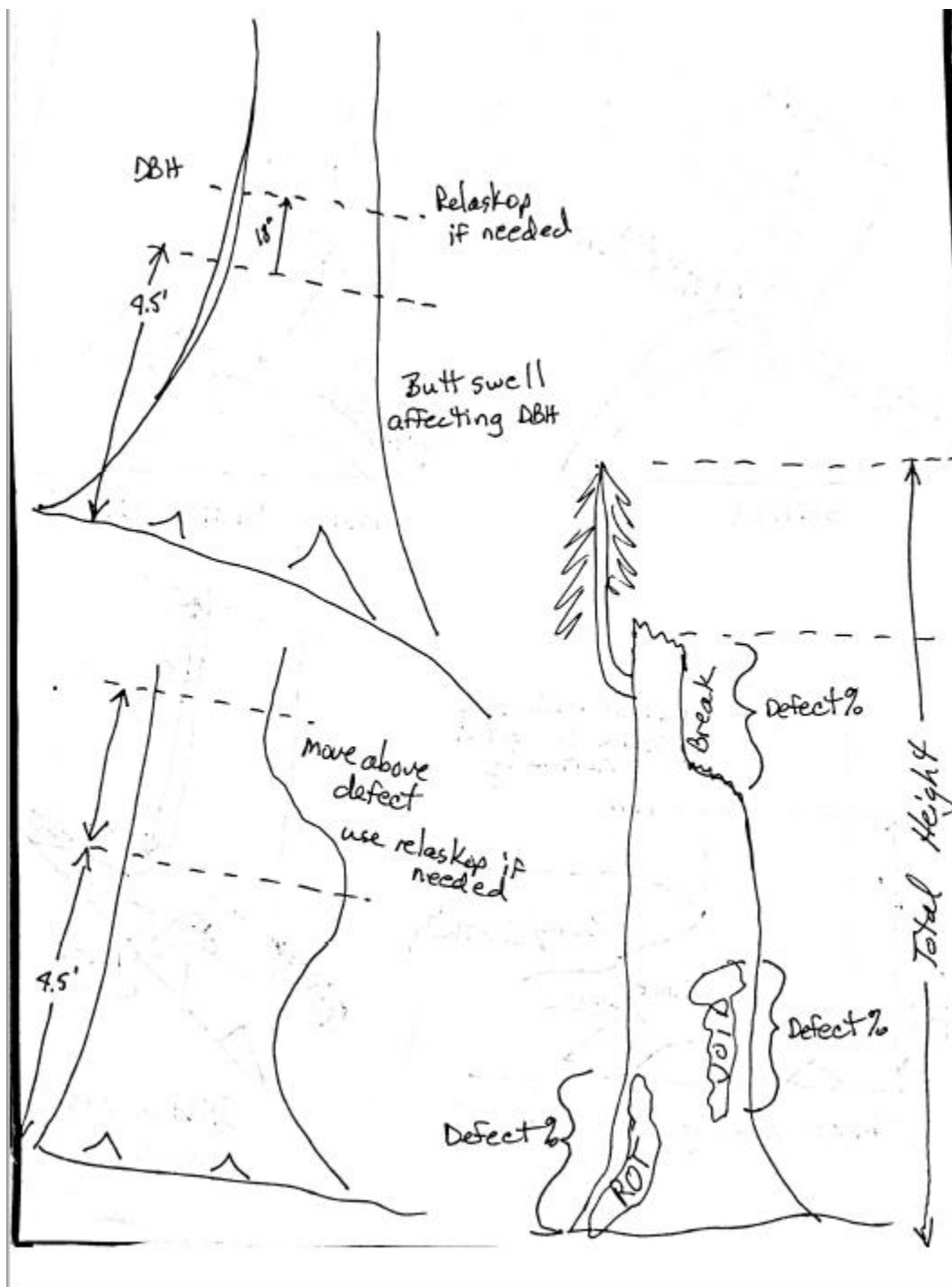
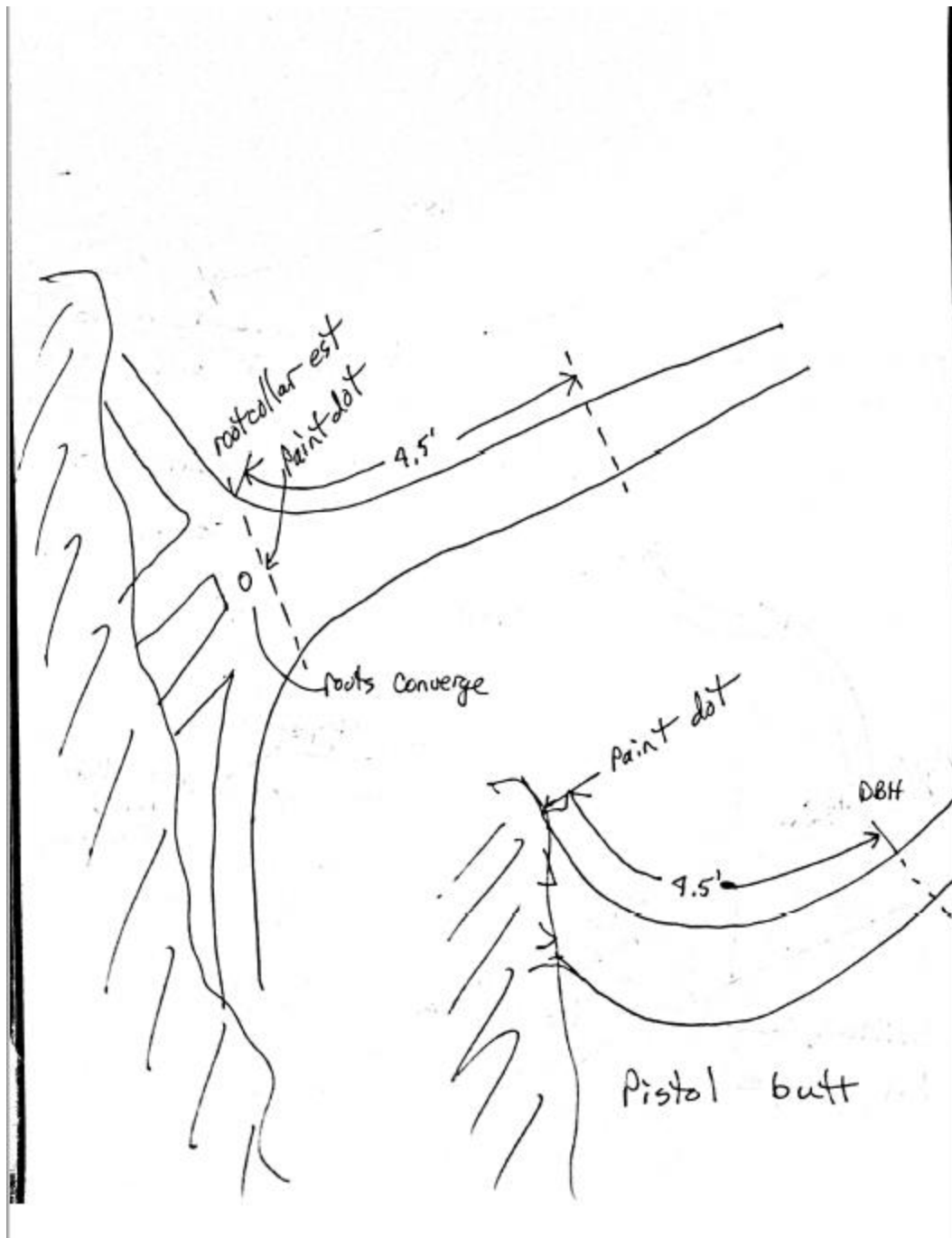


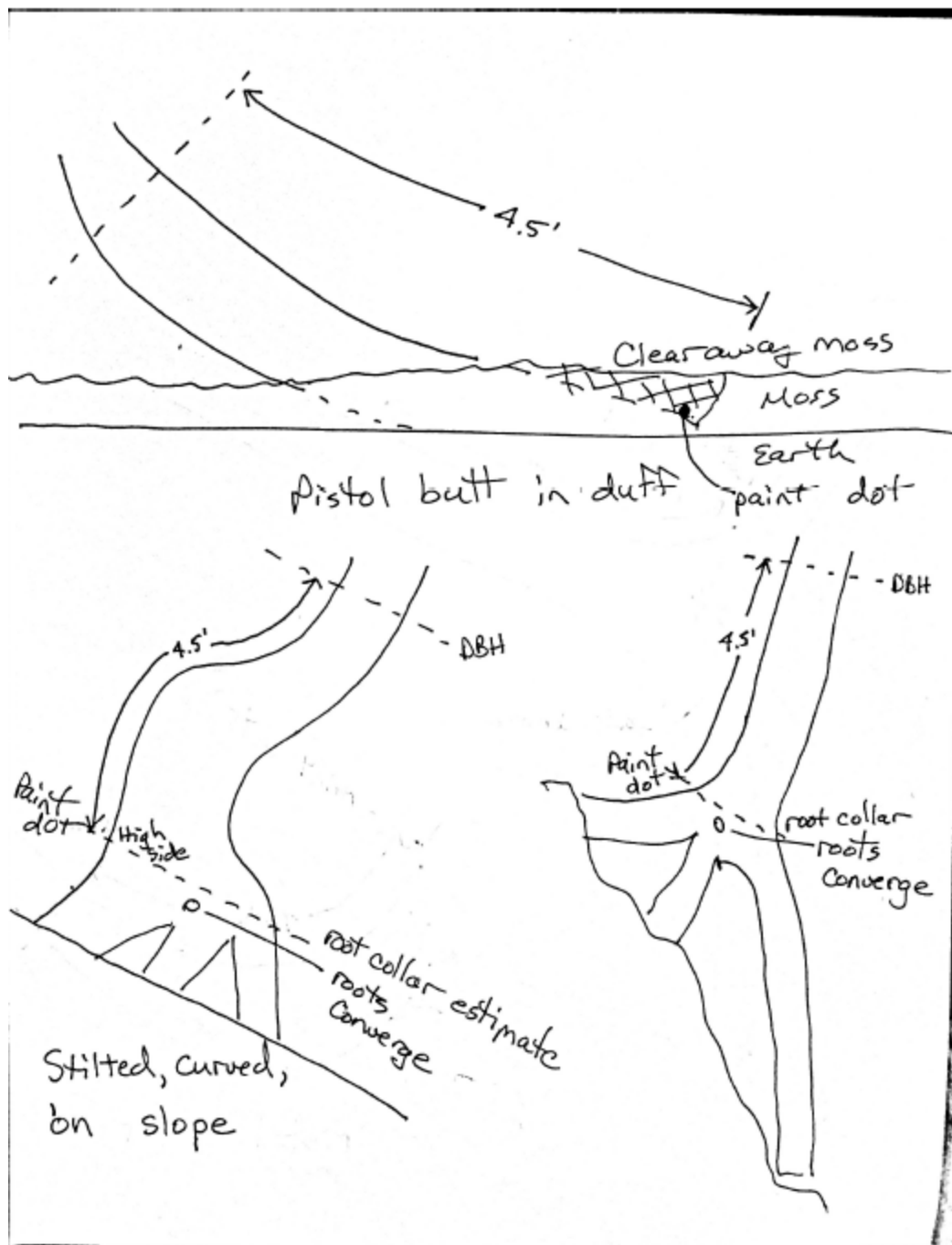
Figure 35. Down tree below duff.

DIAMETER BREAST HEIGHT (DBH) – Stilted Roots









Percent volume allocation chart for soundness deductions (USDA Forest Service Tech Note 347, 1943):

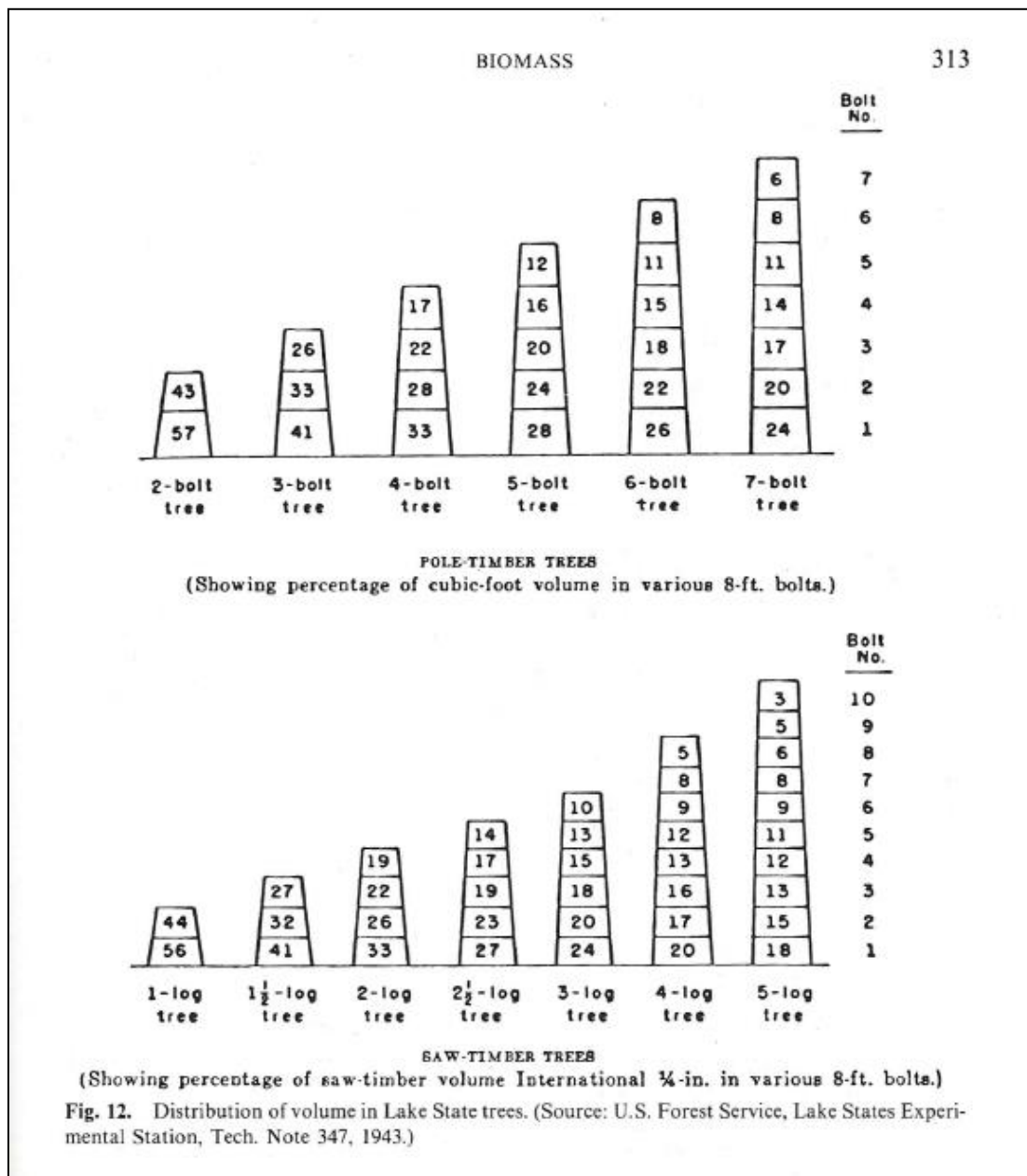


Figure 5. Soundness Deductions

Example: Cruiser has tallied a 2-log saw-timber tree and estimates there is a cavity representing 25% of the 4th bolt. The soundness deduction is recorded as 5% ($19\% \times 25\% = 4.75\%$ rounded to the nearest percent = 5%)

Table 21. Slope Correction Table

Percent of Slope	Degree of Slope	Correction Factor
0 to 9	0-6	1.00
10 to 17	7-10	1.01
18 to 22	11-12	1.02
23 to 26	13-14	1.03
27 to 30	15-17	1.04
31 to 33	18	1.05
34 to 36	19-20	1.06
37 to 39	21	1.07
40 to 42	22	1.08
43 to 44	23	1.09
45 to 47	24	1.10
48 to 49	25-26	1.11
50 to 51	27	1.12
52 to 53	28	1.13
54 to 55	29	1.14
56 to 57	29	1.15
58 to 59	30	1.16
60 to 61	31	1.17
62 to 63	32	1.18
64 to 65	33	1.19
66 to 67	34	1.20
68 to 69	34	1.21
70	35	1.22
71 to 72	36	1.23
73 to 74	37	1.24
75	37	1.25
76 to 77	38	1.26
78 to 79	38	1.27
80	39	1.28
81 to 82	39	1.29
83	40	1.30
84 to 85	40	1.31
86	41	1.32
87 to 88	41	1.33
89	42	1.34
90 to 91	42	1.35

Percent of Slope	Degree of Slope	Correction Factor
92	43	1.36
93 to 94	43	1.37
95	44	1.38
96 to 97	44	1.39
98	44	1.40
99 to 100	45	1.41
101	45	1.42
102	46	1.43
103 to 104	46	1.44
105	46	1.45
106 to 107	47	1.46
108	47	1.47
109	47	1.48
110 to 111	48	1.49
112	48	1.50
113	48	1.51
114 to 115	49	1.52
116	49	1.53
117	49	1.54
118 to 119	50	1.55
120	50	1.56
121	50	1.57
122	51	1.58
123 to 124	51	1.59
125	51	1.60
126	52	1.61
127 to 128	52	1.62
129	52	1.63
130	52	1.64
131	53	1.65
132 to 133	53	1.66
134	53	1.67
135	53	1.68
136	54	1.69
137 to 138	54	1.70
139	54	1.71
140	54	1.72

Percent of Slope	Degree of Slope	Correction Factor
141	55	1.73
142 to 143	55	1.74
144	55	1.75
145	55	1.76
146	56	1.77
147	56	1.78
148 to 149	56	1.79
150	56	1.80

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