A Field Analysis of Riparian Site Attribute and Stand Inventory Data from Approved Forest Practices Applications Along West-Side Type F Streams

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Report

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[1] Both authors were employed as CMER staff by the Northwest Indian Fisheries Commission when field data were collected January to March, 2006.

Forest Practices Adaptive Management Program

The Washington Forest Practices Board (FPB) has adopted an Adaptive Management Program (AMP) in concurrence with the Forests & Fish Report (FFR) and subsequent legislation. The purpose of this program is to:

> Provide science-based recommendations and technical information to assist the FPB in determining if and when it is necessary or advisable to adjust rules and guidance for aquatic resources to achieve resource goals and objectives (Forest Practices Rules, WAC 222-12-045).

To provide the science needed to support adaptive management, the FPB made the Cooperative Monitoring, Evaluation and Research (CMER) committee a participant in the program. The FPB empowered CMER to conduct research, effectiveness monitoring, and validation monitoring in accordance with guidelines recommended in the FFR.

Disclaimer

This technical report contains scientific information from a research study designed to evaluate the effectiveness of the Forest Practices Rules in achieving one or more of the Forests & Fish performance goals, resource objectives, and/or performance targets. The document was prepared for CMER and was intended to inform and support the Forest and Fish Adaptive Management Program. The project is part of the Type F Riparian Prescriptions Rule Group DFC Validation Program, and was conducted under the oversight of the Riparian Scientific Advisory Group (RSAG).

This document has been reviewed by CMER and has been assessed through the Adaptive Management Program's independent scientific peer review process. CMER has approved this document for distribution as an official CMER document. As a CMER document, CMER is in consensus on the scientific merit of the document. However, any conclusions, interpretations, or recommendations contained within this document are those of the authors and may not reflect the views of all CMER members.

Proprietary Statement

Full Reference

McConnell, S., and J. Heimburg. 2010. A field analysis of riparian site attribute and stand inventory data from approved forest practices applications along west-side type F streams. Cooperative Monitoring, Evaluation and Research Committee Report CMER 10-1003. Washington Department of Natural Resources, Olympia, WA.

ABSTRACT

Fifteen of the 150 riparian stands analyzed in the Desktop Analysis study (McConnell, 2010) were randomly selected for a field validation of site attribute and stand inventory data that landowners (LOs) collect and submit with their Forest Practices Applications (FPAs). These data are entered to the DFC Model. The purpose of this "Field Check" project was to ensure that LO-collected data were reliable input data for the Desktop Analysis study.

Data were collected between January and March, 2006 by a two- person crew employed by Cooperative Monitoring, Evaluation and Research (CMER). This crew collected more detailed stand inventory data than was required of LOs. Specifically, trees were recorded by species rather than type (conifer or hardwood), breast height diameter (dbh) was measured to the nearest 1/10 inch rather than 2-inch dbh classes using ocular estimates; tree status was recorded by categories of live, dead, cut or windthrown rather than counting and tabulating live trees only. To estimate dbh of harvested trees, standing live trees were measured at both dbh and stump height and equations for estimating dbh of cut trees from residual stumps were developed.

Site Class was determined from maps available from the Washington Department of Natural Resources (WDNR) using the Forest Practices Application Review System (FPARS). Stand age was determined by coring live trees and/or counting annual growth rings in stumps. Tree ages were adjusted to stump height on live trees and time since cutting on stumps. RMZ length was estimated by measuring the length of the core/inner zone boundary with a string box. Stream size (bankfull width) was determined using Board Manual guidance. Major species was determined from stand data to determine which of Douglas-fir or western hemlock had a higher proportion of stand basal area.

Data are compared graphically or in tables, and context and dimensions of differences and/or similarities are discussed. No tests for statistical differences were conducted. In general, site attribute data and tree diameter distributions within the core and inner zones as measured by both CMER and LOs were sufficiently similar given the context of the DFC Model sensitivity analysis (Roorbach et al., 2006) to variability in inputs. Given that the 15 stands randomly sampled for this Field Check study were from the total random sample of 150 approved FPAs, we concluded that LO-collected data were sufficiently reliable as a data source for the Desktop Analysis study.

While collecting these data, we discovered incomplete or inaccurate guidance from the Board Manual, Rules and the DFC Model Instruction sheet to implement RMZ layout for some attributes, in particular "major species", "RMZ length" and "stream size". These problems are referred to in this report, and are described in detail in the "Model and Manual" report (McConnell and Heimburg, 2010).

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INTRODUCTION

The “Forest Practices Application (FPA) Field Check” study was implemented in 2006 to assess the reliability of landowner (LO)-provided data used in the DFC Model “Desktop Analysis” report (McConnell, 2010). Forest landowners (LOs) proposing timber harvest from the inner zone of riparian forests along west-side Type F streams are required to collect site attribute and stand inventory data, run these data through the DFC Model, and include the DFC Worksheet and outcomes of the DFC Model runs with their Forest Practices Application (FPA). The reliability of these data was unknown. The “Field Check” study was implemented to resolve the uncertainty about reliability of LO collected data reported in FPAs.

Study Design and Context

This study was designed as an exploratory pilot study to determine how similar (or variable) LO-collected data were to data independently collected to a more rigorous standard and one to three years after the LO data were collected. The focus of this study was on evaluating the amount and kinds of variability that exist among LO-collected data and between LO- and CMER-collected data.

At the time this study was implemented (January 2006), no independent in-field assessment of LO-collected data had been made. The Compliance Monitoring Program was not yet established and results were not yet available from a sensitivity analysis of the DFC Model (Roorbach et al., 2006) which later identified model attributes that were more and less important to DFC Model projections. There was, therefore, no basis for setting *a priori* decision criteria for the amount of difference from the CMER-collected data that would constitute an acceptable deviation.

Decision Criteria Used for Accepting Data for Use in the Desktop Analysis Report

The criteria used to assess results, therefore, were broken down into two categories. First we considered whether the data provided by LOs reflected a stand condition that could occur from real data and therefore represented a valid test of DFC Model outputs, EVEN IF there were differences between the site and stand attribute data collected by LOs and CMER. This criterion was established in context of the purpose and objectives of the Desktop Analysis study which was very narrowly focused on understanding model mechanics and did not make inferences about other characteristics or qualities of the data other than how the model behaved under a variety of site-attribute and stand conditions. With this in mind, we considered stands that had data that was reflective of the actual stand to which it was associated to be acceptable for the purpose of using as data for the Desktop Analysis Report. The results of the Sensitivity Analysis (Roorbach et al, 2006) provide quantitative support for this decision; findings of that study show that even differences in tree count of 10 to 20%, and harvest age diameters that differed by as much as 1 or 2 diameter classes (a 2” to 4” inch shift) resulted in stand age 140 bapa differences of less than 10%. Thus even stands that appeared to have differences between LO- and CMER-collected data but appeared to represent a valid set of conditions with which to evaluate DFC Model mechanisms were accepted.

Decision Criteria Used to Identify Systemic Problems in Data Collection Methodologies

The second category of acceptance we used was whether or not the LO-collected data were similar to and consistent with data collected by CMER, and if not, why not. The criteria developed for this test of acceptance was the genesis of an additional report to this package of reports, the Model and Manual Report (McConnell and Heimburg 2010). Soon after work began on evaluating field sites it became apparent that the materials available to provide guidance on how to collect site- and stand-attribute data were often confusing, incomplete, vague and contradictory between sources. There was therefore difficulty in identifying an attribute collected as “wrong” while direction to obtain a “correct” measure was lacking and there were no established criteria for what deviation was considered to be acceptable for a given attribute. Furthermore, for some measurements, for example RMZ length, no methodology was prescribed for how to mark start and end points, how to measure the distance (measure stream length, sinuousity and all? Measure the outer edge of the outer zone? Use an aerial photograph to estimate length? Use a hip chain?). Site-attribute and stand characteristic data were not explicitly accepted or rejected in this report. Rather, different outcomes were identified and discussion provided on why different results may have been obtained. Methodological problems identified that may result in variable results continuing to occur as a result of systematic problems were discussed in more detail in the Model and Manual Report (McConnell and Heimburg, 2010) previously referenced.

Enough differences between data sets were identified that use of the LO-collected data for purposes other than DFC Model projections should be viewed circumspectly. The number of small vs. large streams by DNR Region, for example, were presented in Appendix A of the Desktop Analysis report. With uncertainty over the reliability with which LOs accurately distinguish small and large streams, making comparisons that rely on these data may not be appropriate. Presumably response to problems identified in this study and processing data gathered from the now-robust compliance monitoring program will result in Board Manual and other guidance that will result in more uniform implementation of rules so that site-attribute data can increasingly be relied on and used as the valuable data source that it should be.

Rationale for the Analysis Approach Used

The primary objective of the study was to compare site-attribute and forest stand data collected by LOs and CMER. Because the study is both exploratory in its design and a pilot study in its intent, it was agreed by stakeholders that the comparison of LO vs. CMER crew data would not be compared using inference tests and statistical tools but that comparisons would instead be made using graphical and tabular presentations of data. The rationale for not making statistical comparisons includes:

LO data were collected one to three years before CMER data were collected and some changes to stand conditions would have occurred between collection dates. Expected changes include the following: a) additional diameter growth on trees counted by Los, changing the diameter class into which trees would be placed, b) ingrowth – trees too small to be counted previously growing to a dbh that would qualify them for inclusion in the tree count, c) mortality of some overstory trees attributable to windthrow or other causes, d) problems finding stumps where inner zone timber harvest had occurred and, e) problems with estimating dbh of harvested trees from their residual stumps precluding meaningful comparisons of breast height diameters.

Some data, in particular the tree data, were collected to different degrees of resolution. LOs are required to collect tree data to the nearest 2" diameter class recording only species type (conifer or hardwood) while the CMER crew documented tree species and measured and recorded tree dbh to the nearest $1/10^{th}$ inch. Varying both the data collection method and the time at which data were collected and conducting statistical analyses of these data would not establish real differences between data nor provide insights into why differences were obtained, e.g. whether it was the different time at which data were collected or the different approach used that accounted for differences found.

Not all objectives of research used to inform an Adaptive Management Program are addressed well by the standard scientific approach of establishing clear hypotheses and testing differences to a determined level of statistical certainty. The data compared in this study, in particular the tree data, are used in a model that provides an estimate of stand age 140 bapa (bapa) DFC Targets and is recognized to be an imperfect estimator of those Targets. Additionally, the DFC Model is known to simulate compensatory growth Roorbach et. al, (2006), e.g., if the tpa estimate is high by a few trees, the model simulates growth of individual trees that is slightly lower and basal area growth measured at stand age 140 is more or less similar (and the reverse is true if the original tpa estimate is low). This compensatory growth is consistent with silvicultural research and with the behavior of other forest stand growth and yield models. The importance, therefore, of having harvest-age LO-supplied data that is similar to the data collected by CMER is a more important question than whether the harvest-age data collected are similar to a given level of statistical certainty.

An AMP is a politically charged environment in which to conduct research. People often look at statistical significance as providing evidence that a particular finding is both definitive and important when, in fact, that might not be the case. It would also be easy for people who are not closely associated with the AMP to latch on to a finding of differences between data sets and unknowingly (or otherwise) misrepresent a given finding that does not represent the objectives of the study from which the finding was developed. Given that in this study there were serious impediments to obtaining data sets that could be meaningfully compared, no biological question that is better addressed by making statistical comparisons, and reasonable concern over how findings would be used, making comparisons that involved statistical significance testing seemed both unnecessary and possibly counter-productive, hence, the decision to rely on graphical and tabular data comparisons.

Development of Model and Manual Report Objectives

An important but unplanned component of the Field Check report was to document challenges encountered in laying out riparian zone timber harvest units, or in our case, in replicating this work. Inconsistent or unclear direction provided to LOs in the Forest Practices Board Manual (WFPB 2001a), Forest Practices Rules (WFPB 2001b), directions for collecting data for and using the DFC Model (WDNR 2001) and) instructions for completing western Washington Forest Practices Application/Notification (WDNR 2007) were noted. Improvements that could help to increase reliability of the data collected and increase consistency between LOs are addressed in this report and described in more detail in the Model and Manual report (McConnell and Heimburg, 2010). In particular, data attributes for which standard data collection procedures are needed are described.

Data collection for the Field Check study (this report) and Model and Manual Report (McConnell and Heimburg 2010) was limited to site attributes and stand inventory data that are required to run the DFC Model. These are: 1) stream size, 2) Site Class, 3) major species (Douglas-fir or western hemlock), 4) riparian management zone (RMZ) length, 5) stand age, and 6) stand inventory, e.g., the number of hardwood and conifer trees with a minimum 5” diameter at breast height (dbh), by 2” size classes (e.g., 5” to 6.9” = 6” diameter class, 7” to 8.9” = 8” diameter class, etc.). The Desktop Analysis report (McConnell, 2010) has a thorough description of how these site and stand attributes are used to determine stand eligibility for inner zone timber harvest and assigning specific prescription details to each harvest-eligible stand.

OBJECTIVES

There are both primary and secondary objectives for this study.
The primary objectives are to:

1. validate[2] the stand and site attribute by collecting site inventory and stand attribute data required to run the DFC Model, from each site, and compare results (pre-harvest and DFC Model- calculated post-harvest) graphically and tabularly to the LO-collected data, and,
2. use the data collected from the riparian stream segments represented by the FPAs selected for this study to run the DFC Model and compare DFC Model-projected stand age 140 bapa outcomes using the LO-collected data from the original FPA.

An unplanned secondary objective that was adopted soon after the study began was to:

1. evaluate for completeness, accuracy and repeatability, methodologies used to measure, determine and/or quantify site- and stand-attribute data that LOs are required to collect to implement the DFC Rules and use the DFC Model. These attributes include: a) RMZ length b) stand age, c) stream size and, d) major species.

METHODS

Sampling Strategy

<u>Site selection</u>

Fifteen FPAs were randomly selected from the 150 FPAs used in the "Desktop Analysis" study. The methodology used to select the 150 FPAs used for the "Desktop Analysis" study is described in detail in that report (McConnell 2007). The selection of the 15 stands for this study (Field Check) was done by randomizing the 150 FPAs used in the Desktop Analysis and using an equal probability unstratified random selection without replacement.

Stand and site information reported by LOs on their approved FPAs was obtained by accessing the Forest Practices Application and Review System (FPARS) portion of the DNR website http://www3.wadnr.gov/dnrapp4/fparsweb/public/Default.aspx and downloading scanned copies of FPAs using the Adobe Reader and saving them as .pdf files.

<u>Sample Size Rationale</u>

The basis for subsampling15 sites (FPAs) is simply to have a 10% sample of the FPAs to be used in the Desktop Analysis; this was considered to be a "reasonable" sample size. Additionally, visiting this number of sites was affordable and would provide results back to the AMP within a reasonable timeframe. Because this was an exploratory pilot study intended to provide information about how much variability there were in LO-collected data and no statistical tests were going to be used to compare data, there was no intention to base sample size on achieving

[2] CMER typically uses the word "validate" to indicate an intention to make comparisons. This does not signal an intention to try to establish that the conditions created as a result of rule-implementation are "right". It's use derives from the context within which CMER research is conducted in relation to evaluating rules and providing information to Policy for their use in determining how rules are working and whether there may be need to make changes to rules based on the data collected and information provided to Policy based on these data. One of the first tasks for a CMER research project is to determine whether a rule prescription is effective and works as intended. CMER studies will typically have a treatment that reflects the current rule in any research project implemented. In an AMP, comparisons between treatments will be made objectively based on scientific criteria, but the comparison that is often of most interest because of possible implications to rules, is the comparison against the current rule. The policy-appropriate way to posit comparisons is to "validate" the current rule because a rule change would be premised on a finding that the current rule is not working. Thus, not all hypotheses are equal in standing and interest. We used validate in this study with this AMP common practice in mind. Our use of "validate" does not indicate a presumed or actual disposition on the part of report authors to report findings that support LOs or current rules.

some level of statistical resolution. Sample size was determined entirely by anticipated use of the data, along with budgetary and logistical constraints.

Scheduling

All data were collected between January and March, 2006; therefore, scheduling site visits required preparing for and working around weather that could make some sites inaccessible. We determined elevation for each study site and made it a priority to go to high-elevation sites when they were snow-free. Site-attribute data (Table 1) were used to plan and prioritize sampling trips. RMZ length and the number of trees LOs reported, in particular, were used to indicate how long it might take to sample each site. While the attributes in Table 1 served an important data-collection planning tool, we obtained different values for most of these attributes during sampling. These data are presented in the Results and Discussion section of this report. Only one of the stands originally selected was inaccessible (because of snow), requiring us to select the next stand on the list to replace it.

Table 1 – Site and stand attributes of the 15 stream segments evaluated in the "FPA Field Check Study" from landowner-provided data contained in DNR-approved FPAs. For DNR Region, SPS = South Puget Sound, PC = Pacific Cascades, and OLY = Olympic. For stream size, L = Large (> 10'), S = small (≤ 10'). For Major Species, DF = Douglas-fir, WH = western hemlock. Elev = Elevation. For Harvest Option used, an (*) indicates that stands were not yet harvested at the time of the CMER data collection visit.

Site #	Age (yrs)	DNR Region	Stream Size	Site Class	Major Species	RMZ Length (ft)	FPA Year	Elev (ft)	Harvest Option used
3	55	SPS	L	2	DF	1700	2003	1200	2
6	55	SPS	L	2	DF	2750	2003	1400	2
8	64	SPS	L	3	DF	1350	2004	800	2
11	58	SPS	S	3	DF	3320	2004	2600	*
45	51	PC	S	3	WH	650	2003	300	2
57	40	PC	S	3	DF	600	2004	800	2
61	50	PC	S	3	WH	1400	2004	100	2
66	62	PC	L	4	DF	290	2004	1800	1
87	53	OLY	L	3	WH	1370	2003	1500	1
89	51	OLY	L	3	DF	1150	2003	500	1
98	45	OLY	S	4	WH	325	2004	200	1
103	39	OLY	S	3	WH	304	2004	300	*
120	40	PC	S	2	DF	1015	2003	2000	2
130	45	PC	S	3	DF	555	2004	2000	2
140	47	PC	S	2	DF	800	2004	300	*

Data Collection

Stream size

After we found clear evidence[3] that we were at one end of the portion of the RMZ segment reported in the FPA (e.g. a start point), we evaluated stream size and either noted our concurrence

[3] This is discussed later in the report. There was often no "clear evidence" of where start and end points were as rules do not require that these be clearly marked. We found that often LOs tied double ribbons to mark end points but even then, the location of an end point could vary by up to 50' (25' in either of 2 directions) simply based on where there were tree branches available to hang flagging upon in relation to the RMZ end point used. For short RMZ's, the difference attributable just to this factor could make a big

with the call made by the LO or, in some cases, further evaluated this as we worked. Forest Practices Board Manual Section 2: "Standard method for identifying bankfull channel features and channel migration zones" was used to delineate stream size.

Site Class
Site class was verified before going to each site using the FPARS website and the legal coordinates (section, township and range) provided in each FPA.

Major species
Major species was determined from the stand inventory data we collected to determine which of Douglas-fir or western hemlock comprised a higher percentage of the total basal area of each stand[4].

RMZ length
At each site, our first task was to locate a start point at one or the other end of the riparian stand segment reported in the FPA. Once we found clear evidence that we were at a start point we marked the boundaries of the areas from which we would collect stand inventory data, the core and inner zones, and along which we would measure RMZ length. We marked the boundary between the core and inner zones going in one direction and the boundary between the inner and outer zones in the other (see next section for details). The person walking the core/inner zone boundary carried the string box and recorded the distance (our measure of RMZ length) when the end of the unit was reached.

Stand inventory

Step 1 – marking core and inner zone boundaries

The core and inner zone boundaries were delineated as follows. Working from the point that marks the up or downstream extent of the DFC stream segment, we marked the core/inner zone boundary by having one person walk the stream edge holding a pole with a reflector attached over the outer edge of bankfull width or the outer edge of the Channel Migration Zone (CMZ), whichever was farther from the thalweg. The other person sighted on the reflector with a laser range- finder and positioned themselves 50' horizontal distance from the reflector and tied a flag at that spot marking one point along the core/inner zone boundary. Additional horizontal distance measurements of core zone width (50') were made along the RMZ segment at distance intervals that varied depending on site-specific conditions that affected visibility including topography, vegetation and windthrow. A clearly marked core/inner zone boundary was established from one end of the RMZ segment to the other by flagging a line at and between points at which core zone width was measured. The person walking the stream edge and centering the reflector pole over the appropriate location adjacent to the channel also tied a ribbon line along the CMZ where one was present. When the flag lines marking the CMZ and the core/inner zone boundary were in place, the reflector pole was moved to the core/inner zone boundary line and the person with the laser range- finder moved to the outer edge of the inner zone (width varies by stream size and site class) and flagged the inner/outer zone boundary ..

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difference in proportion to their size and substantially affect area-related calculations made by the DFC Model including tpa and bapa.

[4] At the time we did this study, there was no written guidance provided for making the major species determination so we used basal area per acre. Board Manual Section 7 "Guidelines for Riparian Management Zones" was updated in February, 2010. Direction provided now calls for this determination to be made on the basis of number of stems. Whichever of Douglas-fir or western hemlock has more stems is determined to be the "major species".

Step 2 – collecting stand inventory data

Stand inventory data was collected by measuring dbh of every tree using a Spencer tape, one side of which was calibrated to measure diameter in tenths of an inch. Working as a pair, we inventoried one zone at a time, usually starting with the core zone. Typically, one person measured dbh and reported other tree characteristics, e.g. status (live, dead, windthrow or stump) and species, to the person recording data. The person recording data was responsible for keeping track of trees measured as the team progressed through the zone.

We measured windthrown trees at breast height as if the tree were still standing, sometimes digging a trench underneath to pass a tape through. Where down trees or other obstacles prevented a measurement at "breast height" the closest accessible point to this was measured. Only recently windthrown trees that we believed were standing when LOs made their stand inventory were counted as windthrow.

Where trees had been cut, stump diameters were recorded and a dbh calculated using sample data we collected of dbhs and stump-height diameters from standing live trees of the tree species we encountered (Appendix A). Stumps frequently were irregularly shaped. We attempted to account for this by taking two measurements across the surface of the stump at 90^{o} angles and averaging these. Stump diameters were recorded to the nearest 0.05 foot. We measured every live tree 5" dbh or greater. Minor tree species (black cherry, black cottonwood, Pacific crab apple, cascara sp., flowering dogwood and vine maple) accounted for a very small percentage of total stems. We measured and recorded these but excluded them from our stand inventory analysis because we presumed LOs would not have included these in their inventory. We recorded recently dead trees by species but did not include these data in our analyses except where specifically noted.

Stand age

We determined stand age by either coring standing live trees at breast-height and counting annual rings or by counting rings on the stumps of trees that were cut when the stand was harvested. Adjustment factors were applied in both approaches. For cut stumps, two years were added to the age counted to account for growth to stump height. For cored trees, ages were adjusted by tree species and site class. For Douglas-fir, by site classes 2, 3 and 4, respectively, 7, 8 and 9 years were added to the age counted on the tree core collected at breast height as per King (1966). For western hemlock on site classes 2, 3, and 4, respectively, 6, 7 and 8 years were added to the breast height tree age counted as per Barnes (1962). When coring trees if the core did not go through the pith, we interpolated based on the configuration of rings and our estimate of how many rings we had missed by not reaching the pith.

We noticed after this study was completed that the Board Manual specified procedure for adjusting increment core age to total age is to add 5 years to dbh measured age, regardless of species or site class. We compared DFC Model outputs obtained using our methodology to the Board Manual-directed approach (Appendix B).

DFC Model comparisons

The DFC Model was used to compare three projected outcomes of data collected by LOs and by us: a) pre-harvest stand conditions, b) post-harvest stand conditions, and c) projected stand age 140 bapa. DFC Model use is described in detail in the Desktop Analysis report (McConnell, 2010).

RESULTS

We first compare CMER- and LO-collected site- and stand-inventory attributes collected from the sample RMZ segment identified in each FPA. Then we compare DFC Model-projected outcomes from our data with those in the original FPA.

As noted in Objectives (above) we had both primary and secondary objectives. The secondary objectives were formulated based on ideas we had about possible problems we might encounter with stand configurations that might not fit the objectives of DFC Rules or methodological problems we encountered that might limit the reliability of riparian data collected. We found that there were problems with measuring RMZ length, stand age, determining major species and determining stream size (small or large). Because there are either no guidelines provided or the guidelines provided are incomplete, unclear or inaccurate, we begin the Results and Discussion with the listed and "found" secondary objectives so that readers can consider the implications of these prior to evaluating differences presented in Results. In some cases, the different methods or approaches that can be used for collecting some of the required site attribute data may affect the result obtained.

Secondary Objectives

We encountered several problems in implementing this study using the guidelines provided in Rules, the Board Manual and the Instructions for using the DFC Model. These problems are relevant to how RMZ units are marked on the ground and how site attributes are reported in FPAs because the problems we encountered, could affect the reliability and consistency with which the site attributes gathered during RMZ layout work are reported. This is mainly because, for several attributes collected, there are either no standard procedures or guidelines provided for their collection or there is ambiguity in procedures described which could lead to different implementation practices or measurement procedures among LOs. We describe some of these problems below that we believe could affect the consistency and reliability with which site attribute and stand inventory data are collected for RMZ management in west-side Type F streams.

RMZ length

There are no specified procedures for measuring RMZ length, nor are there requirements for marking the up or downstream boundaries of RMZ segments on which timber harvest in the inner zone is proposed. LOs use a variety of methods to determine RMZ length including calculating the distance from aerial photographs or other image or map products with a known scale, or measuring the distance with a string box. For distances obtained by measuring from an image or map, no scale is specified nor is an acceptable margin of error provided to LOs. For on-site measurements made with a string box (or other measuring tool), no procedures are specified. We observed that LOs measured RMZ length from all of: a) the stream channel, b) the core/inner zone boundary and c) the inner/outer zone boundary. On stream segments that curve, different results will be obtained based simply on the choice made for where to measure RMZ length.

Additionally, there are no requirements to clearly mark the start and end points of RMZ segments. In some cases, RMZ segment end points were clearly marked with ribbon with explicit text written on it. While LOs were helpful in directing us to start points, the units were often laid out by contractors or employees of the LO other than the one that was our contact person. Thus, the personal knowledge of specific information that would help us find start and end point locations was not always available.

We found that double ribbons were a common signal that we were at an endpoint, but this was not definitive. Even when we found a definitive endpoint, it was not always clear from where exactly we should start measuring RMZ length. In some cases it would be possible to be off by 10' or 20'. If we were off by 20' on each side of the unit, this could account for a substantial portion of the total difference in RMZ length on shorter segments.

We experimented with several approaches and adopted a methodology in which we measured RMZ length along the boundary between the core and inner zones using a string-box. We think this approach has merit for several reasons. First, the core-inner zone boundary provides a length measurement that is common to both of these zones, both of which are used in DFC Model calculations for core and inner zone area (and thus affecting also the trees per acre and bapa calculations). Secondly, measuring RMZ length along the core-inner zone boundary was logistically practical, allowing us to measure and flag the core/inner zone boundary in one pass and measure RMZ length on the way back while marking the inner/outer zone boundary. Third, the DFC Rules are designed around RMZ length, not stream length. The core/inner zone boundary is far enough removed from the stream that the measure is made of the length of the terrestrial forest alongside streams, not stream length. Especially for sinuous streams, stream length – the length of a stream that includes twists and turns, will be greater than the associated RMZ length that measures only the terrestrial extent alongside of a stream, but not every contortion a stream will follow. Stream length therefore, especially, along a sinuous stream is an inaccurate measure of RMZ length and not appropriate for use with the DFC Model.

The effect of measuring stream length instead of RMZ length is to attribute the number of trees along a stream reach to a longer than actual RMZ length. RMZ length and RMZ width are the factors used to calculate area and over-estimating RMZ length will result in an area calculated that is greater than if RMZ length was measured in straight line lengths perpendicular to zone widths. The consequence of over-estimating area is to attribute fewer trees to a given RMZ length than if another method was used, providing fewer trees to count towards DFC targets. Because this difference is a result of methodology rather than stand condition, measuring stream sinuosity instead of RMZ length works to the disadvantage of LOs as it less likely that stands will meet DFC targets if tpa is systematically under-counted (see Appendix C).

RMZ length is one of the variables used to define the area of RMZ zones and is therefore an important measure. The current rules, board manual direction and instructions for completing FPA/N's do not provide LOs the guidance necessary to obtain consistent and repeatable measures of RMZ length. The examples above point to the need to at a minimum establish a common length along which RMZ length is to be measured and possibly for developing a program within DFC that can accurately calculate area based on a more complicated set of conditions than is considered in the current model (RMZ length x zone width).

<u>Stand age</u>

Stand age is determined either from stand inventory records LOs maintain for their timber holdings or by coring trees using an increment borer. For riparian areas, stand inventory records can sometimes be a problem because different management was sometimes applied to riparian stands than to the adjacent upland stands. Therefore, the age reported on stand inventory records may be accurate for the bulk of a given stand but inaccurate for the riparian stand. Additionally, residual trees or narrow buffers were left on some older stands so that stands are now multi-aged.

Increment borers give generally accurate ages but are time-consuming to use. There can also be local differences in the time required for stands to get to breast height, so the 5-yr adjustment factor to adjust for total age from age measured at dbh may not serve well as a universal adjustment. Board Manual direction to LOs is to add 5-yrs to the age determined from increment counts across all all site classes and tree species. We did not notice this directive when developing our sampling methodologies; instead we reviewed literature and found different ages to add by site class and species (see Stand Age in Methods section above). Since we had data to compare these two methods in context of the DFC Model, we did (Appendix B). Using the DNR methodology stands were determined to be 1 to 3 years younger than the same stands using the "CMER" method. Across all sites, this accounted for a 4.6% difference in stand age. This difference showed up as only small changes of 1 to 2 % in projected stand-age 140 BAPA attributes. The difference in age made an actual difference to the prescription applied to only one stand (#140) where the required inner zone no- cut width changed from 97' using the CMER method for adjusting age to 98' using the DNR Board Manual approach, a difference of only 1ft in cutting width.

There is confusion amongst LOs on what age to report. Some LOs told us that their understanding was that they were supposed to round stand age to the nearest 5-yr increment. We did not find this direction written in any of the reference materials, so this was apparently anecdotal. Many LOs in fact do report stand age rounded to the nearest 5-year increment (McConnell, 2010, Desktop Analysis, Appendix A, Figure 10) but it is not certain if this is because LOs believed that they were directed to do so or because LOs recognized that stand age was an inexact number and rounded it as a matter of convenience.

Despite our failure to find the appropriate direction for adjusting stand age to total age from an increment core measured at breast height, measuring stand age did not seem to us to be as lacking in guidelines as some other attributes required for running the DFC Model. The DFC Model is also not as responsive to small variations in stand age as it is to variation in other stand attributes (Roorbach et al., 2006) unless a stand age of less than 35-yrs is used, in which case a glitch causing a significant over-estimate of stand-age-140 bapa occurs – (see "Model and Manual" report, McConnell and Heimburg, 2010). In our opinion, developing additional protocols, guidelines or training for measuring stand age is lower priority than for other site attributes. The guidelines and direction provided for using the DFC Model could be improved, however, by noting that the DFC Model runs off of "total age" not breast height age.

Stream size

The DFC Model requires an entry for stream size, giving two choices – small (≤ 10') or large (> 10'). While stream size is defined in terms of width in feet, a descriptor for what stream metrics define the points from which to measure width to and from is not defined in the Forest Practices Rules, in the Board Manual (Section 7, p. M7-7) or in DNR's recently updated instructions for completing FPAs and implementing rules correctly in western Washington[5]. Despite its omission from guidance material provided to help implement west-side Type F riparian rules, the DNR affirmed that "Stream Size" is "bankfull width". Bankfull width is defined in rules (p. 16-2) as "the measurement of the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth. In cases where multiple channels exist, bankfull width is the sum of the individual channel widths along the cross-section". Bankfull channel features are also described in the Board Manual, Section 2, p. M2-21-M2-24.

[5] This and other similar problems with definitions and guidance provided in Rules, the Board Manual and other materials are discussed in detail in the "Model and Manual" paper (McConnell and Heimburg, 2010).

Even though stream size is measured by bankfull width, the core zone measurement begins at the edge of the channel migration zone (CMZ), not the edge of bankfull width, regardless of whether it is a large or small stream. This is addressed in the Board Manual (Section 2, p. M2-3) "Identification of the CMZ is important for proper placement of the riparian management zone (RMZ), such that near-term riparian function is not lost due to the natural processes of channel migration. Placement of the RMZ outside the bounds of channel migration helps ensure the longevity of the riparian area."

In our subsample, most streams (10 of 15) were either clearly "large" or clearly "small" and the stream -size determinations made were the same for both our and LOs. On some streams, however (5 of 15) we believe there was either a reasonable case to be made for a different stream-size call than was made by the LO and/or a need for better rule or board manual guidance for the situation encountered to ensure that rules would be consistently applied by all LOs. Differences in stream size determinations, in our opinion, most often resulted from different interpretations of the point where the stream entered the floodplain(the criterion that determines the point from which bankfull width measurements should be made), not from inadequate or inaccurate measurements of stream size.

Without a common understanding of where to measure, quantitative measures would not determine a "correct" bankfull width call. Thus, we opted to not take quantitative measurements of stream size as was proposed in the study plan (McConnell et al. 2005). We have no specific training in determining bankfull width. Therefore, that we differed in our assessment of stream size does not suggest that our calls were right and those made by the LOs were wrong, although in one instance (stand #61) we believe the "case" was clear. The ability to make bankfull width determinations as per rule intent would require training, practice and careful definition. Stream size is a highly significant determinant of the management riparian forests receive, because timber harvest is more constrained in the inner than in the outer zones and the amount of inner zone area is greater along large streams than along small streams. For Option 2, the no-cut "floor" portion of the inner zone is 30' for small streams and 50' for large streams. For Option 1, inner zone widths along large streams range from 17' wider along Site Class 1 streams to 8' wider along Site Class 5 streams. Thus, training to ensure that the correct stream size determinations are made is a somewhat hidden but very important component of riparian zone layout.

If the amount of area affected in riparian forests is deemed to be an important factor for determining the relative priority of different types of training, procedures for measuring bankfull width would rate very high on this list. Since the difference in management outcome is significant, a 20' width area of the inner zone that is eligible for timber harvest or not, depending on the outcome of the determination made, we believe that it is important to have an expert evaluate the calls we made and identify both a change made (if applicable) and document factors that can lead to confusion on close calls that can be employed in future training. The bankfull width determination is one of the most significant calls made in setting up RMZ's in terms of cut or reserve area affected. If our findings are accepted, the clear trend is that LOs have a systematic bias towards finding that they have small streams when the case might be in doubt and they have a clear and understandable financial motive for erring in that direction. It is therefore important that training on how to make these calls result in foresters for industry, the DNR and other stakeholders that are highly skilled in making this call accurately and that consistency in this call between observers is high.

Major species

The DFC Model has two "variants" designed to reflect the conditions and attributes of the two most common dominant species in forest stands in low and medium elevations in western Washington, Douglas-fir and western hemlock. LOs are asked to identify which of these is the major species. Major species is not defined in guidance materials. How to make this determination could be an issue because the DFC Model grows trees faster using the DF "variant" than for the "WH" variant (Roorbach et al., 2006), meaning that stands that may not be eligible for inner zone timber harvest using the WH variant might be using the DF variant. Similarly, the amount of timber available for harvest may differ between variants because stand bapa increases more rapidly using the DF variant. The consequence of modeling identical data sets with both models would be that more current basal area is available for timber harvest using the DF variant. This is because less current basal area is required using the DF variant than for the WH variant to achieve an identical future stand basal area.

Primary Objectives

1. Site Attribute Comparisons

Stream size

The stream size determinations made by report authors and those made by LOs are presented in Table 2. We present possible explanations for different determinations or challenging calls in text below.

Table 2 – A comparison of stream size calls made by (Cooperative Monitoring Evaluation and Research) staff (CMER) and as reported by LOs (LO) for stream segments from 15 FPAs along Type F streams in western Washington with timber harvest proposed in the inner zone of Riparian Management Zones (RMZs). Small streams are ≤ 10' wide and large streams are > 10' wide, bankfull width. Noteworthy attributes of some streams are listed in the "characteristics" column. The bolded text indicates where our findings differed from those of LOs.

Site #	CMER	LO	Characteristics
3	Large	Large	
6	Large	Large	
8	Large	Large	
11	Small	Small	
45	**Arguably Large**	**Small**	Unconstrained channel
57	**Arguably Large**	**Small**	Unconstrained channel
61	Large	Small	Braided channel
66	Large	Large	
87	Large	Large	
89	Large	Large	
98	**Arguably Large**	**Small**	Stream Associated Wetland
103	**Arguably Large**	**Small**	Active channel with CMZ
120	Small	Small	
130	Small	Small	
140	Small	Small	

Site #45 had an "L" shaped RMZ, part of which was alongside a small, moderate gradient stream and part of which extended along a larger main channel stream. The larger main stem channel appeared to us to have a CMZ present. However, on the FPA, the box noting "no channel migration zone present" was checked. If no CMZ was present, then the indicators used for field identification of the bankfull channel edge should have been used to determine bankfull width (Board Manual, Figure 20, p. M2-22). Based on vegetation and morphology, this channel was in excess of 40' BFW in some places. We believe that a more accurate call would have been either that it was a small stream with a CMZ, or that it was a large stream.

The stream at site #57 was similar to the larger main stem stream in site #45 in that it was low gradient with a wide area that either was a CMZ along a small stream or a large stream.

The stream at Site #61 was a braided channel that extended across a broad valley very near to where the stream entered salt water. This channel should have been called "large" as per the definition of bankfull width (WAC 222-16), e.g., "In cases where multiple channels exist, bankfull width is the sum of the individual channel widths along the cross-section". This type of stream is described in Board Manual Section 2, p. M2-18 as one of the "Examples of Difficult Channel Migration Zone Determinations" because of the possibility of confusing a braided channel with a CMZ.

The stream at Site #98 was an example of a potentially difficult stream size determination as the cutting area bordered a wetland complex that was connected to but distant from the main channel of the stream. The LO correctly classified this as a Type F stream as per DNR Instructions (2005, p. 11), e.g. "For periodically inundated areas of associated wetlands – line of periodic inundation". It was unclear to report authors who visited the site how the small stream size call was made but presumably the sum of channels in this braided system was less than 10'. One of the reviewers of a previous draft of this paper (Allen Pleus, personal communication) asserts that "An associated wetland is within the stream's BFW out to the line of periodic inundation – not the sum of its wetter or scour channels. If the associated wetland is wider than 10' from edge to edge, it must be classified as a large stream." If this is the case, site #98 should have been classified as a large stream. This is another example of an arguably confusing stream size determination that would make a difference in the management implemented.

The stream at site #103 was "active" in that it clearly moved around in its banks frequently and the channel affected by stream movement was clearly greater than the wetted width. We believe this stream either had a CMZ that should have been acknowledged and accounted for, or it was a large stream.

<u>Site Class</u>

The LO-declared site classes, obtained from DNR maps were reported accurately on all FPAs evaluated.

<u>Major species</u>

We summed basal area by tree species and found our results to concur with LO determinations in all but one case. In that case (site #120), the majority (51.4%) of riparian stand basal area was western hemlock while the LO had declared it to be Douglas-fir. The only options for major species available to LOs are Douglas-fir and western hemlock. In some cases, mixed stands had basal areas of one of these species as low as 32.8% (site #6). One stand (Site #103) was dominated by Sitka spruce (89.4%) of basal area but was declared to be western hemlock by virtue of 6.8% of stand basal area in this species. No Douglas-fir was present on this site.

<u>RMZ length</u>

Greater differences in RMZ length (expressed as a percent of total length) were found for shorter streams (Table 3) emphasizing the importance of being able to determine exact locations for RMZ start and stop points and a standard measure for method for measuring RMZ length. In general our RMZ lengths were longer than those determined by LOs. In one unit, (# 87) the upstream 320' was in an RMZ from a harvest made a year or two before the current sale and it was unclear why this piece was included in the RMZ for this FPA, however, by doing so, based on a tpa count of the full length of the riparian unit, LOs were able to harvest some of the outer zone leave trees left from the sale a few years previous[6].

Table 3 – Riparian Management Zone (RMZ) length for stands measured in this study (CMER) and as reported in Forest Practices Applications (FPAs) by landowners (LOs). Differences presented in feet are the amount that RMZ lengths measured by CMER were greater or less than lengths reported by LOs. The percent differences are CMER-measured length minus LO-reported length, expressed as a percentage of the LO-reported RMZ length. Some stand characteristics that may affect measured RMZ length are noted.

Site #	CMER	LO	Difference in feet	Difference in percent	Characteristics
3	1900	1700	+ 200	+11.8	Sinuous stream
6	2615	2750	-135	- 4.9	Sharp turns along stream at upper and lower end of a "C" shaped RMZ
8	1137	1150	-13	- 1.1	
11	3590	3320	+ 270	+ 8.1	RMZ is on both sides of stream.
45	813	650	+ 163	+ 25.1	L shaped RMZ bordering both a tributary stream and larger main stem stream (both classified by LO as small)
57	669	600	+ 69	+ 11.5	
61	1513	1400	+ 113	+ 8.1	
66	351	290	+ 61	+ 20.1	Unit follows a sharp curve along a large stream
87	1370	1370	0	0	Upstream 320' was part of a previous sale
89	1197	1150	+ 47	+ 4.1	
98	400	325	+ 75	+ 23.1	
103	380	304	+ 76	+ 25	
120	1093	1015	+ 78	+ 7.7	
130	594	555	+ 39	+ 7.0	
140	750	800	- 50	- 6.3	2 sided; small stream fed into larger stream, 100' (times 2) of RMZ measured is in buffer of large stream

Two of the units had 2-sided RMZs. Under guidance provided by the DNR (2005, p. 17), LOs are advised to "Treat each side of a stream as a separate RMZ". For our purposes this made no difference except that where we found a difference in length that was increased by a factor of 2. Lack of a standard location within RMZs at which to measure RMZ length can make for large differences in RMZ length. In particular, where streams curve, the difference in length between measurements made in the stream channel as compared to the outer edge of the inner zone, can be substantial (see Appendix A).

[6] An explanation of outer zone rules is provided detail in the "Model and Manual" report in a sub-section titled "Outer Zone Trees". LOs for this site presumably unaware that cutting outer zone trees is proscribed by WAC 222-30-021 (1) (c), third sentence "Riparian leave trees must be left uncut throughout all future harvests."

Stand age

There is no clear pattern of ages reported being less or more than the age determinations we made, adjusted to the date the FPA was submitted (Table 4). On two sites (6 and 61) the ages reported in the FPA were 10 and 11 years younger, respectively, than the age we estimated

Accurate stand ages are important because the DFC Model projects increases to stand bapa for conifer trees over time. Using an age that is younger than the actual age will result in more bapa accruing than if actual stand age were used in the projection, which will sometimes allow for more harvest of the current stand than would be allowed if the actual (older) stand age were used[7]. Similarly, using an older than actual age will cause the DFC Model to calculate a lower stand-age-140 bapa than if actual age were used.

Table 4 – Stand age by site as determined in our field checks and by LOs (LO) in their Forest Practices Applications. Our ages taken from live trees are adjusted to account for years that transpired between when age was collected and the year that the FPA was submitted. The differences in age are the number of years determined by us minus the number of years reported by LOs The percentage difference is the age difference reported, expressed as a percentage of the landowner-reported stand age. Where the age difference is accompanied by a "+" sign, the age measured by us is greater than the age reported by the LO, and the reverse is true where the age difference is accompanied by a "-".

Site #	Stand age determined by CMER (years)	Stand age reported by LO (years)	Difference in age (years)	Difference as a % of LO-reported stand age
3	52	55	- 3	- 5.5
6	65	55	+ 10	+ 18.2
8	68	64	+ 4	+ 6.3
11	64	58	+ 6	+ 10.3
45	57	51	+ 6	+ 11.8
57	36	40	- 4	- 10
61	61	50	+ 11	+ 22
66	64	62	+ 2	+ 3.2
87	47	53	- 6	- 11.3
89	58	51	+ 7	+ 13.7
98	40	45	- 5	- 11.1
103	39	39	0	0
120	37	40	- 3	- 7.5
130	39	45	- 6	- 13.3
140	47	47	0	0

Stand inventory

The total number of trees we measured across all diameter classes, is expressed (Figure 1) as a percentage of the number of trees from LO-provided DFC worksheets for each of the 15 FPAs used in this analysis. Similarly, the difference in RMZ length measured by report authors are contrasted against RMZ lengths obtained from LO-provided DFC worksheets, also expressed as a percentage (Figure 1). On five sites (3, 6, 11, 87 and 130), the count of trees and RMZ lengths were similar for both tree counts and RMZ length. On site #45, in contrast, we measured 1.6

[7] There is not a direct relationship between the amount of timber that can be harvested and the amount by which a stand is projected to exceed the DFC bapa target. Other factors such as tree diameters also affect the outcome, especially for Option 1 (McConnell, unpublished data).

times more trees than were reported by the LO and our measured RMZ length was 1.2 times the LO-reported length. On site #66, our recorded tree stem count was only 77% that reported by the lLO, while the RMZ length measured by us was 20% greater.

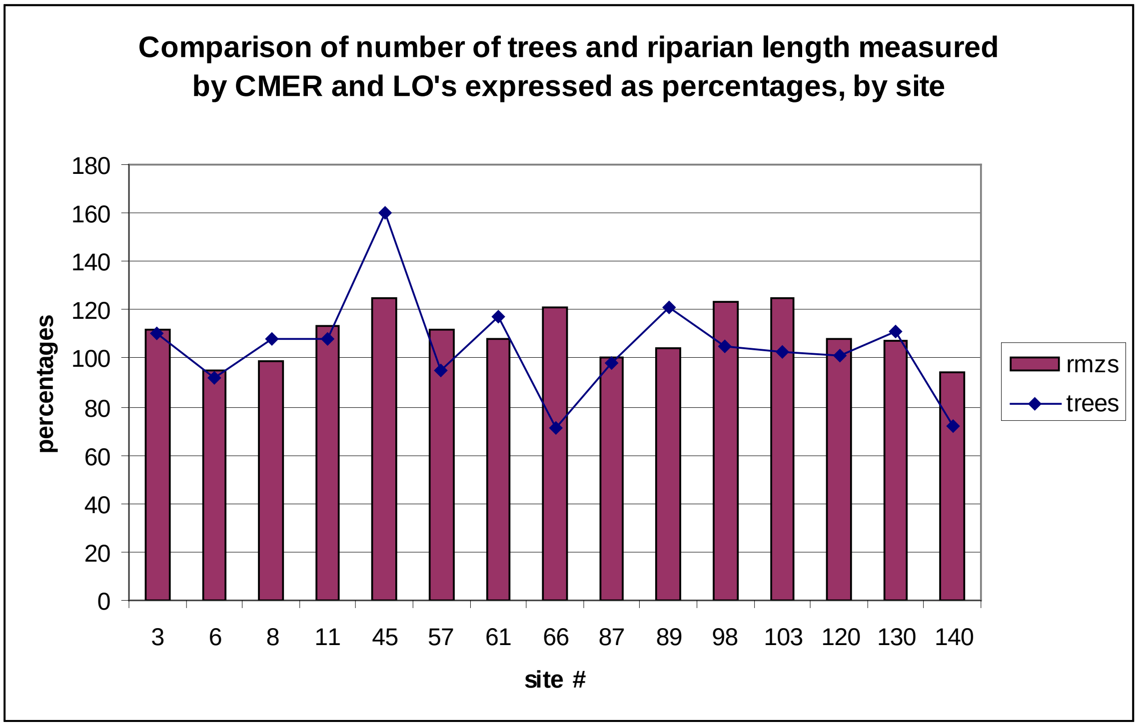

Figure 1 – The number of trees and RMZ length measured by report authors expressed as a percentage of those attributes reported in Forest Practices Applications. The "RMZs" refer to riparian management zone length, measured in feet. "Number of trees" includes all trees, both conifers and hardwoods, from both the core and inner zones.

No statistical analyses were done to compare the diameter distribution curves for trees by size class for each stand. In general, in our opinion, shape of the tree diameter distribution curves, by diameter class were similar between those reported by LOs and those measured by us (Appendix D, Figures 1-15) However, for almost every stand there are differences between our and LO-collected data for the core, inner or both zones. There was no distinct pattern to the difference in tree numbers by diameter class observed. As compared to our data, LOs both under-reported (see for example sites # 3, 8, 11 [core zone], 61, 87, 89, 98 [inner zone] and 103), and over-reported (see for example sites # 8, 11 [inner zone], 57, 66, 98 [core zone] and 120, 130 and 140), the number of trees at each site.

One source of difference that occurred on several stands was for LOs to fail to report trees in the smaller (6" and 8") size classes. For example, no 6" trees were reported in the core zone for stand #61 and, no 6" inner zone trees were reported for stand #103. On both stands #61 and #98 no 6" or 8" trees were reported in the inner zone. In each case, there were quite a few trees in these size classes, according to our data. Possibly LOs who know that the stand will meet DFC do not bother to quantify the smaller diameter trees that contribute less to basal area. In sites where there will be a basal area credit reported by the DFC Model from measuring only the larger, easy-to-measure trees, there is no advantage to LOs to report basal area in excess of these. It takes more time and effort for LOs to count trees in smaller diameter classes and reporting more basal area where the DFC targets are already exceeded provides no advantage to LOs, because they will be constrained in the amount they can harvest by the minimum no-cut “floor” widths using Option 2 and by the 57 required inner zone leave trees per acre using Option 1.

Conversely, we did not find as many small inner- zone trees at stand #6 as were reported by LOs although our core- zone distributions were nearly identical. The difference in the inner zone could have resulted from the abundance of logging slash on that site, and deep evergreen vegetation (salal) that made locating stumps, especially smaller ones difficult. This may also account for differences in tree counts on other sites but was a particularly likely cause for reaching a different count on this site.

There are several other factors that could cause our counts to differ from those made by LOs. The first of these is the assumption we made about standing dead trees: we recorded these but did not include them in the comparison of tree counts We assumed that tree death was a continuous process and was reasonably constant on these sites over the 2 or 3 year interval between the LO inventory and ours. LOs do not report dead trees so we did not include dead trees in our stand tallies. Some of the dead trees we encountered, however, were recently dead and may have been alive at the time of the LO inventory and therefore may have been included in the LO inventory done. Secondly, cut dead trees posed a problem. LOs would not have counted standing dead trees in the inner zone but these would have been cut during timber harvest for purposes of ensuring worker safety. We recorded cut trees as stumps and assumed that these were from living trees because it would have been difficult to identify stumps from dead trees, especially trees that had died shortly before the cut was implemented and it is unlikely that we could do this accurately. Our recording all stumps as from live trees would cause us to over-estimate tree count in the inner zone count as compared to LOs, if dead trees were in fact present. Third, the estimations of dbh made from stump measurements may not be accurate, causing trees to be placed into the wrong diameter class. Some trees that had small stump diameters may have had a breast height diameter of 5 or more inches but we may not have measured these, causing us to report fewer small diameter trees than LOs. Fourth, small trees that were not big enough to be counted by LOs may have grown enough to be counted by us which could have caused us to record a greater number of smaller trees. Finally, diameter distributions were not expected to match exactly, because LOs estimated tree size to the nearest 2” diameter class while we took actual dbh measurements; our more precise measurements may have detected growth since the initial measurements, and shifted some trees into a larger diameter class.

In summary, we document differences in RMZ length, tpa count and stand diameter class distributions in some stands, with stands #45 and 61 especially having different distributions than we think can be easily explainable by anything other than LOs taking a shortcut on measuring stand attributes as carefully as directed by the rules. There were few clear or consistent patterns on how stand data were collected by different LOs. Some appeared to lump many trees into smaller (6” and 8”) diameter classes while we measured more trees than LOs did in the 10, 12 and 14 inch classes. Some LOs appeared to be put all trees (although scattered and few) that were greater than 20” dbh classes into a 20” class while in fact there were trees on site that extended up to classes that went up the high 30’s. Some LOs recorded small trees as being larger than what we recorded and using fewer DBH categories than were actually present, sometimes lumping both larger and smaller trees into a few broadly inclusive classes (for example Site 61).

The only consistent patterns that emerged were that: 1) for all stands, the diameter distributions were generally similar between our and LO collected data – none of the data we obtained appeared to be from a different or fabricated and 2) diameter distributions often did not match as well as expected, indicating that LOs may be collecting stand data to a scale of resolution that is coarser than was intended by rules and guidelines.

In general, stand data collected and other site-attribute calls made by LOs are reasonable for use as input data for the Desktop Analysis study. For other purposes, however, the differences we found might be more consequential. Some of the differences are attributable to lack of clear direction in how to collect data and lack of clarity on what level of resolution is acceptable. We suggest our results be reviewed from the perspective of considering where training and better written guidance on implementing DFC rules might be beneficial.

<u>DFC Model-derived pre-harvest stand conditions</u>

The DFC Model calculates current stand conditions for density (trees per acre), stand basal area, and the portion of basal area that is represented by conifer species. The model then projects stand bapa at age 140 for each of three prescriptions: no timber harvest, thinning- from- below (Option 1), and leaving trees closest to the stream (Option 2).[8] The following figures provide means to graphically compare DFC Model computations for some attributes of pre-harvest stand conditions, post-harvest stand conditions, and stand conditions at age 140 using the data sets we collected by and inventories provided by LOs on the DFC Worksheet of the FPA.

The number of DFC Model calculated tpa are shown in Figure 2, bapa are compared in Figure 3 and the percent conifer are compared in Figure 4. TPA counts are lower for the LO-collected data than for our data on three stands (#8, 45 and 89) higher on four stands (#57, 66, 98 and 103) and very similar between data sets on the remaining eight sites (Figure 2). The DFC Model-calculated current age stand bapa (Figure 3) is higher for the LO data than for the CMER collected data on four stands (# 61, 66, 98 and 103) and is lower on seven stands (8, 11, 45, 89, 120, 130 and 140) and nearly the same on the remaining four stands (3, 6, 57 and 87). Our field data had a higher proportion of conifers than did the LO-collected data (Figure 4) on four stands (#45, 66, 87 and 89) and a lower proportion of conifer on two stands (#61 and 140).

In general, the LO and CMER tpa comparisons fit closely with the exception of stand #66 which had an exceptionally short RMZ length (290' – LO data, 351' CMER data) on which the amount of error from determining start and end points alone can make a large difference in the number of trees counted, and the consequence of this can look worse when taken from a straight tree count to a tpa count for purposes of the comparison made below. Taken as a whole, on three stands our tree count was higher than LOs, and on two it was lower with the rest matching closely. Across all sites, the data match up well but, of course, in DFC rules, each site is considered independently. The Sensitivity Analysis (Roorbach et al. 2006) show that the DFC Model is not highly sensitive to differences in stand density of up to 20% . These data therefore appear to reasonably represent the attributes of the stands from which they are collected at least to the scale of precision and accuracy required to use the DFC Model for the specific objectives of the Desktop Analysis report.

[8] Option 2 can be used only on stands on site classes 1 and 2, and site class 3 along small streams.

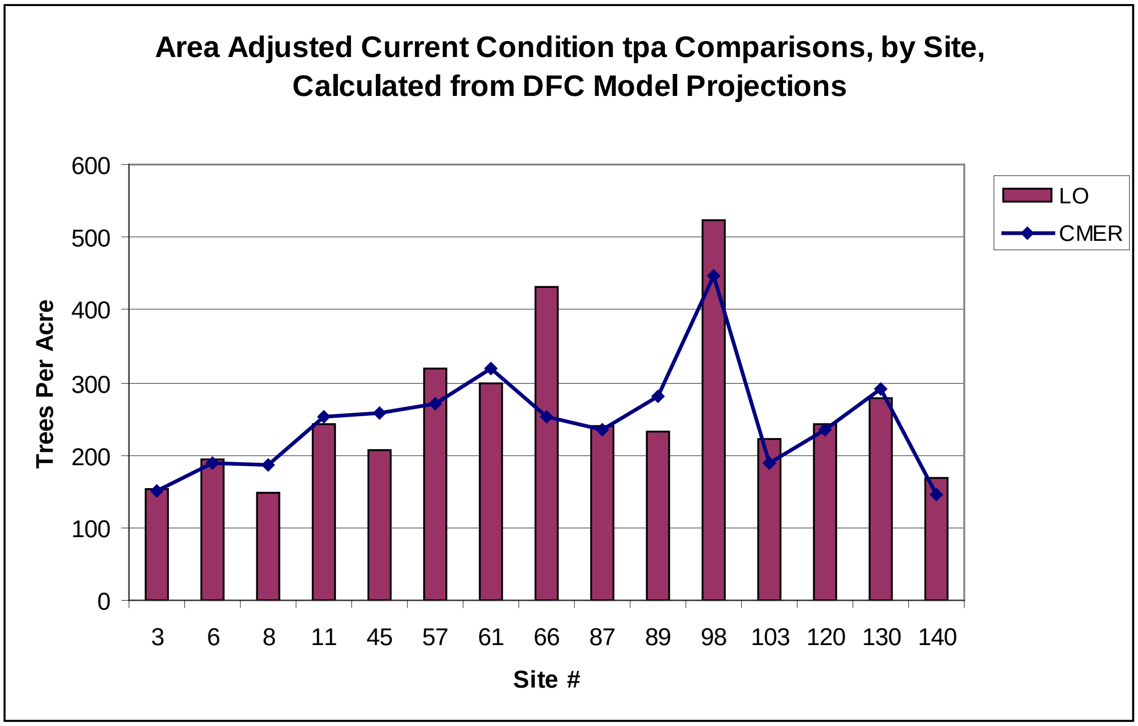

Figure 2 – Number of trees per acre from the combined, area weighted, core and inner zones for each data set. LO = data collected by LOs obtained from the DFC Worksheet on their Forest Practices Application. CMER = data collected for this project, the DFC "Field Check" Study.

TPA, bapa and percent conifer were all higher for the CMER collected data than for the LO data for site 66 and to a lesser extent, stand #98 (Figures 2, 3 and 4). This can be explained primarily by stands #66 and 98 being small as compared to other stands with RMZ lengths, respectively, of 351' and 400' using CMER data and 290' and 325' reported by LOs. The difference in measurements made by CMER and LOs on small stands made for big differences in results.

The effect a few trees less or more can have to stand characteristics highlights a potential problem with management using DFC Rules when applied to short RMZs; DFC Model-projected outcomes could have big differences that determine whether a stand is eligible for timber harvest along with prescription details based on the difference of only a few trees. The differences noted also highlight the importance of establishing re-locatable endpoints and using a repeatable method for measuring RMZ length as there are a number of reasons why LOs, other stakeholders or regulatory agencies may wish to be able to re-establish RMZ stand boundaries sometime in the future.

There were no other consistent patterns to differences found in the stand inventory data collected by LOs and CMER other than those addressed above: 1) under-reporting small diameter trees, and 2) the large effects to stand inventory data of minor differences in tree numbers on stands with short RMZ lengths.

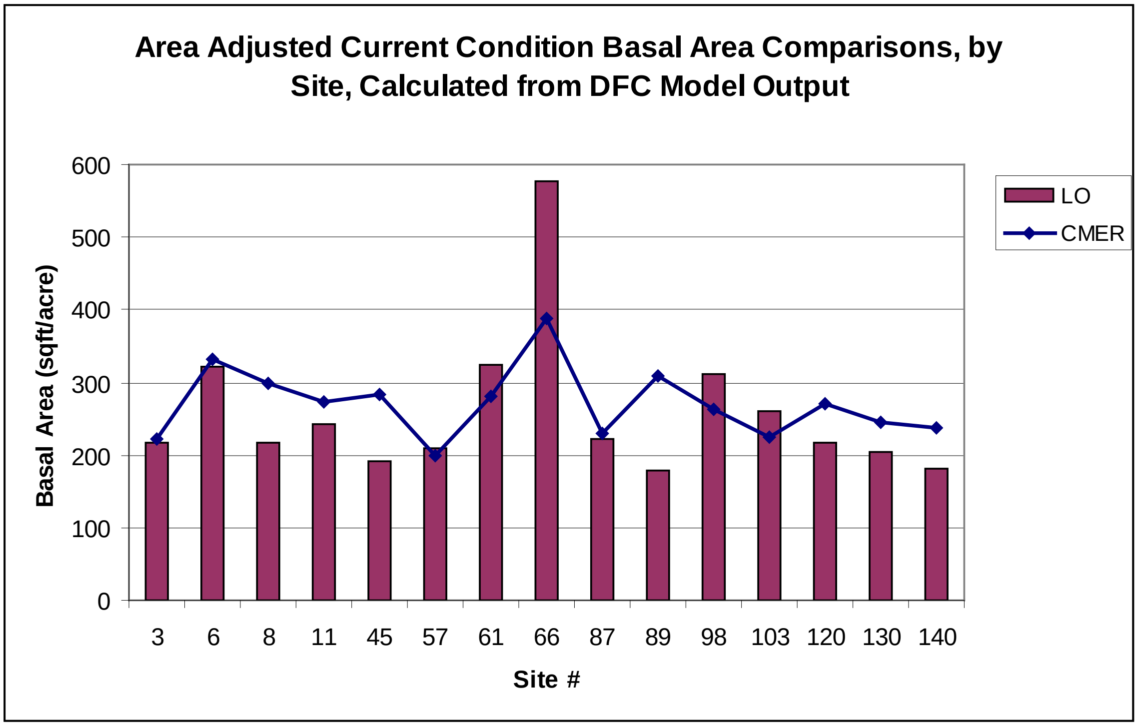

Figure 3 – Basal area (ft^2/acre) from the combined, area weighted, core and inner zones for each data set. LO = data collected by LOs obtained from the DFC Worksheet on their Forest Practices Application. CMER = data collected for this project, DFC "Field Check" Study.

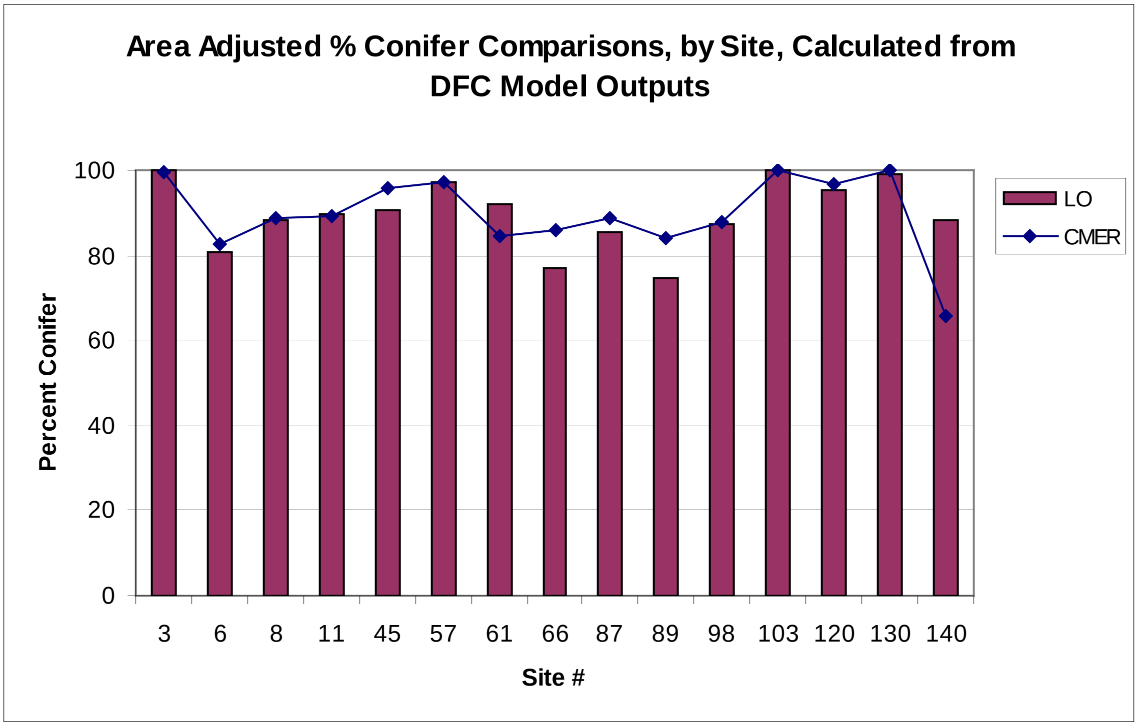

Figure 4 – Percent conifer (average % of total stand bapa) from the combined, area-weighted, core and inner zones for each data set. LO = data collected by LOs obtained from the DFC Worksheet on their Forest Practices Application. CMER = data collected for this project, the DFC "Field Check" Study.

<u>DFC Model-derived post-harvest stand conditions</u>

<u>Option 1</u>

Data presented below (Figures 5-7) are for DFC Model projections for each of the riparian stands used in this study using both our and LO-collected data. In actuality, only 5 of the 15 sites were harvested using Option 1 (Table 1). These data are presented to compare DFC Model outcomes IF Option 1 were implemented for each site, using both data sets.

More basal area would be left at timber harvest on 14 of 15 sites (site 87 is the lone exception) using our data than if the LO data were used (Figure 5). The differences were especially great for sites 8, 120, 130 and 140. On these four sites, we recorded more large trees than did LOs (Appendix D), thus a thinning from below treatment that leaves the same number of trees (Figure 6), but has larger trees on site, results in more projected post-harvest residual stand bapa. Timber harvest is not constrained for any of these stands using either data set by stand bapa DFC targets. Instead, for all of the stands in this analysis, inner- zone timber harvest amount is constrained by the requirement to leave 57 trees per acre of the largest diameter trees found in the inner zone of that riparian stand. The amount of basal area left in each stand after harvest (Figure 5) is determined by the basal area contained in the trees left uncut which, for all of these stands are the largest trees in the inner zone until the 57 trees per acre limit is met.

Sites #66, 98 and 103 all have short RMZ lengths and the DFC Model is programmed to always round up on fractions of leave trees meaning that the DFC Model will always err to leave more trees than are required rather than less. On small stands a single tree may represent as much as 9 tpa. The DFC Model is programmed such that rather than leaving 56.9 tpa it will default instead to the next higher increment, even if that means leaving 66 or more tpa. This characteristic of the DFC Model accounts for the reported number of leave trees that exceed 57 trees per acre on these stands (Figure 6). The size of required residual trees varied little between data sets (Figure 7). Required leave tree diameters did not differ by more than one diameter class between data sets because in most stands, the diameters recorded in both data sets were sufficiently similar that when the thinning from below was simulated, the residual trees identified were of the same size in each data set. For eight sites, the minimum residual tree diameter was the same for each data set. For five sites, larger leave trees would be required using our data than for the LO data set and for two sites the LO data set indicates leaving larger trees than for the CMER collected data. The different leave tree sizes reflect minor differences in the distribution of tree diameters between data sets and hence differences in outcomes in terms of model-determined size of residual trees to leave after thinning from below to 57 tpa.

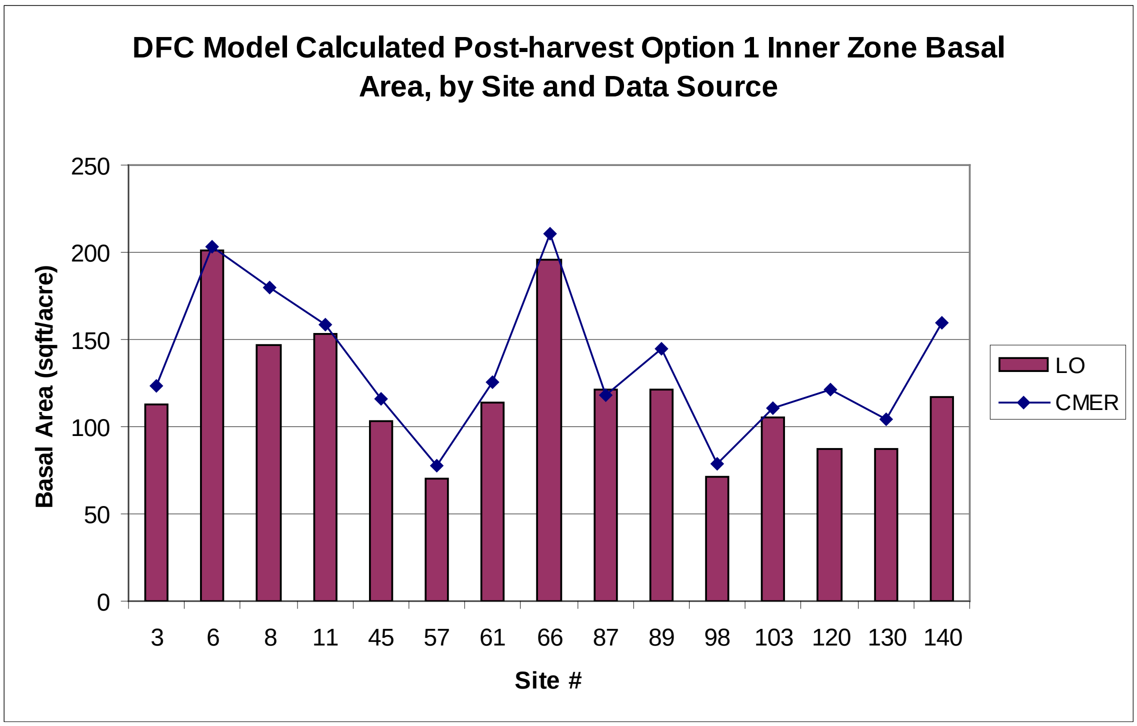

Figure 5 – DFC Model-calculated post-harvest stand basal area (sqft/acre) from the inner zone of riparian areas following an Option 1 harvest, by site and data source. LO = landowner, LO data is from the DFC Worksheet on the Forest Practices Application. CMER = CMER, CMER data was collected from the same sites as for LOs. Sites were numbered by CMER and are linked to specific FPAs.

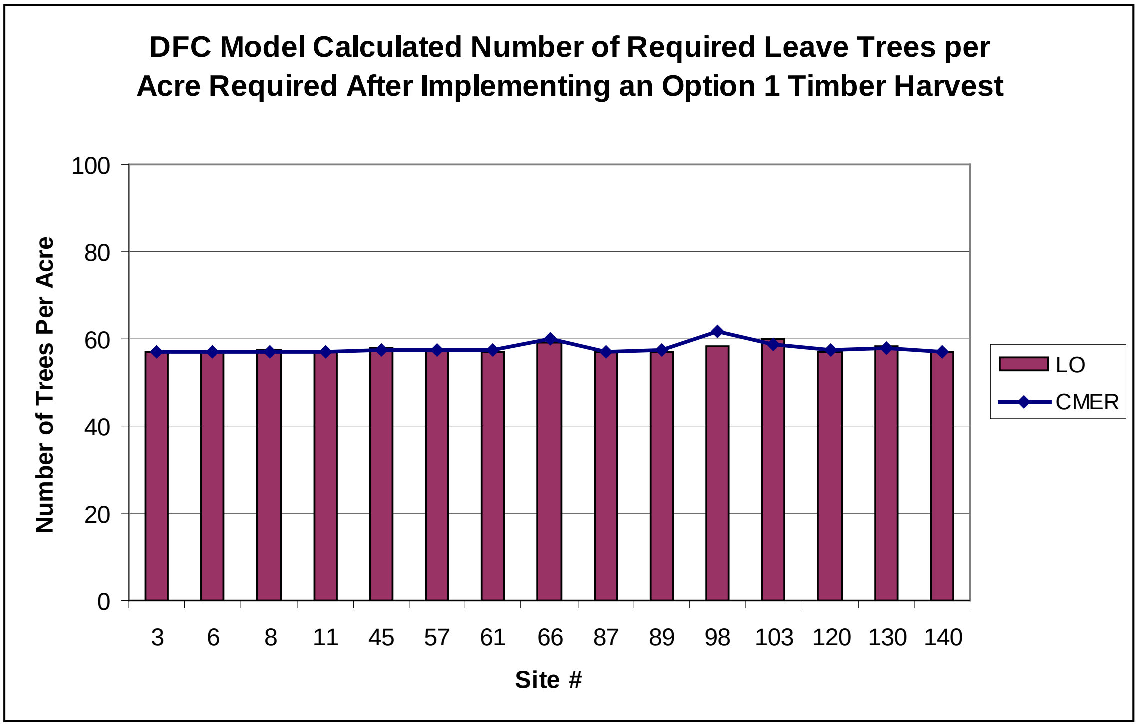

Figure 6 – DFC Model-calculated post-harvest required number of inner zone leave trees following an Option 1 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study. Sites were numbered by CMER (site #) and are linked to specific FPAs.

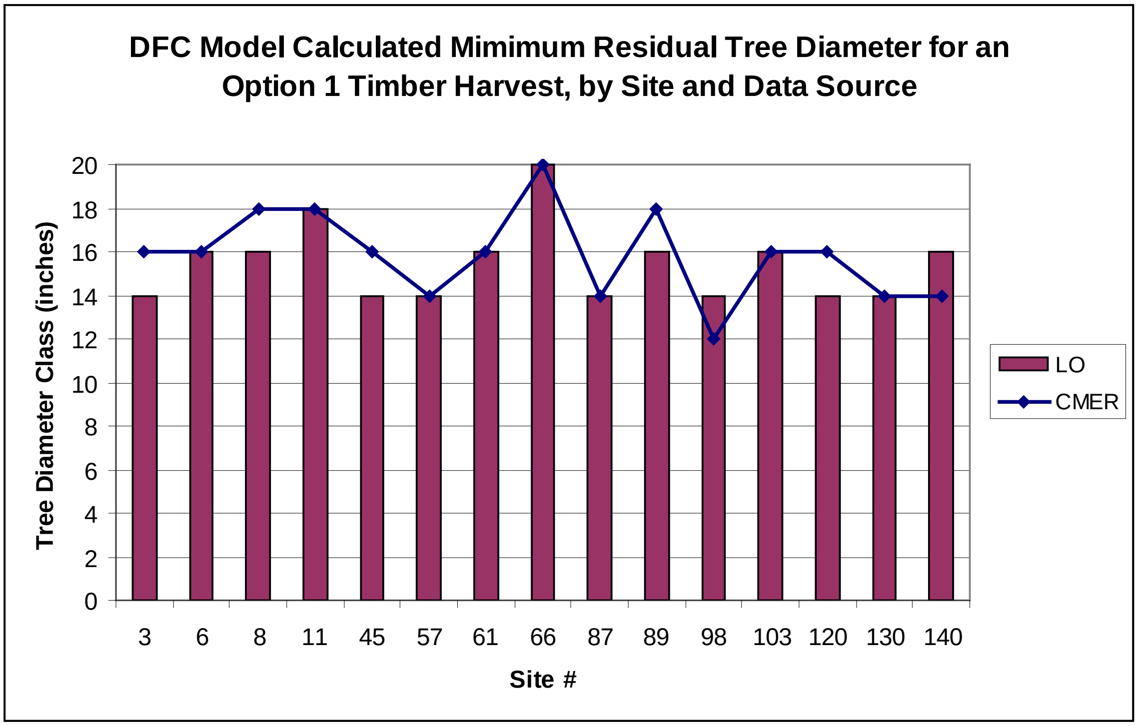

Figure 7 – DFC Model calculated post-harvest minimum inner zone residual tree diameter following an Option 1 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on Forest Practices Applications. CMER = Cooperative Monitoring, Evaluation and Research data collected for the DFC "Field Check" Study.

<u>Option 2</u>

Ten of the fifteen sites met the site class and stream size requirements for Option 2 timber harvest using the LO data set while nine met these criteria using the CMER data set. Stand # 61 had a braided channel that cumulatively exceeded 10' in our (report authors) opinion thus should have been classed as a large stream. Since stand #61 is Site Class 3, option 2 would not have been allowed by rules. We include this site in the analyses presented below since LOs proposed and implemented timber harvest at this site using an approved FPA and harvested inner zone timber using Option 2.

The required floor width varied between data sets only for site #140. Using the stand inventory data for this site collected by LOs, the required floor width was 83'. Using the data collected by report authors, the required floor width would have been 98'. This is the only site of the ten stands for which more than the minimum floor width was required using either data source. This site (# 140) was set along a small stream that fed into a large main stem stream. The RMZ unit went from a fish passage barrier at the upstream end to the confluence with the large stream. No timber harvest was proposed for the inner zone of the large stream. Thus LOs were required by rules to leave uncut the 105'wide, for this site class / stream size combination, core plus inner zone adjacent to the larger stream. Almost all trees in the portion of the RMZs for each stream that overlapped both streams were hardwoods. Since there are no guidelines to how and where RMZ units may begin and end, presumably the LO could have instead submitted an FPA with an RMZ length that was 105' feet shorter and began at the edge of the no -cut buffer for the large stream. Doing this, the LO would easily meet the DFC target along this small stream and be able to cut to the minimum floor width. This demonstrates that there are a variety of ways that riparian cutting units can be configured. It may also raise questions as to whether there should be any limits to RMZ configuration in terms of determining start and end points, setting a minimum length., and/or setting a limit on the number of riparian segments can be created within a specified length of stream segment (for example, could a LO submit 5? 10? short segments that meet DFC adjacent to one upslope stand)?

The DFC Model-calculated stand basal area credits (Figure 9) were greater using our rather than LO-collected data for 5 of the ten stands evaluated (#3, 11, 45, 57 and 130), less on four stands (#6, 61, 103 and 120) and equal on one stand (#140) on which there was no basal area credit for stand #140 using either data set. Across all ten stands, the difference in basal area credit calculated was 123.9 sqft/acre compared to 121.6 sqft/acre using LO-collected data making our results 101.9% of the credit calculated using LO data. The differences measured in percent were greater. Across the 8 stands that did not have a zero value, the average amount by which basal area credit was greater using our data was 116.1 %. The range was 70.7% on plot 61 to 308.5% on plot 45. Adjusting these figures to the size of stands represented by each would provide a more accurate indicator of how big a difference size of stand makes on DFC Model projections.

Stand #120 does not have a basal area credit using our data but does have one using the LO-collected data. This occurs because we determined that western hemlock was the “major species” on this stand measured by proportion of basal area in this species. The LOs, in contrast, reported Douglas-fir to be the major species. Basal area credit is affected because growth projected by the DFC Model adds basal area more slowly using the western hemlock “variant” of the model than is added using the Douglas-fir “variant”. The difference in projected stand basal area growth is enough to allow for surplus basal area using the LO data while providing just enough basal area to meet DFC within the minimum required inner zone “floor” width using the CMER data with western hemlock used for major tree species.

Major species was identified as the site attribute that makes the most difference to DFC Model-projected stand age 140 bapa (Roorbach et al., 2006). Stands identified as Douglas-fir being the major species are projected to attain a greater basal area than are identical stands projected using western hemlock as the major species.

For this stand, the only practical difference that potentially results from misidentifying major species is that the LO could potentially harvest up to half of the outer zone trees (10/acre) while using the major species designation as we determined it, no outer zone trees could be harvested. It is not certain that even this difference would affect the allowable timber harvest amount, however, as LOs often clump outer zone trees around sensitive sites. An effect to harvest of outer zone trees would only apply if trees were left using the “dispersal strategy” and the LO used the credit to harvest up to half of outer zone trees on a basal area for basal area basis.

There are no guidelines for determining major species in Rules, Board Manual or the instructions for using the DFC Model. Because the major species determination is the most sensitive factor to stand basal area growth of any input in the DFC Model, there should arguably be guidelines for making this determination. This is addressed in more detail in the Model and Manual report (McConnell and Heimburg, 2010).[9]

[9] In the recently revised (February 2010) Board Manual (Section 7) guidelines for determining major species have been added.

A reviewer of an earlier draft of this report commented that the LO identification of Douglas-fir as the major species on the site presented above (#120) appeared to be "a pretty blatant disregard for the rules". However, in this instance it was not at all clear that that was the case. And, especially with no guidelines in place, the determination made by the LO was apparently reasonable. The percentage of western hemlock in this stand obtained from a complete census of trees identified by species and measured with a diameter tape to the nearest 1/10" (CMER data), was 59.4% while the basal area of Douglas-fir was 39.4%. The Douglas-fir were generally larger than the western hemlock which may have made assessing whether the larger, fewer Douglas-fir provided more basal area than the smaller, more abundant western hemlock. LOs are only required to record trees by type (conifer vs. hardwood). LOs report species type based on their best estimate, not from species-specific quantitative data as we did. Additionally, the plantation adjacent to this stand had been planted to Douglas-fir; clearly the LOs were intending to manage this area for Douglas-fir. In this context, the major species determination made by LOs did not seem unreasonable. However, this is another example of a consistent trend we observed – in any instance of an inaccurate call being made, the call made appeared to favor the LOs ability to harvest more and leave less even if in this instance, it did not make much difference[10].

The DFC Model-calculated required number of trees in the outer part of the inner zone and in the outer zone (Figures 10 and 11) is very similar between sites. The number of outer zone trees reported is for 20 trees per acre but on almost all sites for both data sources, half of these can be cut because of the "basal area credit" (Figure 9) if outer zone trees are left using the "dispersal strategy". The number of trees to leave in the outer part of the inner zone and in the outer zone, are prescribed by the DFC Model on a per acre basis. The differences in site attributes between data sets have some effect on stand area but make relatively little difference in terms of number of trees when starting from a low per acre number to begin with. Big differences in stand area would be required to cause more than minor changes in the number of inner or outer zone leave trees required.

[10] It is interesting to note that the new (February 2010) Board Manual guidelines (Section 7) for identifying major species that use a criterion of stem count by species would make this stand more clearly a WH stand than the bapa metric we used. Considering only DF and WH trees in this stand, there was more WH than DF bapa by 57% to 43% while tpa favored WH 66% to 34%. In general, since WH is a shade-tolerant tree species that will establish and grow under canopy cover, there are likely to be more WH stems than DF stems in riparian stands in locations in which both tree species will grow, many of them being smaller understory trees. The new Board Manual guidelines therefore will likely have the effect of putting some stands that previously would have been classed as DF as WH. The DFC Model will project less growth on these stands than if DF was determined to be the major species, meaning that some stands that otherwise would meet DFC may not and in some stands, the harvest opportunity will be less than if classed as a DF stand.

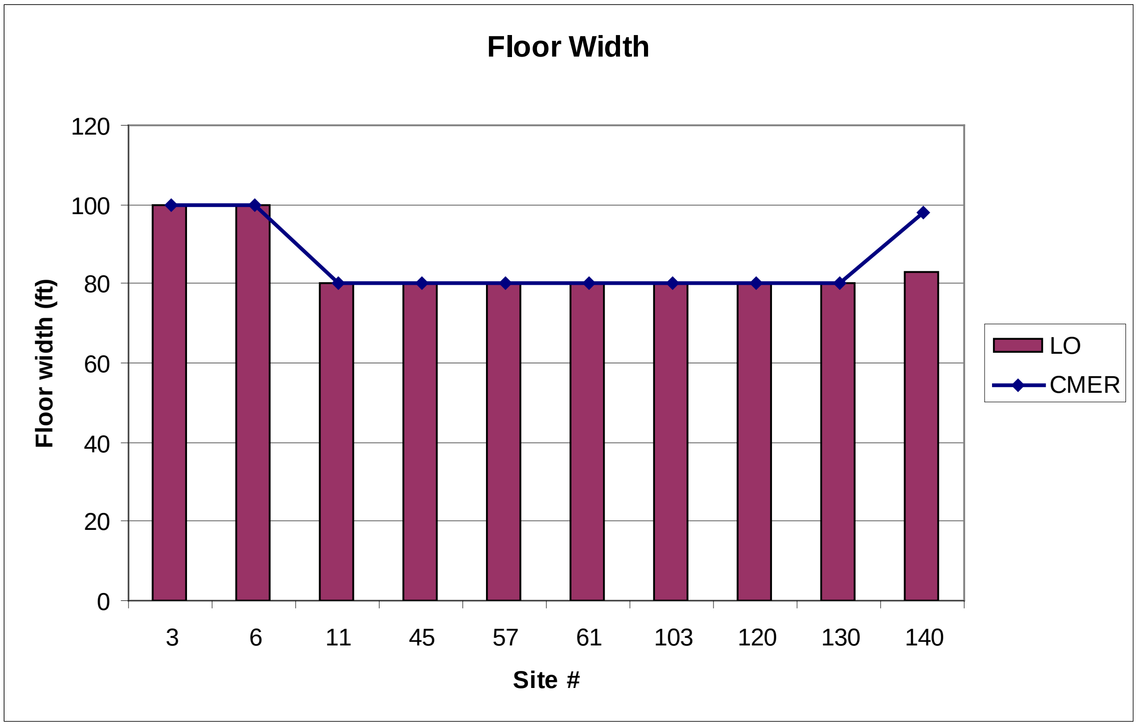

Figure 8 – DFC Model-calculated floor widths for Option 2 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study.

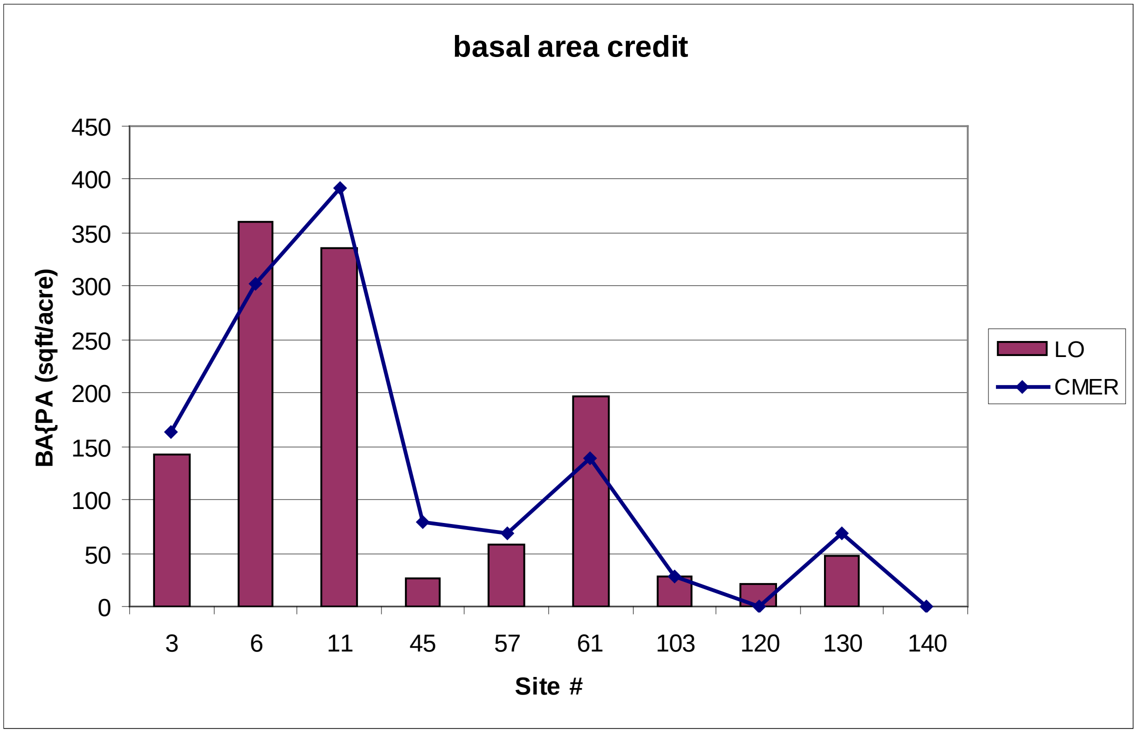

Figure 9 – DFC Model-calculated basal area credit amounts for Option 2 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study.

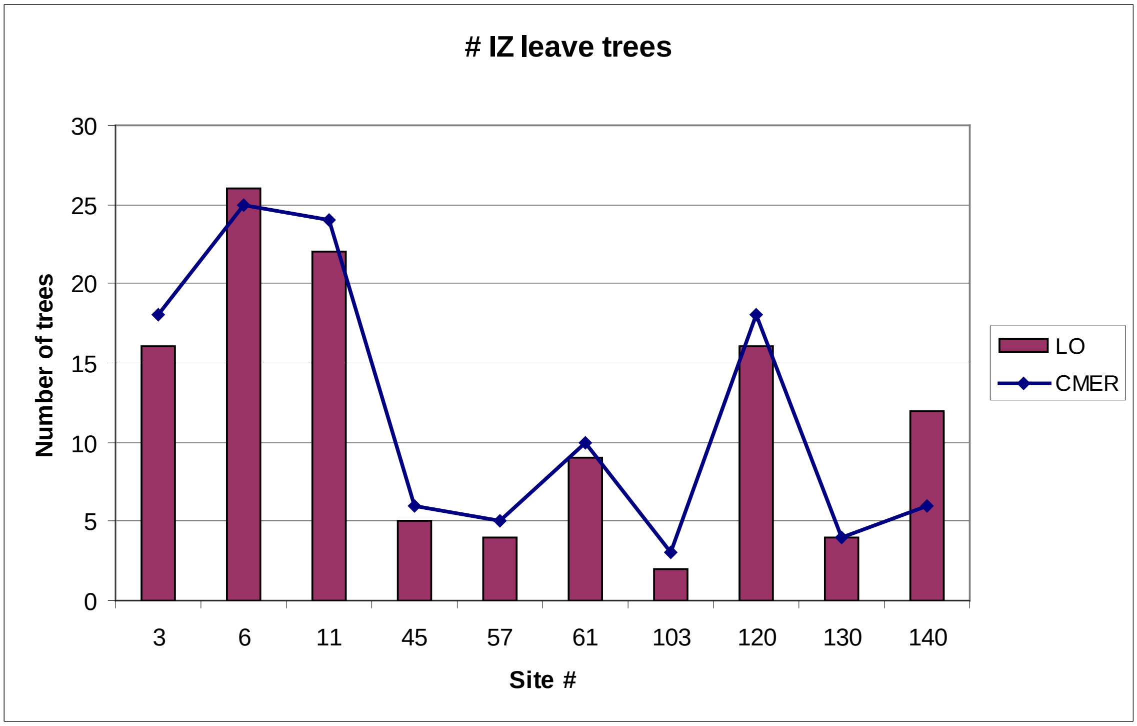

Figure 10 – DFC Model-calculated required leave trees for the outer part of the inner zone for Option 2 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study. Sites were numbered by CMER (site #) and are linked to specific FPAs.

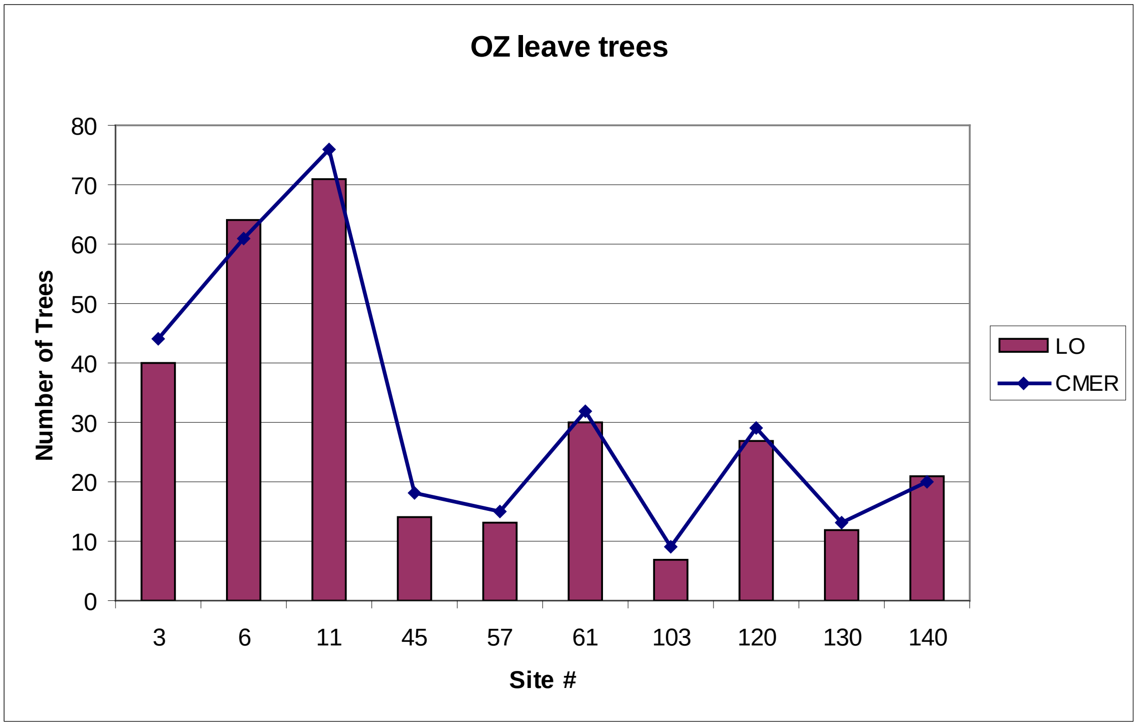

Figure 11 – DFC Model calculated required outer zone leave trees for Option 2 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study. Sites were numbered by CMER (site #) and are linked to specific FPAs.

Site attributes

We found some differences in stream size; on 5 of 15 stands we thought there was reasonable argument to be made for a different call than the one made by the LO and approved by the DNR. Stream size call is one of the most important of site attribute calls because it affects inner zone width, the width of the no-cut "floor" in the inner zone using Option 2, and can determine stand eligibility for harvest using Option 2 on Site Class 3[11]. Almost half (74 out of 150) of stands evaluated in the Desktop Analysis were Site Class 3 indicating the likely proportion of riparian harvest units in Site Class 3 in western Washington (Desktop Analysis, Appendix A, Figure 2, McConnell, 2010).

Neither of the CMER crew members had specific training on determining bankfull width so the differences observed by CMER should not be considered definitive. We used the Board Manual to support the determinations we made. We found the Board Manual to be well-written and clear but still inadequate as compared to having field training with experts. We believe that additional work on a revised Board Manual would be less productive than training for increasing the accuracy and consistency of making accurate stream size determinations and we suggest that effective training on stream size could make more difference to ensuring that riparian rules are implemented as prescribed than for all other attributes except ensuring that the correct major species is identified.

We found differences in major species on only one site. On this site Douglas-fir was determined by LOs to be the major species while we determined that a higher proportion of stand basal area

[11] Option 2 is allowed along small streams for Site Class 3 but is not allowed along large streams.

was in fact of western hemlock. The Douglas-fir "variant" of the DFC Model adds basal area to stands more quickly than does the western hemlock "variant". Thus, it is important that this call be correct as there will be stands that meet DFC using the "DF" variant that will not meet it using the WH "variant". There are no guidelines that provide direction to LOs on how to make this call, and no good methodology for doing so accurately short of recording tree species while collecting stand inventory data. The data collected in this study are inadequate to address the question of how often this may occur.

We also found that there is no established protocol for determining RMZ length. The lengths we measured were generally close to those measured by LOs, at least within the context provided by the Sensitivity Analysis (Roorbach et al, 2006) that indicated that the DFC Model was relatively insensitive to this RMZ length. RMZ length affects the measure of stand area, which affects stand density. Stand basal area projected into the future ~90[12] years tends to equalize even where initial differences in stand density are large. While projected stand age 140 bapa may not differ much, any use of the data for other purposes, in particular current conditions, would be more problematic.

While we had concerns going in to this study as to the reliability of collecting stand age data, the guidelines provided for determining this are relatively straight forward as compared to the guidelines provided for other stand attributes. Our stand age determinations were similar to those collected by LOs in all but two instances. The problem with different measures being attained is probably not a problem with methods, thus this would best be remedied through attention to it in compliance monitoring or pre-approval reviews, if differences are perceived to be great enough to warrant attention at all.

In general, the shape of the diameter distribution curves, by species type, were similar between data sets although there were some instances where LOs classed trees into different diameter classes than we did or failed to record trees in smaller (6" and 8") diameter classes.

2. Future Stand Conditions Projected by the DFC Model
<u>Option 1</u>

DFC Model-projected stand basal area[13] differed little between data sets (Figure 12). The greatest difference was for Site #120 where different major species determination (Douglas-fir by LO, western hemlock by us) resulted in greater projected growth using the LO data.

LOs reported substantially more trees in the inner zone of site #6 than we did (stumps were difficult to locate in slash and brush on this site and some, especially smaller diameter stumps were likely missed) possibly accounting for the difference between data sources on this site.

We report more large diameter trees on Stand 8 than did LOs which likely accounted for the higher projected stand age 140 bapa that we projected for that stand.

The stand-age-140 bapa for stand #140 was higher for the LO-collected data than for our data, but the cause of this difference is more complicated than for the other stands. Determining the cause for this difference helps identify how complex the rules are, as well as providing an opportunity

[12] The average age of the 150 stands included in the Desktop Analysis is 51.6 years, meaning that on average, projected post-harvest growth is projected for 88.4 years.
[13] The measure made is of combined core and inner zone stand basal area, weighted by core and inner zone area.

to understand some of the dynamics of the DFC Model. The LO data reported more medium-sized conifer trees (16"-24") while we reported more small trees (< 16") as well as a fewer large trees (> 24") than for the LO data. The estimated inner- zone basal area after a thinning from below using our data was 159.1but using LO data was 116.5. Conversely, our estimate of, core-zone conifer bapa was 109.6 as compared to 125.7 for the LO data. The weighted average stand age 140 bapa for the combined core + inner zone was substantially greater for the LO data (371 ft^2/acre) compared to the DFC projection based on our data (338 ft^2/acre).

Model projections for stand #140 were also affected by the presence of hardwood trees in the core zone. For example, core- zone stand composition determined from our data was 47.7% conifer vs. 76.3% using the LO-collected data. The percentage of basal area target calculated on the DFC Worksheet using our core zone data was 92.5%, while for LO data it was 129.3%. If all of the core zone hardwood trees are excluded from the CMER collected data, the DFC Model projects that core zone bapa will achieve 108.7% of the basal area target, an increase in percent of 16.2 and a difference in projected bapa of 44.5 sqft/acre. The core + inner zone projected stand age 140 bapa difference of 33 sqft/acre between the CMER and LO data would be reduced to 20 ft^2/acre because, without core zone hardwoods, the projected stand age 140 bapa increases to 351 ft^2/acre. LOs may omit hardwood trees from their core zone inventories believing that since they do not count towards the DFC basal area target they are irrelevant. In fact, the DFC Model does factor them in to growth model projections and omitting hardwood trees will result in higher stand-age-140 bapa of conifers than would be obtained if hardwood trees were included. The intent of the DFC Model was to produce reasonably reliable and accurate growth model projections but, like all models, results depend on having the type and quality the model was designed to accommodate. It might be helpful for guidelines to better emphasize the need for data that accurately places trees into the right diameter class and records all trees, not just those that count towards basal area targets.

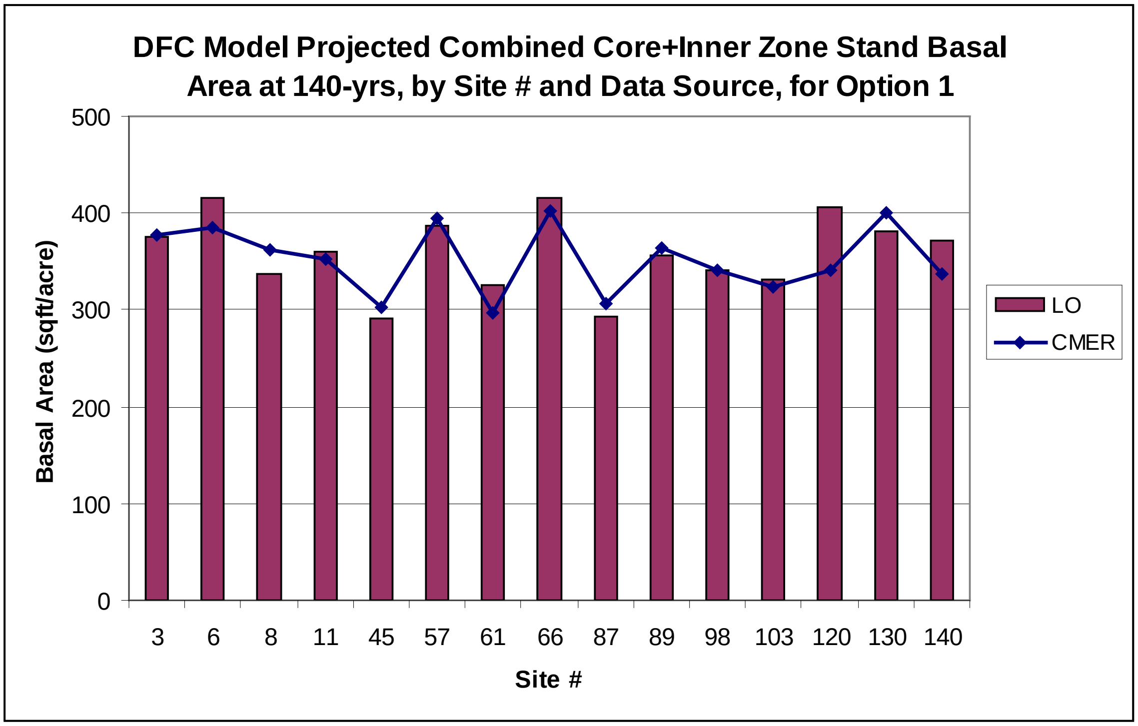

Figure 12 – DFC Model-projected combined core + inner zone stand basal area at age 140 following Option 1 harvest, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study. Sites were numbered by CMER (site #) and are linked to specific FPAs.

<u>Option 2</u>

DFC Mode projections show little difference in stand age 140 bapa by data source for Option 2 (Figure 13). The key factor explaining differences between data sources is which has more large diameter trees. Basal area growth on large diameter trees is greater than for small diameter trees and for all sites on which there is a difference in the distribution of tree size between data sources (Sites 11, 45, 61, 120, 130 and 140 – see Appendix B). The data source reporting more large-diameter trees is projected to have more stand bapa at age 140. Note that basal area values compared in Figure 13 account only for trees in the core and floor portion of the inner zone; required leave trees in the outer part of the inner zone are not accounted for.

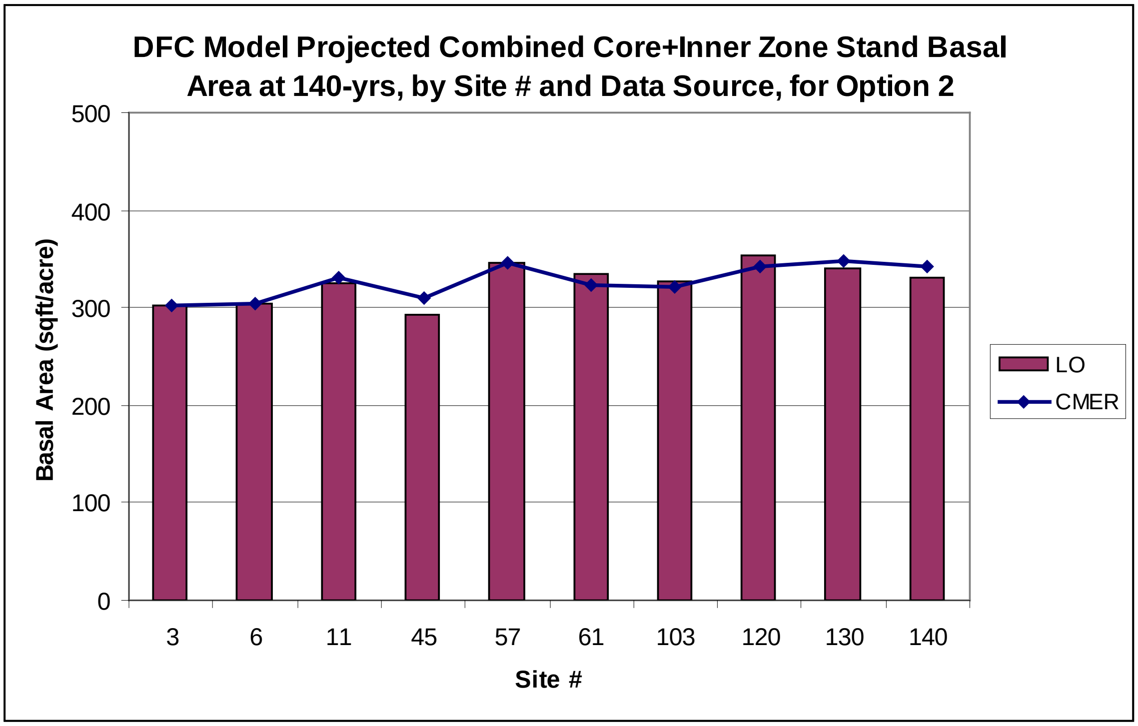

Figure 13 – DFC Model-projected stand basal area at age 140 for the combined core + inner zone following Option 2 harvest for the subset of stands eligible for this treatment, by site and data source. LO = landowner. LO data is from the DFC Worksheet on the Forest Practices Application. CMER references the data set collected for the CMER DFC Field Check Study. Sites were numbered by CMER (site #) and are linked to specific FPAs.

Summary of DFC Model-projected results

In general, the DFC Model projections of stand age 140 bapa differed little between data sets. This conforms to results of the Sensitivity Analysis (Roorbach et al., 2006), which found that for most of the site attributes and stand inventory (tree density and tree size) configurations tested, stand basal area tended to equalize over the long period of time for which growth is projected. Where we noted different stand age 140 results, these were directly attributable to differences in the data collected. For example, the difference in major species (stand 120) made a difference in stand age 140 bapa (Figures 12 and 13) as did substantially higher tree densities in LO data as compared to CMER data (Stand 6).

DISCUSSION

This project was implemented because the reliability of site-attribute and stand inventory data used in the Desktop Analysis Study (McConnell, 2010) was unknown. Data were compared graphically and tabularly and no tests of statistical significance were made. The LO-collected data are representative of actual stand conditions on the sites managed using these rules and are a reasonable source of input for the Desktop Analysis study given the focused and specific objectives of that study. We found some differences in site and stand attributes from our data and from data provided by LOs. We recommend that the LO data be accepted as a valid data source for use in the Desktop Analysis, especially in light of the findings by Roorbach et al. (2006) that the DFC Model is robust in its ability to obtain prescription-useable results despite variability in input data.

We identified a number of opportunities for improving directions provided in the Forest Practices Board Manual to LOs about data collection and layout of riparian area units using DFC Rules for western Washington. Opportunities for gathering better data include: developing guidelines for determining RMZ length and major species and providing additional training to ensure that LOs accurately define CMZs and stream size (bankfull width). These are inter-related and important. The rules emphasize stream size, another name for bankfull width. The proper location for the core zone, however, begins at the outer edge of the CMZ which may be at a different location along the stream side than is the outer extent of bankfull width.

Uncertainty exists among LOs about how to report some site attributes or measure riparian stand characteristics. For example, some LOs believed that they were supposed to round stand age to the nearest 5 years, but others reported whatever age they determined to be accurate. Some LOs did not record conifer trees less than 8 or 10" diameter or omitted hardwood trees despite their presence on the site.

The DFC Model results did not differ substantially even where there appeared to be some substantial differences between the data sets in one or more stand attribute. This is because the DFC Model projects information further into the future than is usually done for stand growth models and over this time period (usually 80 to 100 years), the metric evaluated, stand bapa, will compensate and tend towards a site-appropriate bapa for that age. Some differences in starting stand density and diameter distribution become relatively unimportant over that time span, although the major species identified will result in a big difference in ending bapa using the DFC Model.

Current stand conditions may vary substantially while projected stand bapa differs only minimally between data sets. Differences in RMZ length, for example, may not make a difference to projected stand age 140 bapa but will make a difference to estimates of current stand conditions. The biggest effects to on-the-ground implementation are stream size, as this directly affects inner zone width, and major species, as this affects projected stand basal area growth more than any other attribute (Roorbach et al, 2006) enough that it can make a difference in whether a stand is eligible for harvest and affect the riparian prescription provided if eligible. This study does not provide any data that can provide insights to the frequency of occurrence of inaccurate determinations of stream size or major species and does not conclude that any of these were made inaccurately in the stands evaluated in this study, except for the stream size call made on site #61 which was reported as a small stream but we believe would properly be classified as a large stream.

This study also does not evaluate or characterize how much difference might be made by inaccurate determinations of stream size or major species across different stand configurations, results of this study pertain only to the specific FPAs evaluated. Investigation of the effect to rule implementation of inaccurate site-attribute determinations might be a useful complement to the Sensitivity Analysis (Roorbach et al. 2006) and help provide context for the relative importance of making accurate determinations of site and stand attributes required for use with the DFC Model and DFC rules.

In addition to the listed objectives, some of the data collected for this study provide information on how timber harvest is implemented by LOs using both prescription options. The tree data were collected according to whether they were live (and standing), dead, cut or windthrown. These data are sufficient to characterize post-harvest stand conditions including the amount of cutting and the diameter distribution of trees cut in both the core and inner zones and windthrow.

The windthrow data from these sites could be useful for doing a survey to determine windthrow amount from these stands, managed under DFC rules. Data collected one to two years after timber harvest (and for three stands pre-harvest) could be compared against data collected several years later, providing basic information to help with design of a larger windthrow study currently being considered by RSAG and CMER. The data on timber harvest could provide information on how rules are currently implemented and insights into developing Rules that are operationally feasible from a timber harvesting perspective. The data on windthrow and cut amounts were not part of the objectives of this study and so are not included in the body of this report.

CONCLUSIONS

The data collected by LOs was judged to be suitable for use as input data for the Desktop Analysis report (McConnell, 2010) given the narrow and specific objectives of the Desktop Analysis report and the lesser importance of having completely accurate data than having data representative of stands managed under DFC rules from a broad range of conditions.

There were differences in data collected by LOs and us for every site attribute except Site Class, which is obtained from DNR maps.

Most of the differences in site attributes were the result of lack of guidelines on how to collect data, in particular for RMZ length and major species.

Stream size is the most important site attribute collected in terms of on-the-ground effects because of its influence on the width of the no-cut floor using Option 2 and on determining the inner zone width for both Options.

Stream size is one of the more challenging determinations to make and even with good direction from the Board Manual training may be required to make this call accurately and consistently between individuals responsible for making this determination accurately – DNR FPF foresters, compliance monitoring crews, timber industry foresters and others.

Where differences in DFC Model-projected basal area occurred, these were attributable to differences in major species and stand density as estimated by LOs and measured by us.

Major species was determined (as per the Sensitivity Analysis) to be a substantial source of difference between in projected stand bapa yet there are no guidelines provided to LOs for making this determination.

All results of this study are from a small sample of stands and their general applicability to west-side Type F riparian studies should be considered with that in mind.

There is not enough data to conclude that there is systematic bias in how site and stand attribute determinations were made by LOs but it is also the case that in every instance in which we made a determination that was different than the LOs, the outcome of that difference favored the LO, e.g., with all else being equal, the difference in determinations made or data collected would allow the LO to harvest more timber.

The different methodologies used to estimate stand age, ours, derived from literature and the method in the Board Manual, which does not attempt to account for differences in age to breast height across different Site Classes, made very little difference in stand-age-140 bapa projections.

The effect a few trees less or more can have to stand characteristics highlights a potential problem with management using DFC Rules when applied to short RMZs; DFC Model-projected outcomes could have big differences that determine whether a stand is eligible for timber harvest along with prescription details based on the difference of only a few trees. The differences noted also highlight the importance of establishing re-locatable endpoints and using a repeatable method for measuring RMZ length as there are a number of reasons why LOs, other stakeholders or regulatory agencies may wish to be able to re-establish RMZ stand boundaries sometime in the future.

RECOMMENDATIONS

One: Provide for expert review of the bankfull width determinations we made in the report. We followed established Board Manual guidelines and believe we made the right calls in each instance but we did not have specific training in making bankfull with calls. Because the implications of making stream size calls are great – whether streams are judged to be GT or LT 10' width can mean the difference in cutting a 20' width of inner zone under Option 2 of rules (floor of 80', small stream vs 100', large stream).

Two: Develop a single standard methodology for measuring RMZ Length and include directions for how to implement it in the Board Manual.

Three: Develop a methodology for marking the upper and lower extent of RMZ's from which RMZ length can be measured and the area included within the RMZ can be easily identified.

Four: Clarify expectations of LOs. For example, many LOs provide a stand age that is rounded to the nearest "5" but the DFC Model is calibrated for total stand age and changes to bapa are continuous, anticipating that actual stand age will be used. Since the Model was set up for annual change, the apparent expectation is for exact (estimated) age and guidelines for users should make that clear. Additionally, the stand diameters by tree type is an already coarse measure of stand charecteristics but LOs appeared to lump trees across even coarser DBH categories than rules allow. Assuming directions are to be followed for getting this stand data, guidelines should emphasize the importance of doing this accurately.

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APPENDIX A – Stump to DBH ratios used for estimating the 2" live tree diameter class of cut trees.

These data were not collected in a scientifically rigorous manner. Data were collected from only five of the fifteen sites sampled. Data collected was from the base and dbh of trees, by species. We attempted to get data from a range of size classes for each species, e.g. we made up rough divisions of small, medium and large trees at each of the sites sampled, depending on the diameter distribution present, and tried to fill in this matrix. We have varying sample sizes for each species and some species were not present on all sites. Diameter at breast height for cut trees was calculated by multiplying the measured stump diameter, measured in tenths of a foot, by 12 inches, and multiplying that product by the ratio, for the appropriate species, from the table below.

Tree Species	Scientific name	DBH to base ratio (%)	# of trees	# of sites
Douglas-fir	Pseugotsuga menziesii (Mirb.) Franco	86.2	22	2
Red alder	Alnus rubra Bong.	85.8	19	2
Pacific silver fir	Abies amabilis (Dougl.) Forbes	84.0	15	2
Sitka spruce	Picea sitchensis (Bong.) Carr.	79.8	40	3
Western hemlock	Tsuga heterophylla (Raf.) Sarg.	85.6	46	4
Western redcedar	Thuja plicata Donn	77.6	15	1

APPENDIX B – Total stand age estimations using different methods for calculating age to breast height and current and DFC Model-projected stand conditions that result.

The "DNR" method is from Forest Practices Board Manual Section 7 – Guidelines for Riparian Management Zones – which specifies that "Increment boring shall be made at 4.5 feet above the ground on the uphill side of the tree. Add five years to the growth ring count to account for growth up to boring height."

The "CMER" method was derived from literature and specified different ages to boring height by Site Class. Specifically, for cored trees, ages were adjusted by tree species and site class. For Douglas-fir, by site classes 2, 3 and 4, respectively, 7, 8 and 9 years were added to the age counted on the tree core collected at breast height as per King (1966). For western hemlock on site classes 2, 3, and 4, respectively, 6, 7 and 8 years were added to the breast height tree age counted as per Barnes (1962).

Table B1 – Estimated age and current and DFC Model-projected stand age 140 outcomes using the "DNR" method for estimating total stand age from increment cores collected at breast height.

Method	Site #	Current-Age Core Zone BAPA	Current-Age Inner Zone BAPA	Age	Stand Age 140 Projected BAPA	Required BAPA	After Thin Projected BAPA	BA Credit	Floor Width	Outer Part of Inner Zone Trees	Outer Zone Trees
DNR	3	151.7	145.7	53	401	184	362	168.2	100	18	44
DNR	6	151.6	139.1	66	382	184	375	314.2	100	25	61
DNR	8	157.1	150.4	67	388	124	339	n/a	n/a	n/a	n/a
DNR	11	148.9	154	63	397	111	335	408.2	80	24	76
DNR	45	141.5	150.3	58	388	134	237	80.8	80	6	18
DNR	57	159.6	160.2	35	413	79	392	69.6	80	5	15
DNR	61	143.9	144.9	61	374	126	235	142.2	80	10	32
DNR	66	192.4	191.7	62	429	0	379	n/a	n/a	n/a	n/a
DNR	87	143.3	139.1	48	359	156	257	n/a	n/a	n/a	n/a
DNR	89	157.6	154.1	58	398	123	343	n/a	n/a	n/a	n/a
DNR	98	176.4	166.9	39	374	0	229	n/a	n/a	n/a	n/a
DNR	103	145.1	144.3	39	372	123	270	27.9	80	3	9
DNR	120	145	138.7	39	382	177	298	0.5	80	18	29
DNR	130	161.6	160.2	38	413	73	397	69.3	80	4	13
DNR	140	94.1	143	47	393	288	412	n/a	97	6	20
Average		151.3	152.2	51.5	390.9	125.5	324.0	160.1	85.7	11.9	31.7

APPENDIX B (continued) -

Table B2 – Estimated age and current and DFC Model-projected stand age 140 outcomes using the “CMER” method for estimating total stand age from increment cores collected at breast height.

Method	Site #	Current-Age Core Zone BAPA	Current-Age Inner Zone BAPA	Age	Stand Age 140 Projected BAPA	Required BAPA	After Thin Projected BAPA	BA Credit	Floor Width	Outer Part of Inner Zone Trees	Outer Zone Trees
CMER	3	150.8	144.4	55	397	185	354	163.2	100	18	44
CMER	6	150.5	137.7	68	379	186	367	302.2	100	25	61
CMER	8	155.6	148.6	70	383	128	327	n/a	n/a	n/a	n/a
CMER	11	147.1	152.6	66	394	117	323	391.6	80	24	76
CMER	45	140.9	150	60	387	135	233	79.6	80	6	18
CMER	57	158	158.7	38	410	84	378	67.7	80	5	15
CMER	61	143.1	144.3	63	372	129	232	139	80	10	32
CMER	66	190.6	190.3	66	426	0	364	n/a	n/a	n/a	n/a
CMER	87	142.8	138.5	50	357	158	251	n/a	n/a	n/a	n/a
CMER	89	155.9	152.3	61	393	127	331	n/a	n/a	n/a	n/a
CMER	98	175.5	165.9	42	372	0	225	n/a	n/a	n/a	n/a
CMER	103	144.5	143.8	41	371	124	266	27.5	80	3	9
CMER	120	144.9	138.5	40	381	177	296	0	80	18	29
CMER	130	160.4	158.9	41	410	77	384	67.9	80	4	13
CMER	140	92.5	141.5	49	389	291	404	n/a	98	6	20
Average		150.2	151.1	54.0	388.1	127.9	315.7	154.8	85.8	11.9	31.7

Table B2 – Similarity of stand age estimates and current and DFC Model-projected stand age 140 outcomes using the “DNR” and “CMER” methods for estimating total stand age from increment cores collected at breast height.

% Similarity DNR / CMER		100.7	100.7	95.4	100.7	98.1	102.6	103.4	99.9	100.0	100.0

APPENDIX C – Sample RMZ length calculations demonstrating issues related to stream sinuousity

Taking just a simple example of a stream that undulates to the left and then back to the right. The undulation to the left can be calculated using the formula for calculating circumference from a given diameter, and then dividing that value by $1/4^{th}$. If a straight line segment is used to represent the radius of a circle and its length is 50', the corresponding stream length that follows the curve of the circle would be as follows:

Equation 1: $D = 2 * r$
Equation 2: $D = 2 * 50 = 100$
Equation 3: $C = Pi * D$
Equation 4: $C = 3.14 * 100$
Equation 5: $C = 314$
Equation 6: Undulation is assumed to equal $1/4^{th}$ of circumference, so U = 314/4 = 78.5'over a radius distance of 50'.

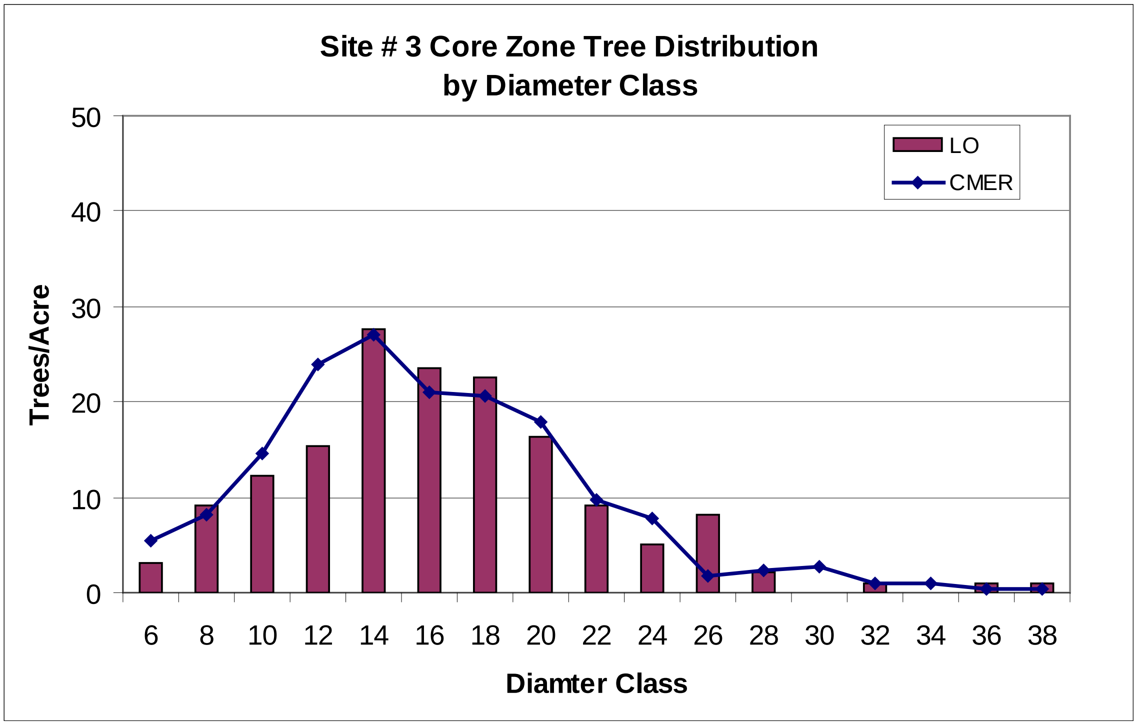
Doubling the result of Equation 6 to account for a stream that takes an equal and opposite curve back to its original direction, means that for a 100' length of stream, a corresponding measure of stream length along a sinuous stream could be up to or more than 157'. Both lesser and greater sinuousity is possible. Measuring stream length will yield a greater RMZ length than would be obtained by measuring distance along side of streams but not in them, except where streams are straight. The effect will be to overestimate RMZ length, resulting in a larger than actual unit area as defined by length time zone width. Trees measured in this area will be assumed to be distributed across a greater than actual area with the result that a lower tpa and bapa will be calculated than if a more accurate measure of RMZ length than stream length were used. Thus it is important that RMZ length accurately measure a length on which per area measurements of terrestrial vegetation can be made.

A similar problem exists in determining where to measure RMZ length. If you assume a segment of stream that is in a "C" or "U" shape, you can again use equations for calculating a circumference of a circle (and therefore semi-circle) to calculate different stream lengths. Assuming a stream is in a "C" shape (semi-circle), and a stream length of 400' is measured on the inside of the "C" immediately alongside the stream (so full circumference would be 800'), the diameter of the circle would be 800/3.14 = 254.8' and the radius is half of that, or 127.4'. If you add 50' to that radius to calculate the distance you would measure along the break between the core and the inner zone, the measured radius is 177.4 and the corresponding half of the circumference is (354.8*3.14)/2 = 557' so RMZ length measured along the outer edge of the core zone would exceed the length measured adjacent to the stream by 157' (557-400=157).

Assuming that the stream was Site Class I, large stream, the radius from streamside to the outer edge of the inner zone would be 177.4' + 100' = 277.4'. The length of a semi-circle with that radius is (554.8*3.14)/2 = 871'. Adding another 50' to the radius to account for the outer zone would give a radius of 327.4 and the resulting semi-circle length 200' from streams edge would equal (654.8*3.14)/2 = 1028. So, in this near "worst case" scenario of maximum buffer widths (Site Class 1, large stream) and a stream that flows along a full semi-circle, the difference between RMZ length measured at streamside vs along the outer edge of the outer zone can differ by 1028/400*100 = 257%. Notice that these figures could be reversed. If the stream were flowing along the length used above to illustrate the outer extent of the outer zone, the stream length could be 1028' and length measured along core, inner and outer zones be less, respectively. In the case of the top example of trees measured from the core and inner zones will be presumed to be from a smaller area than actual, so tpa and bapa calculations will be inflated as compared to actual conditions. In the second example, the tpa and bapa will be presumed to have been collected from a larger area than they in fact were, and tpa and bapa calculated will be less than actual.

Appendix D – Tree diameter distributions.

Diameters are compared by 2” diameter class (example 5-7.9” = 6 inch class) for the Forest Practices Applications (FPA) Field Check study sites. For each figure LO = landowner; and CMER = report authors. Tree numbers for LO are from the DFC Worksheet in the applicable Forest Practices Application. CMER tree per acre counts by diameter class were collected for the Field Check Study from the same RMZ unit as for the LO data.



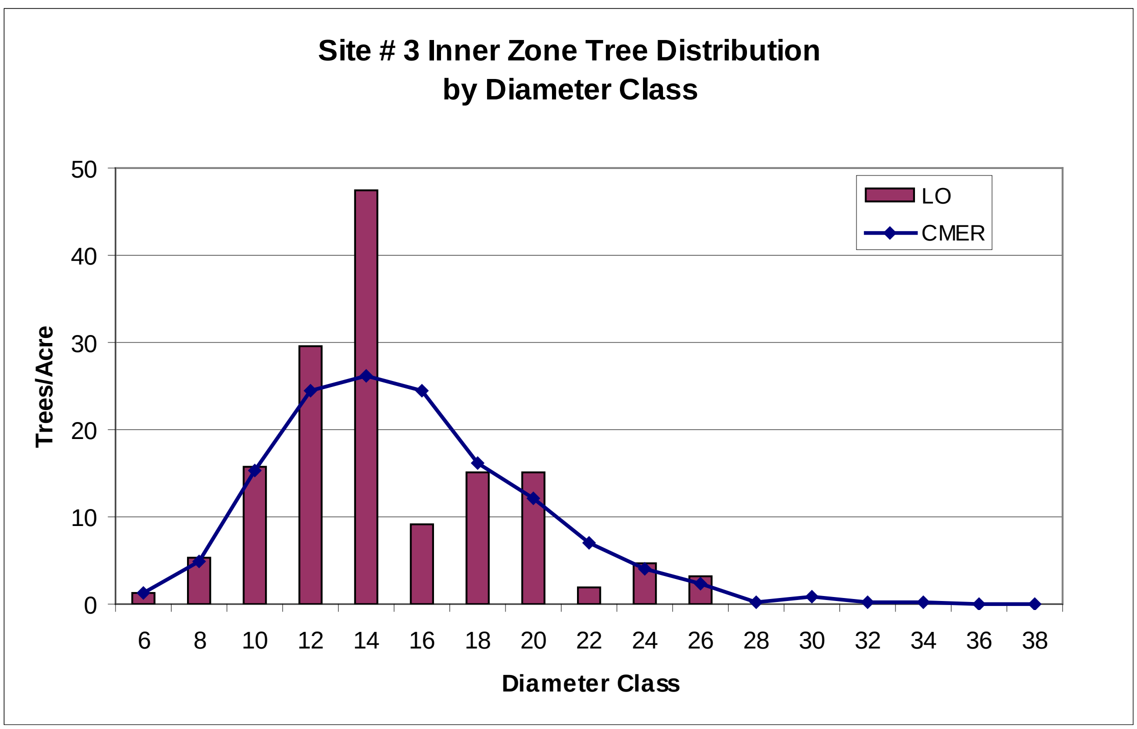
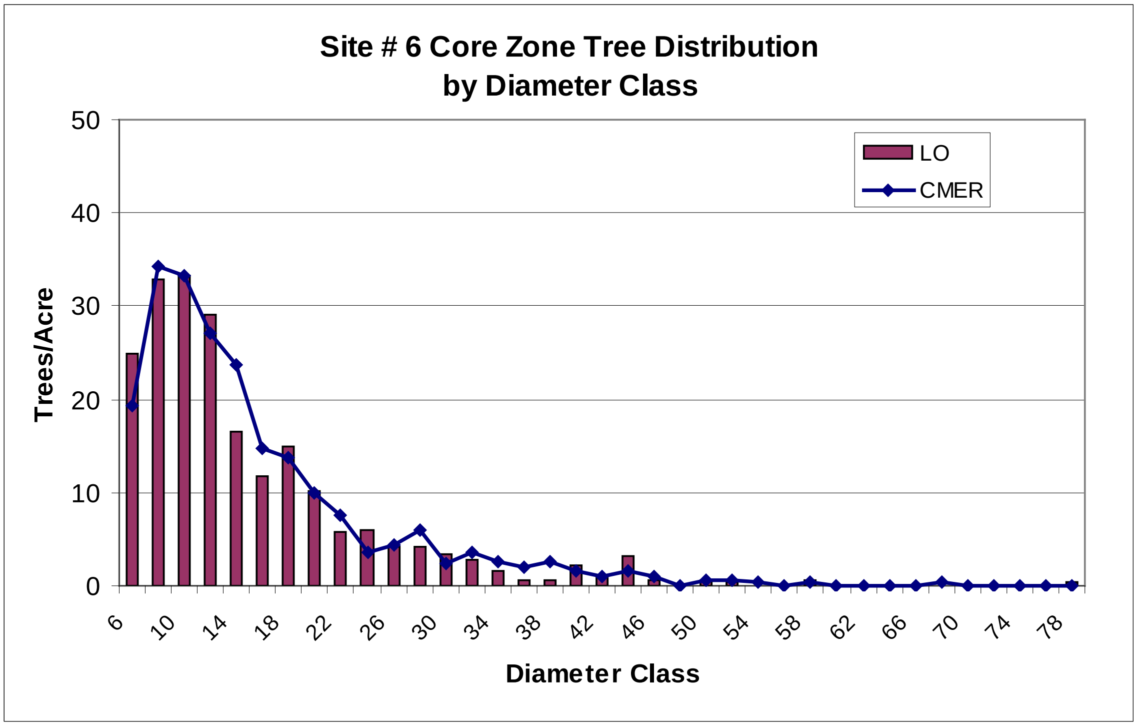


Figure D1 – Tree diameter distributions for site #3.



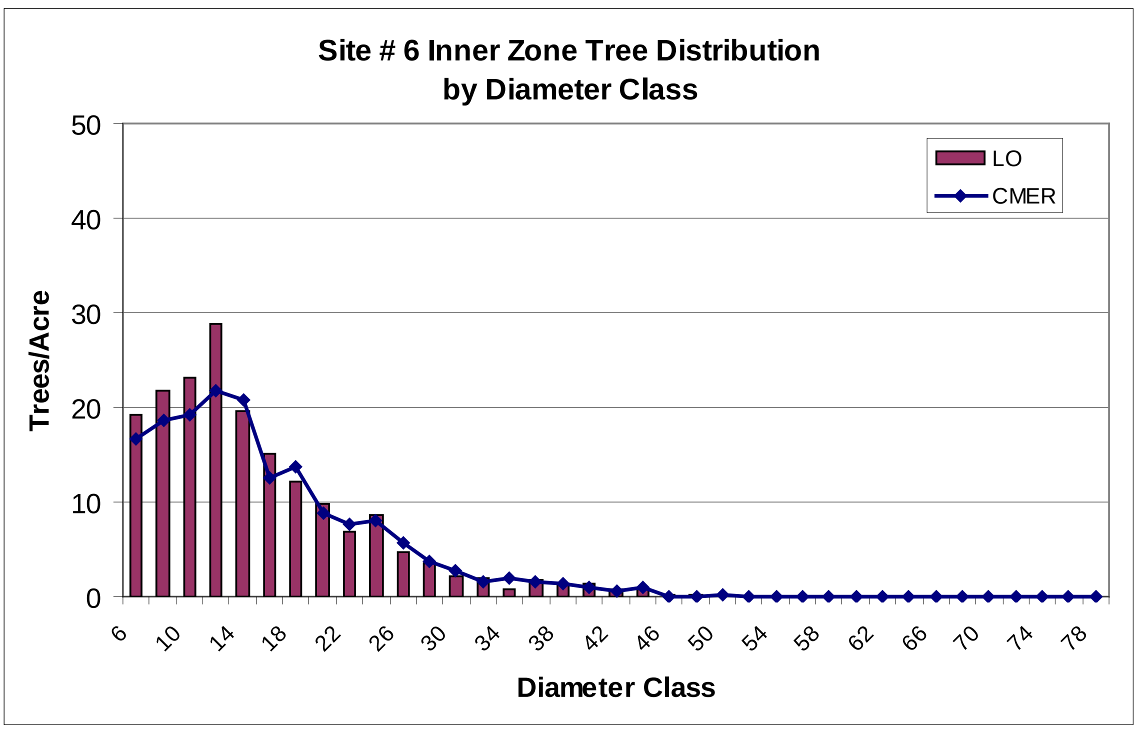
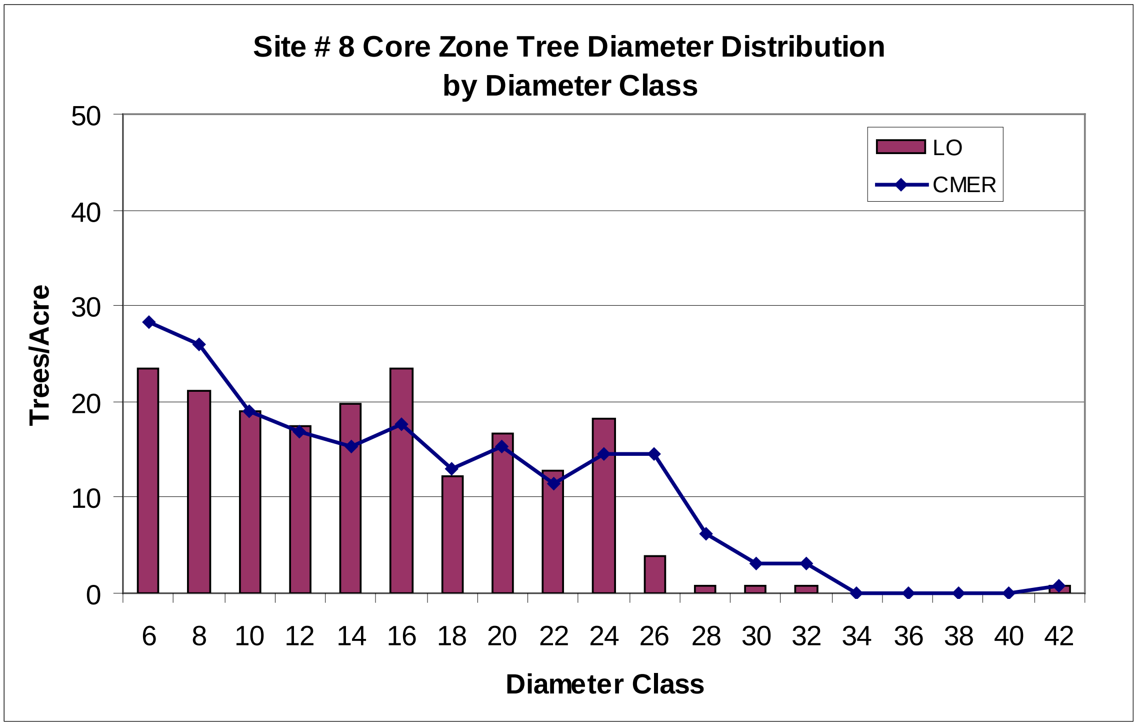


Figure D2 – Tree diameter distributions for site #6.



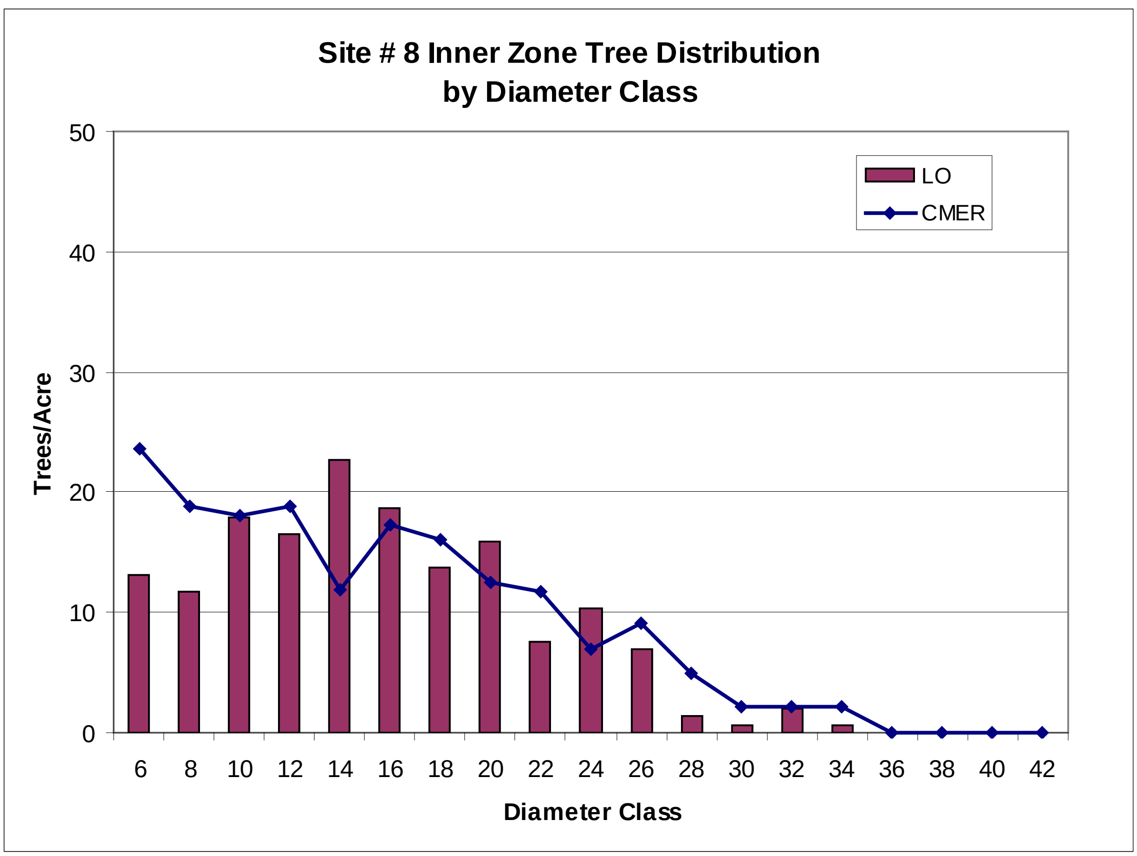
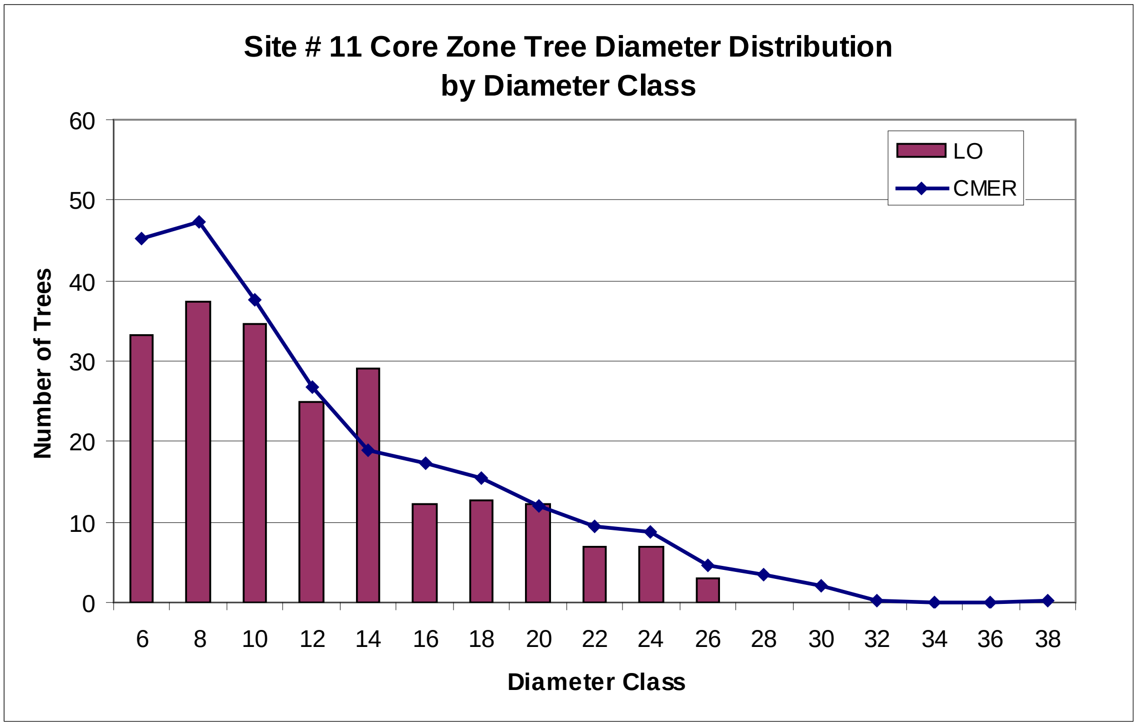


Figure D3 – Tree diameter distributions for site #8.



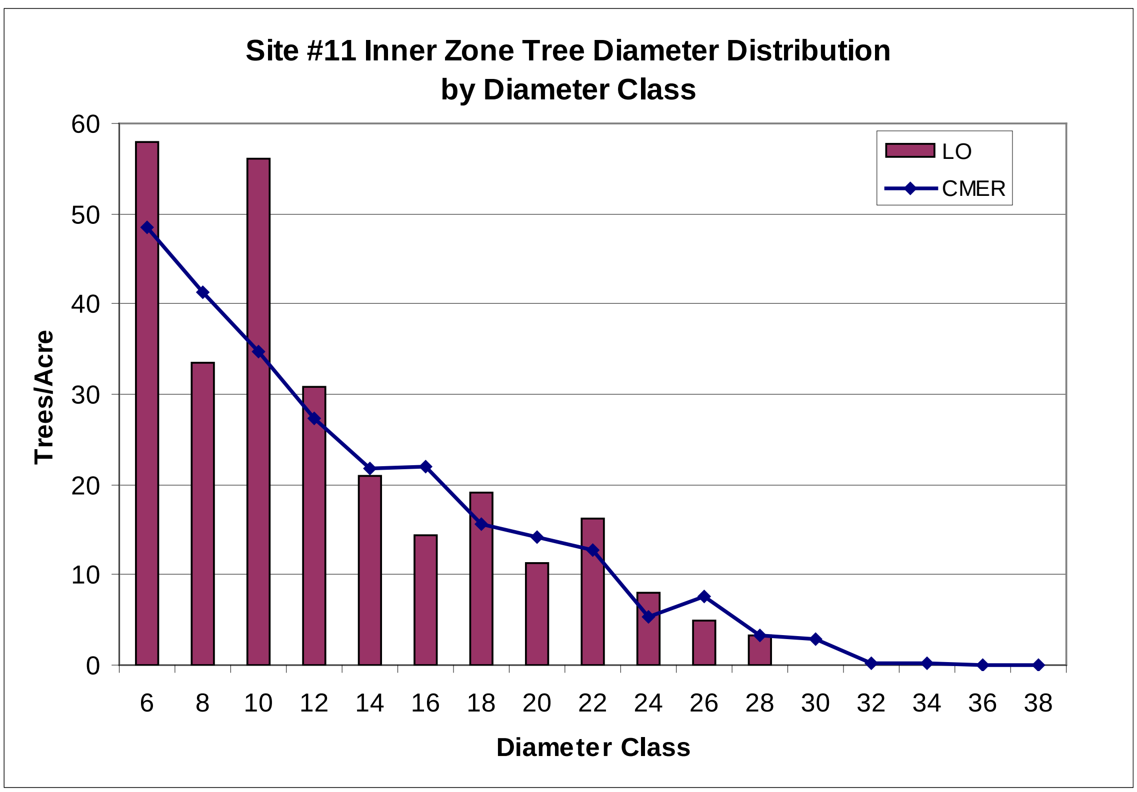
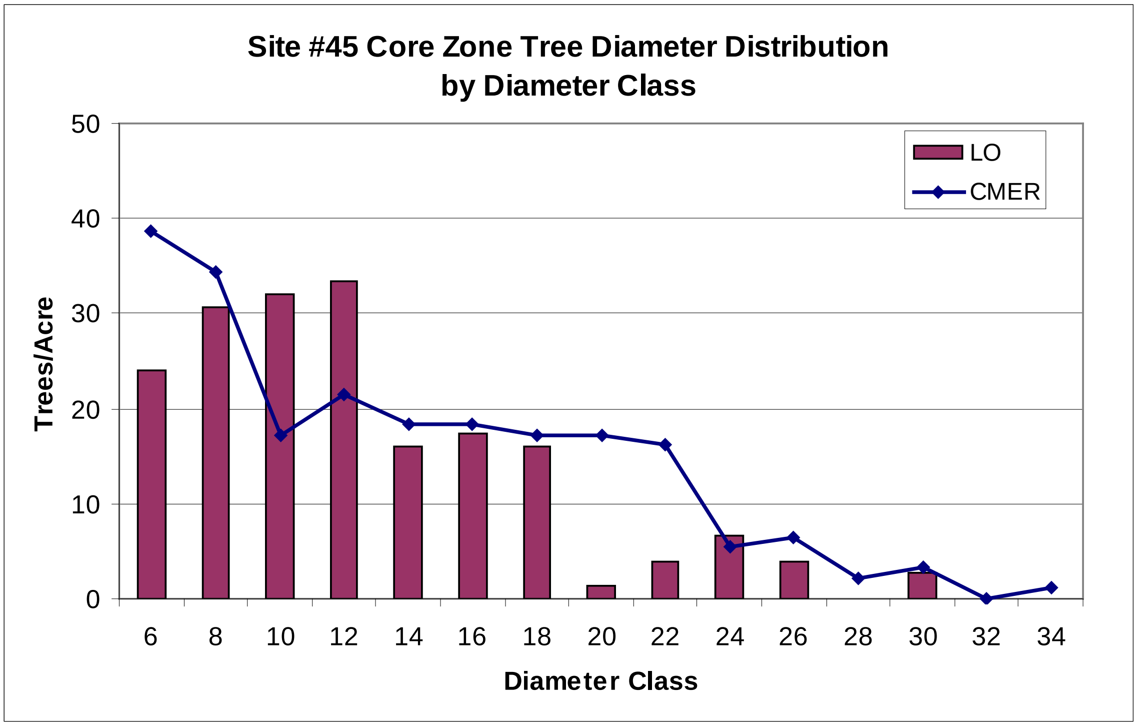


Figure D4 – Tree diameter distributions for site #11.



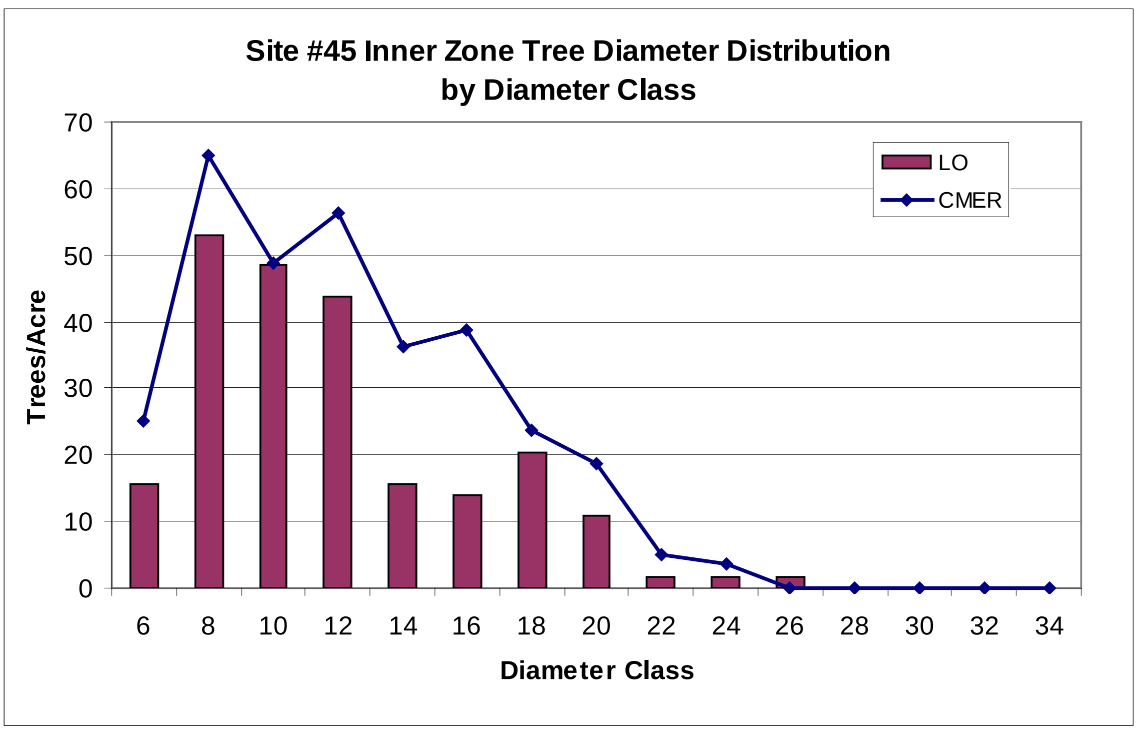
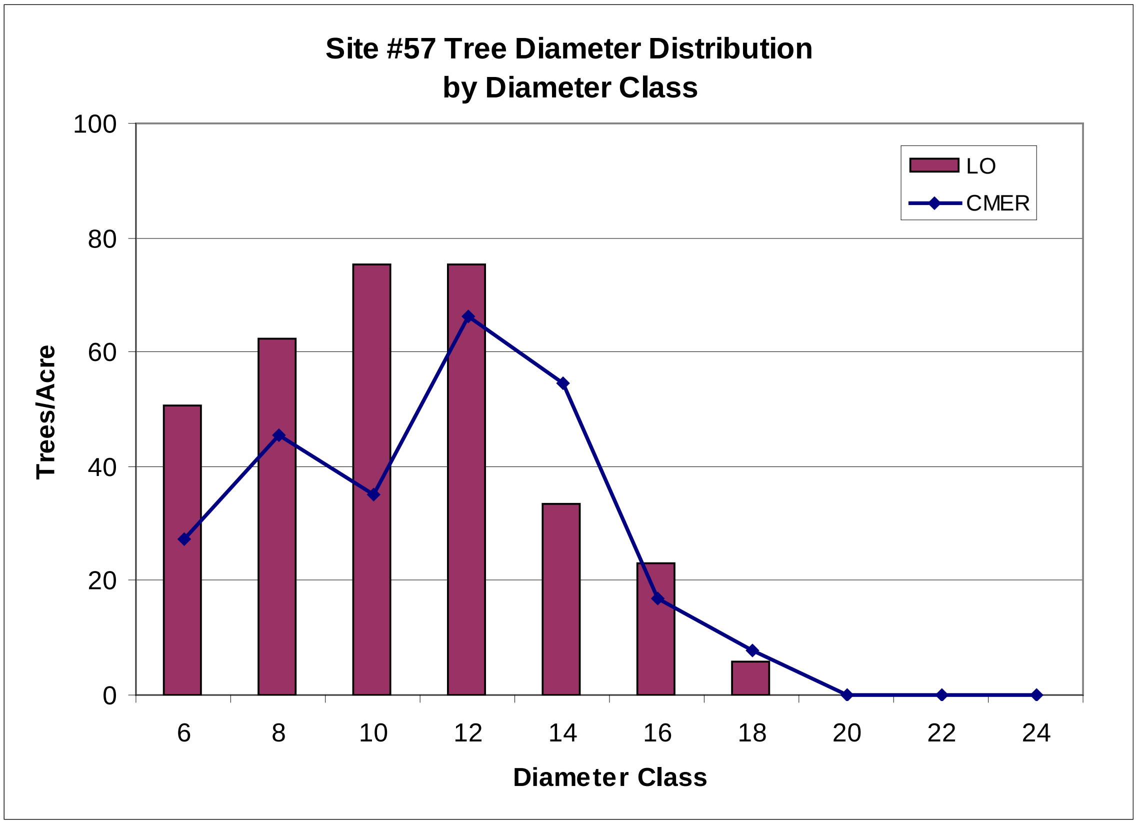


Figure D5 – Tree diameter distributions for site #45.



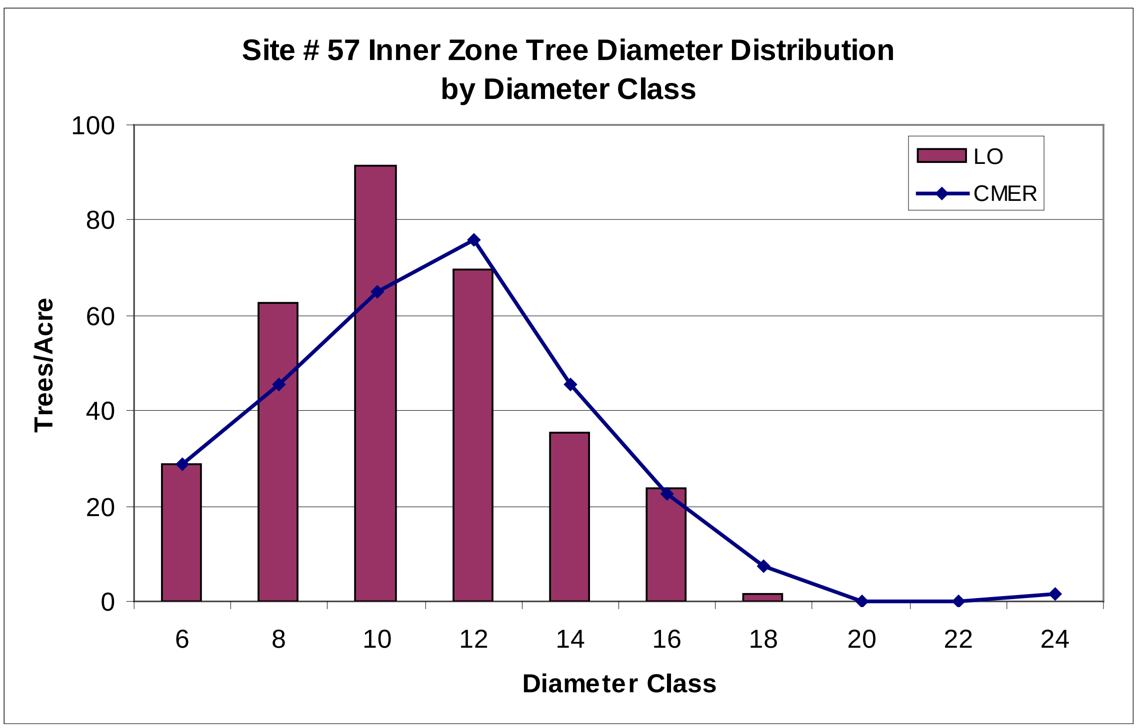
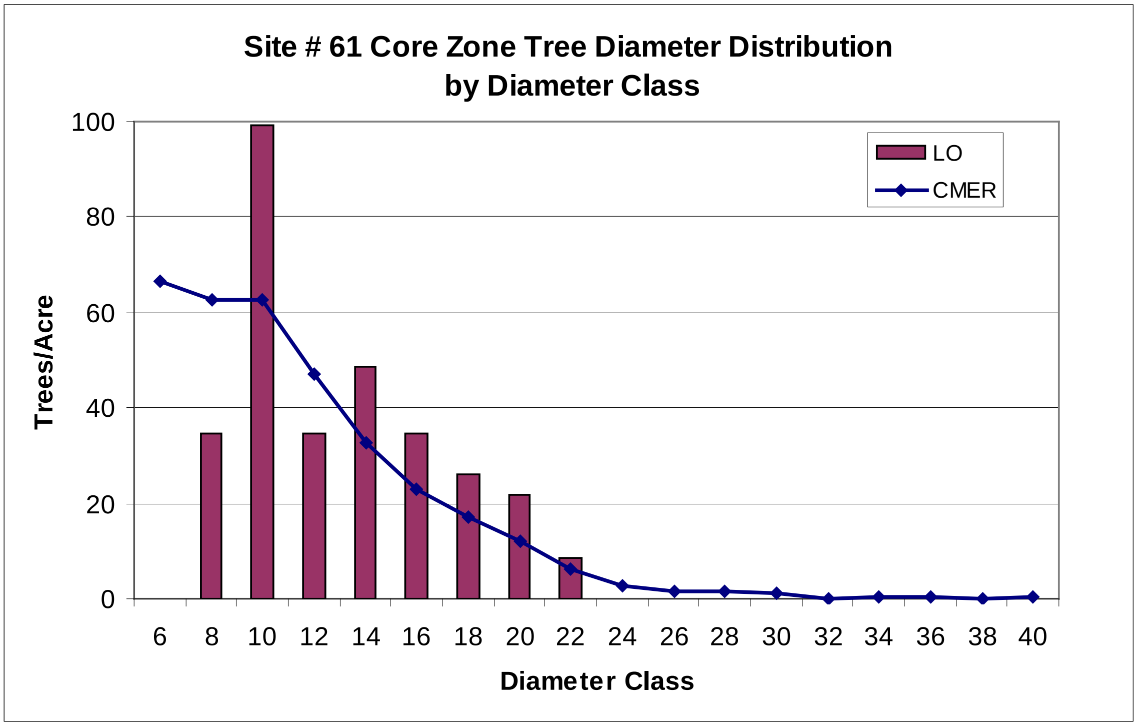


Figure D6 – Tree diameter distributions for site #57.



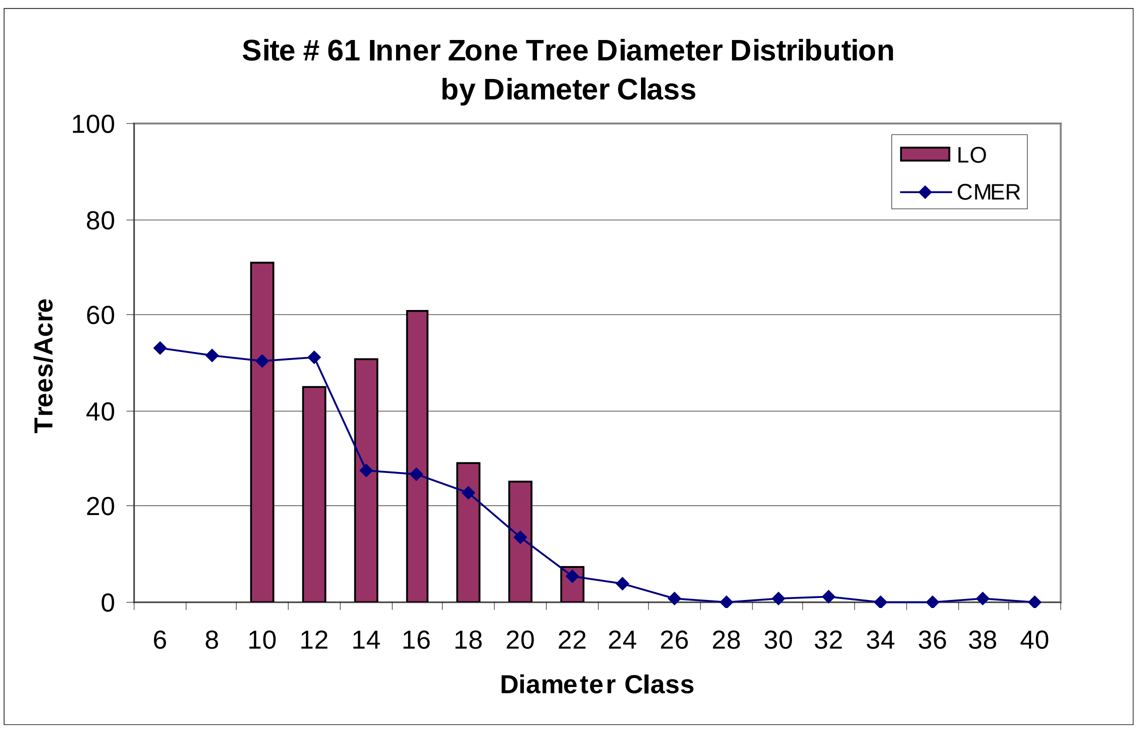
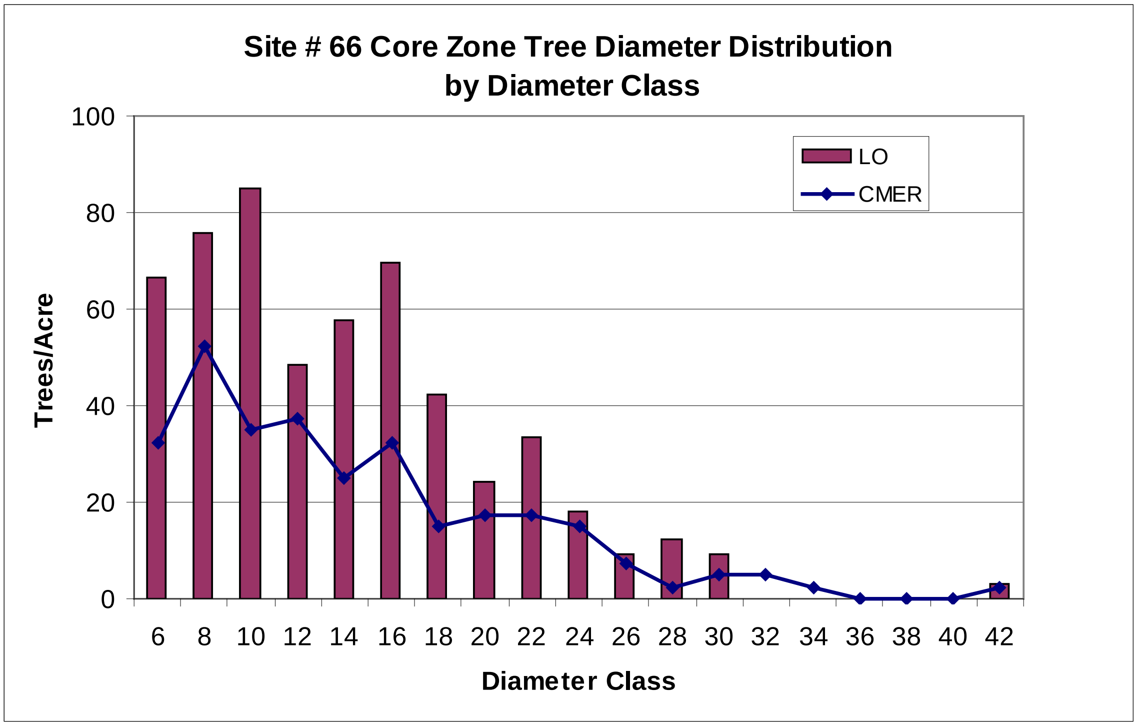


Figure D7 – Tree diameter distributions for site #61



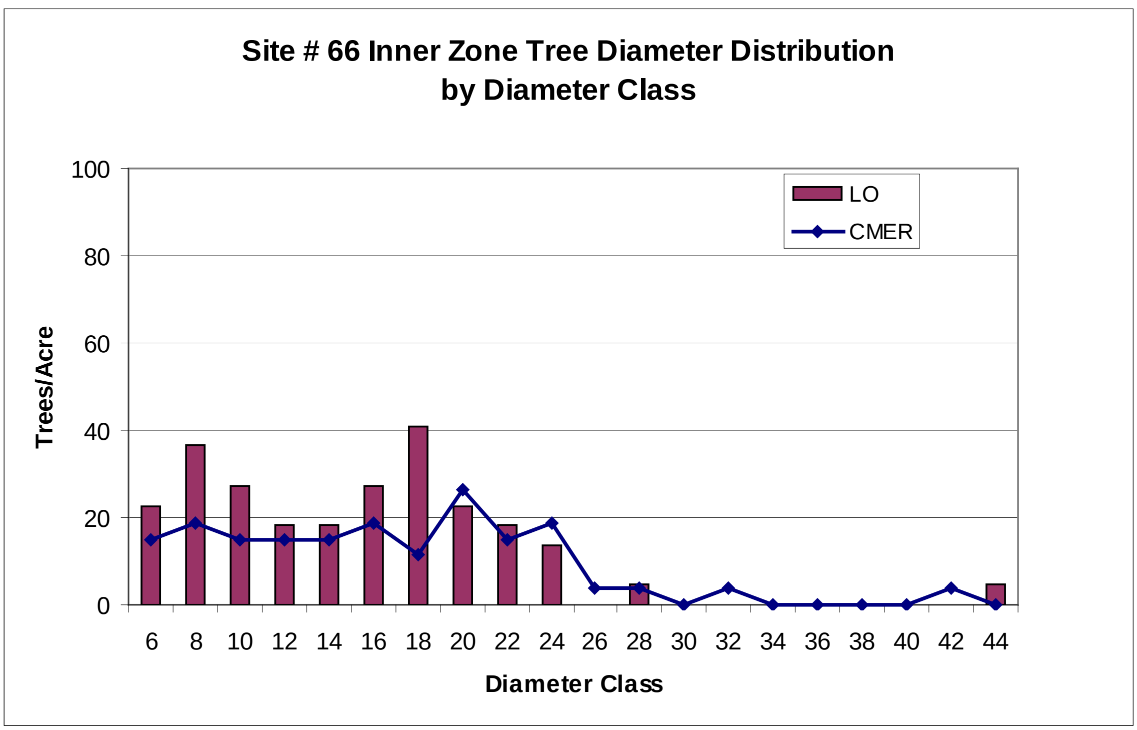
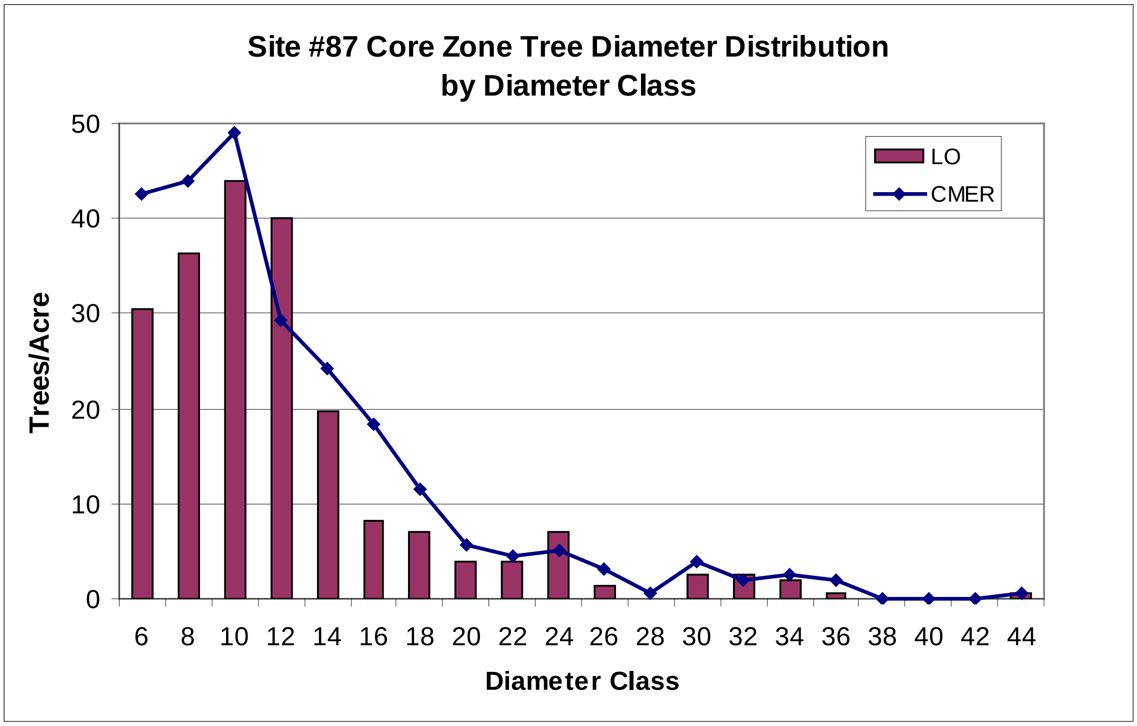


Figure D8 – Tree diameter distributions for site #66.



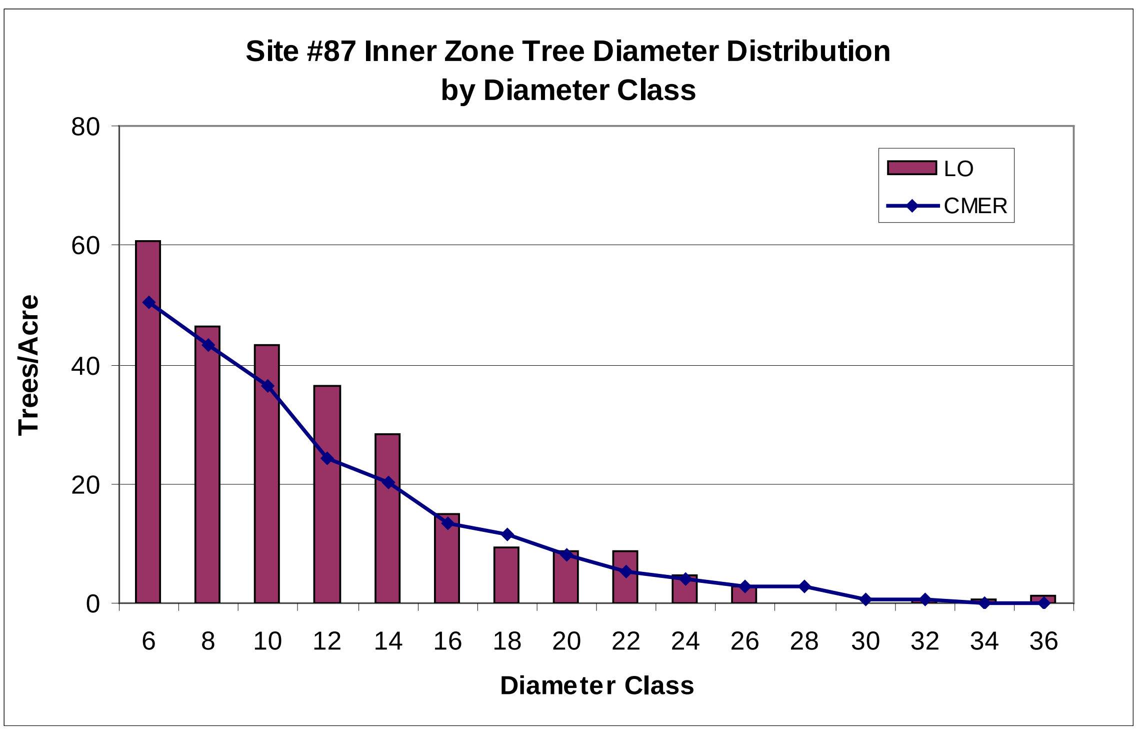
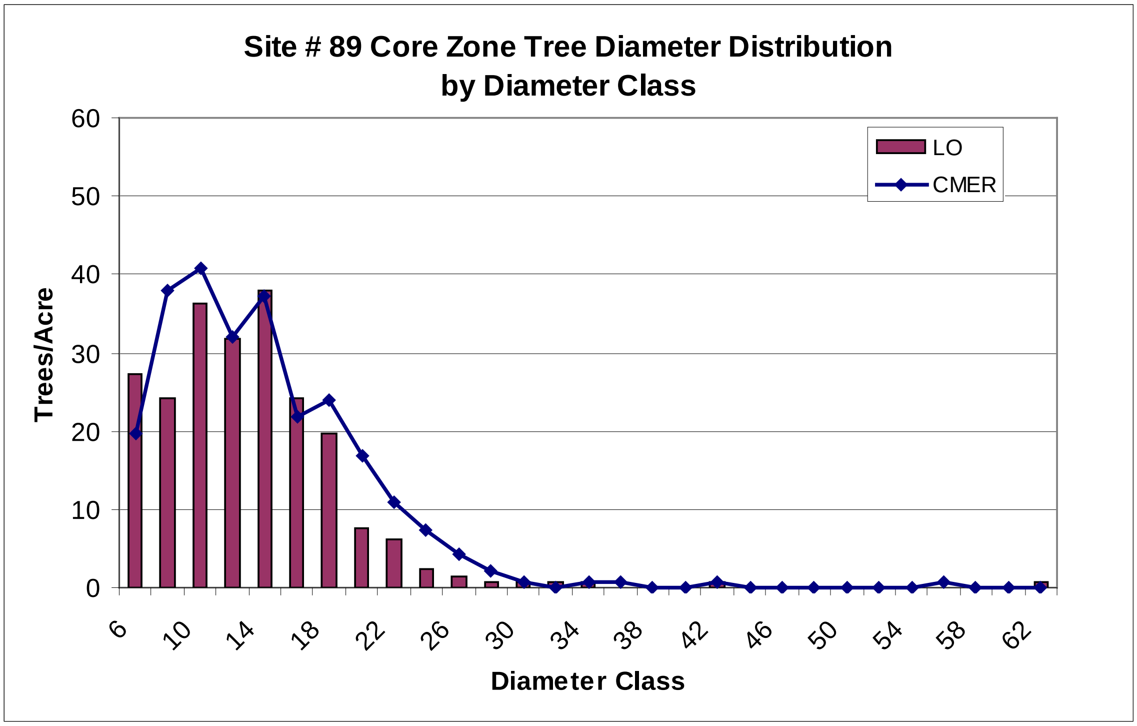


Figure D9 – Tree diameter distributions for site #87.



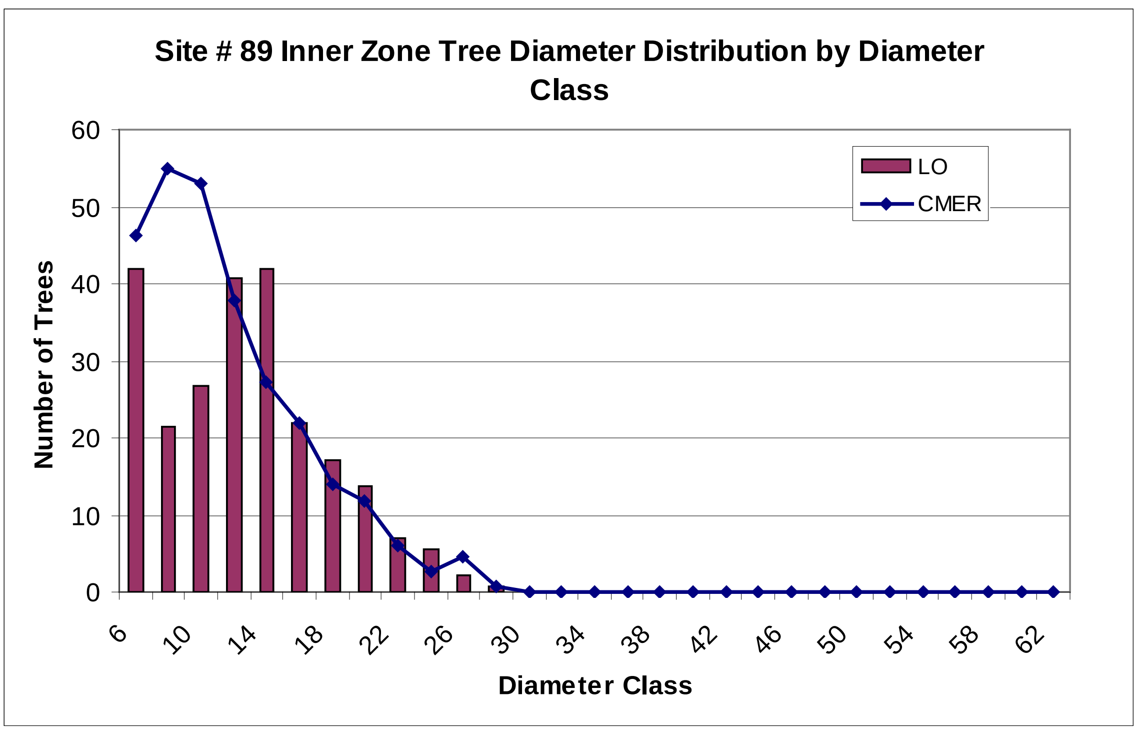
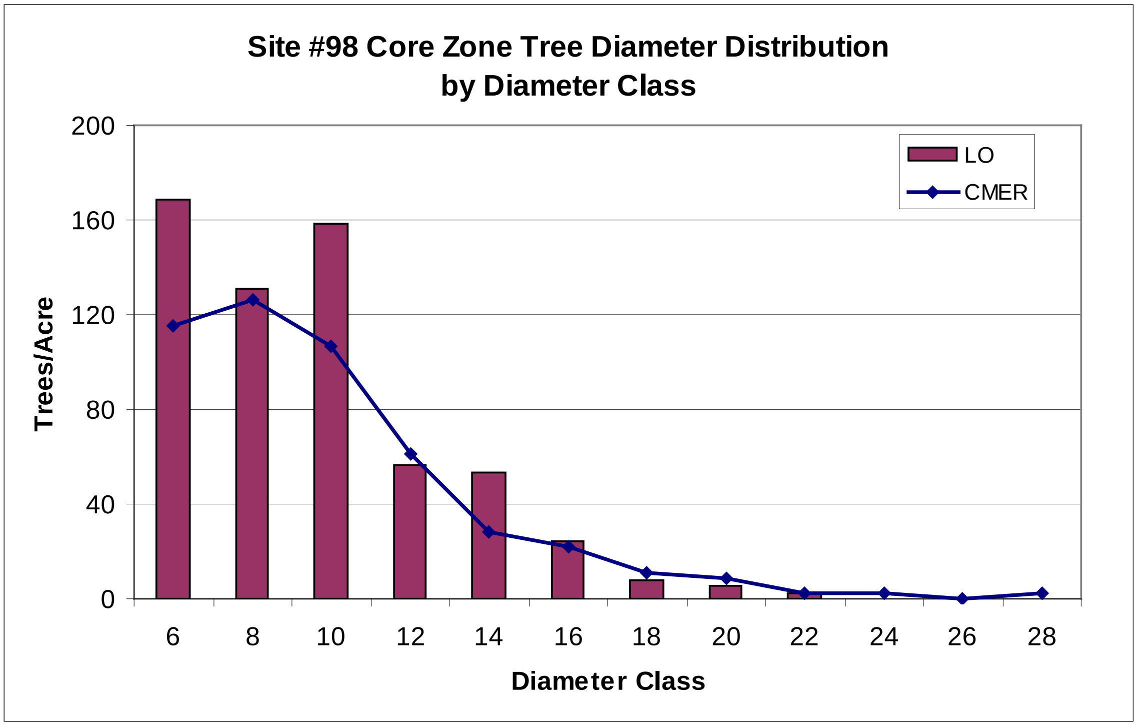


Figure D10 – Tree diameter distributions for site #89.



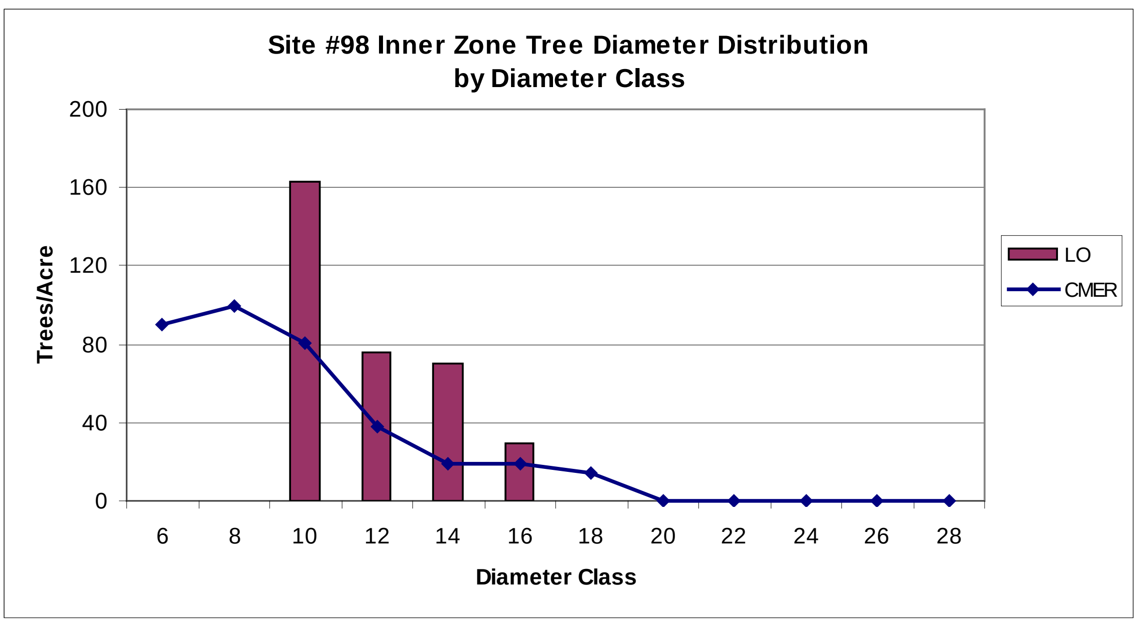
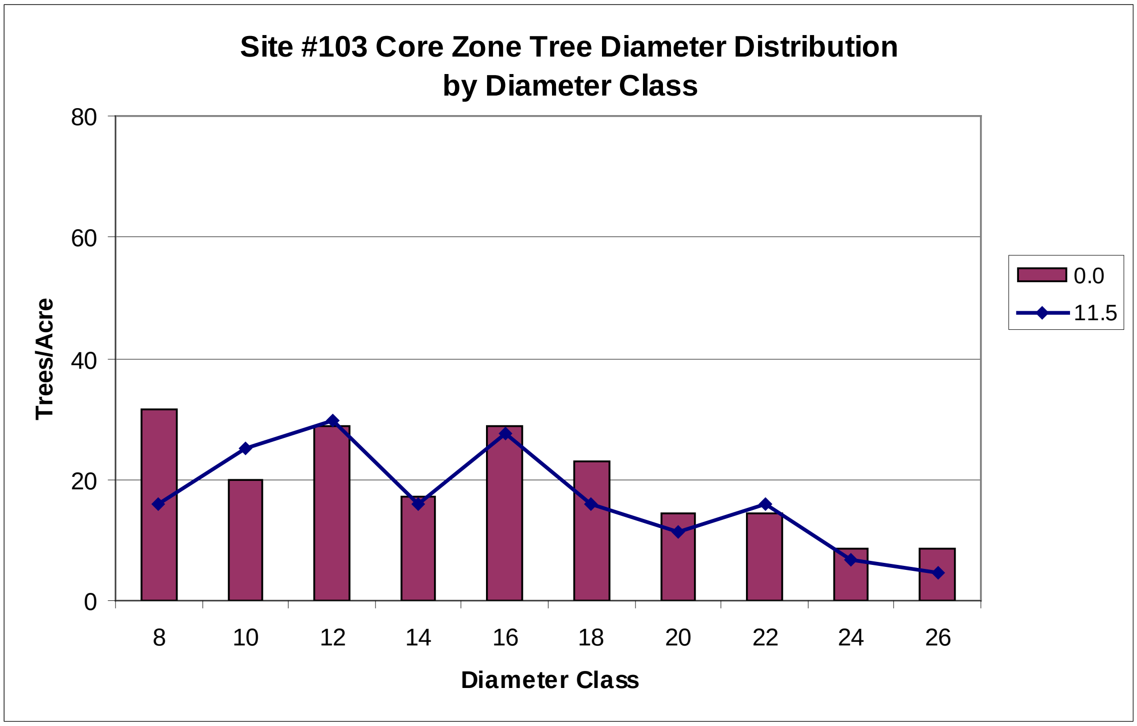


Figure D11 – Tree diameter distributions for site #98.



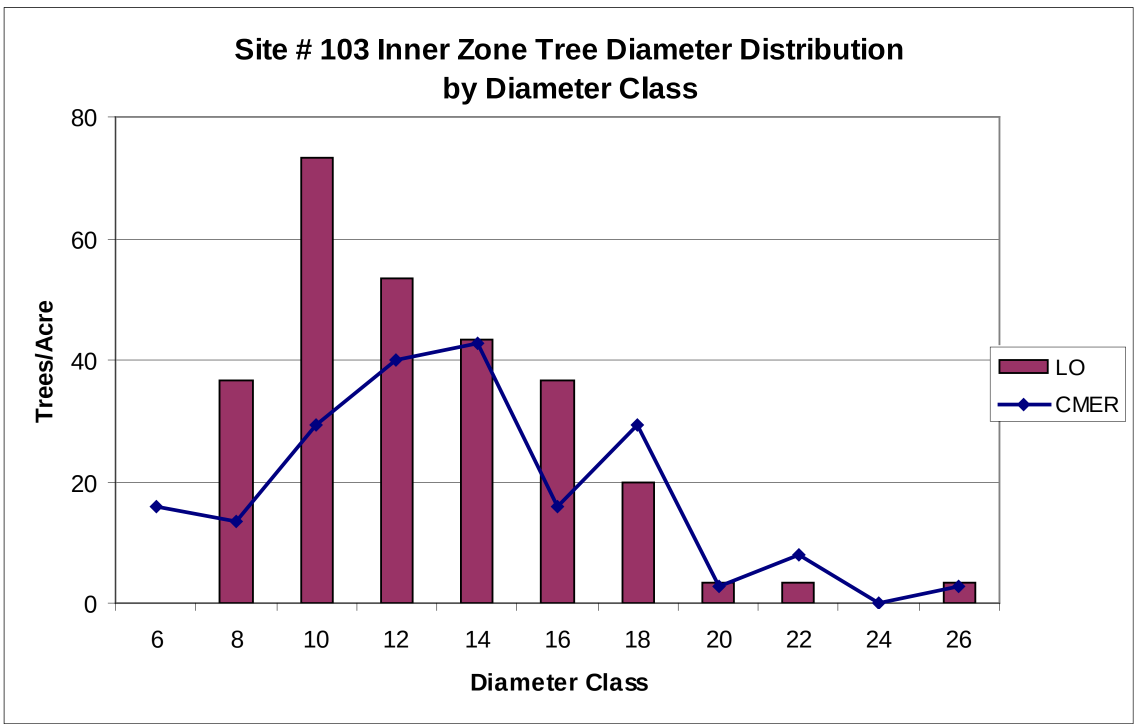
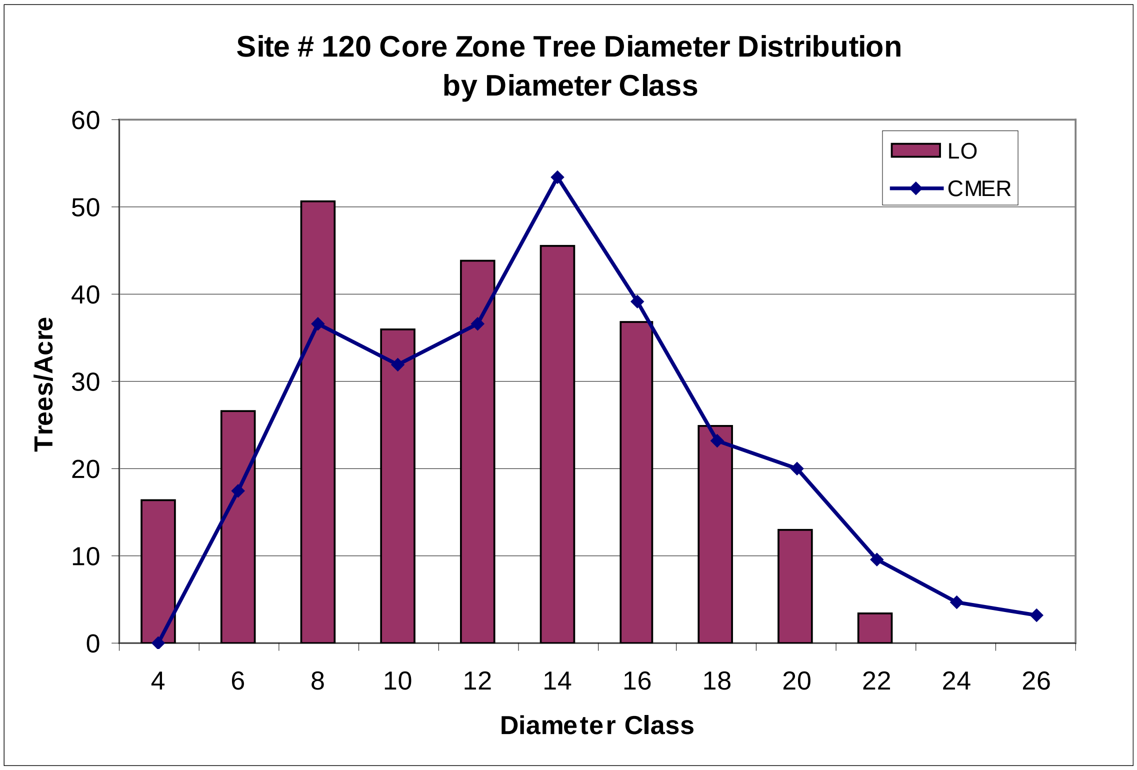


Figure D12 – Tree diameter distributions for site #103.



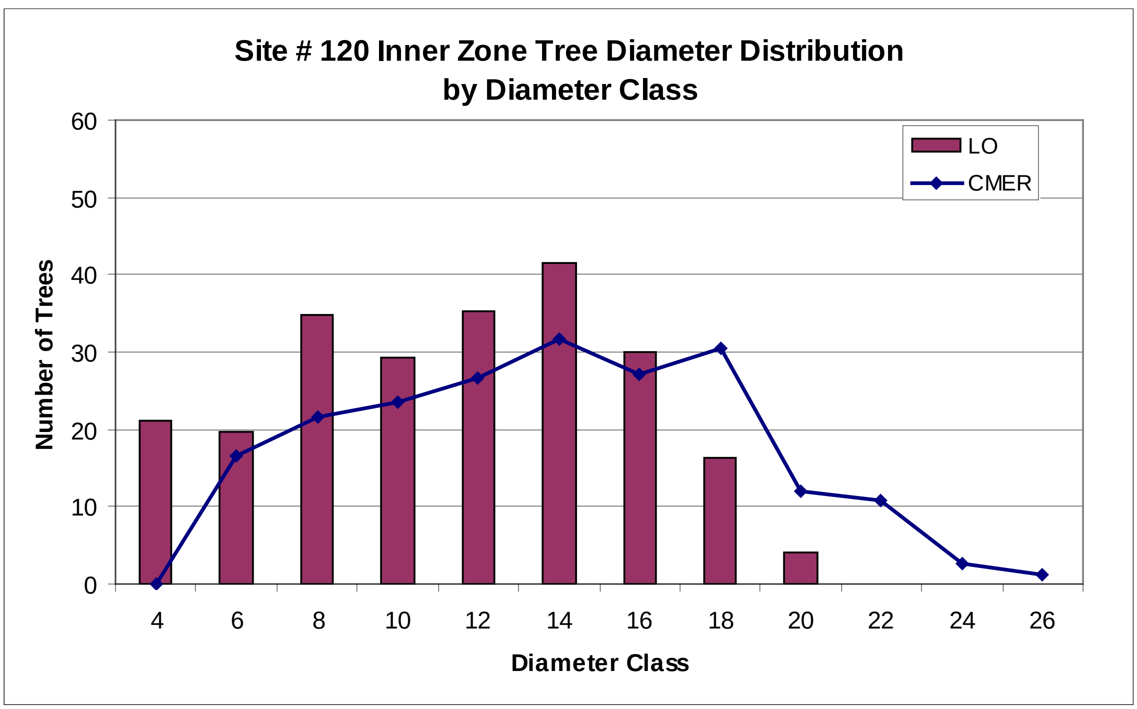
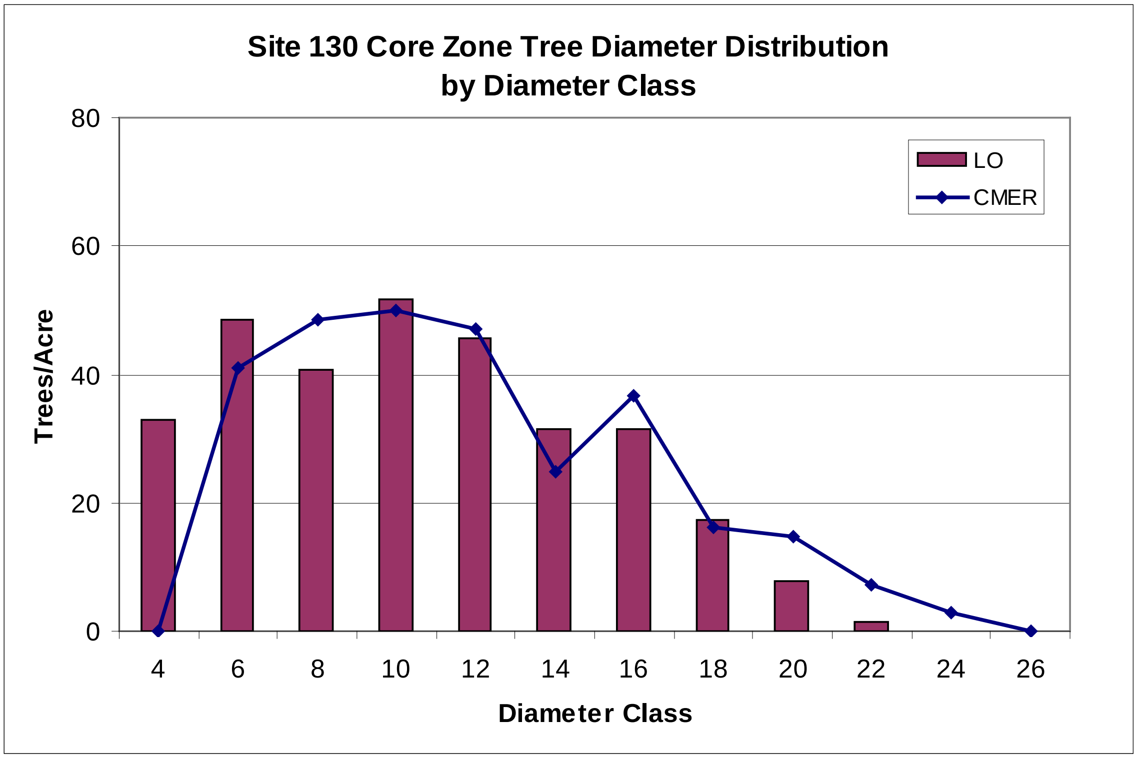


Figure D13 – Tree diameter distributions for site #120.



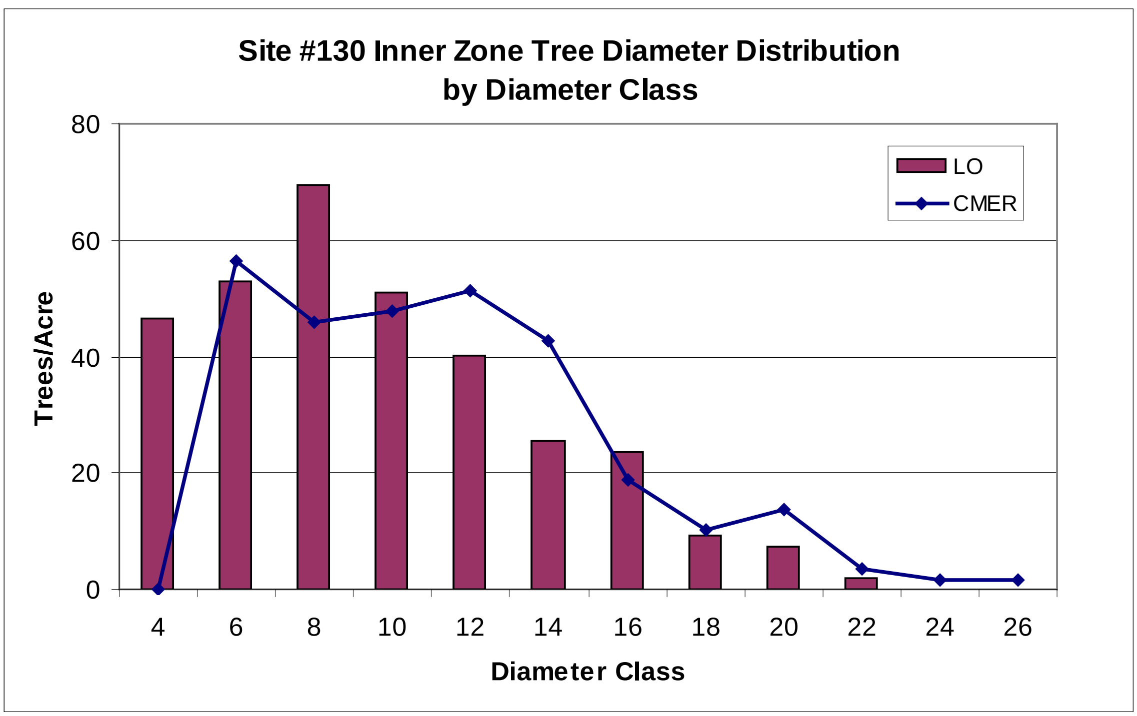
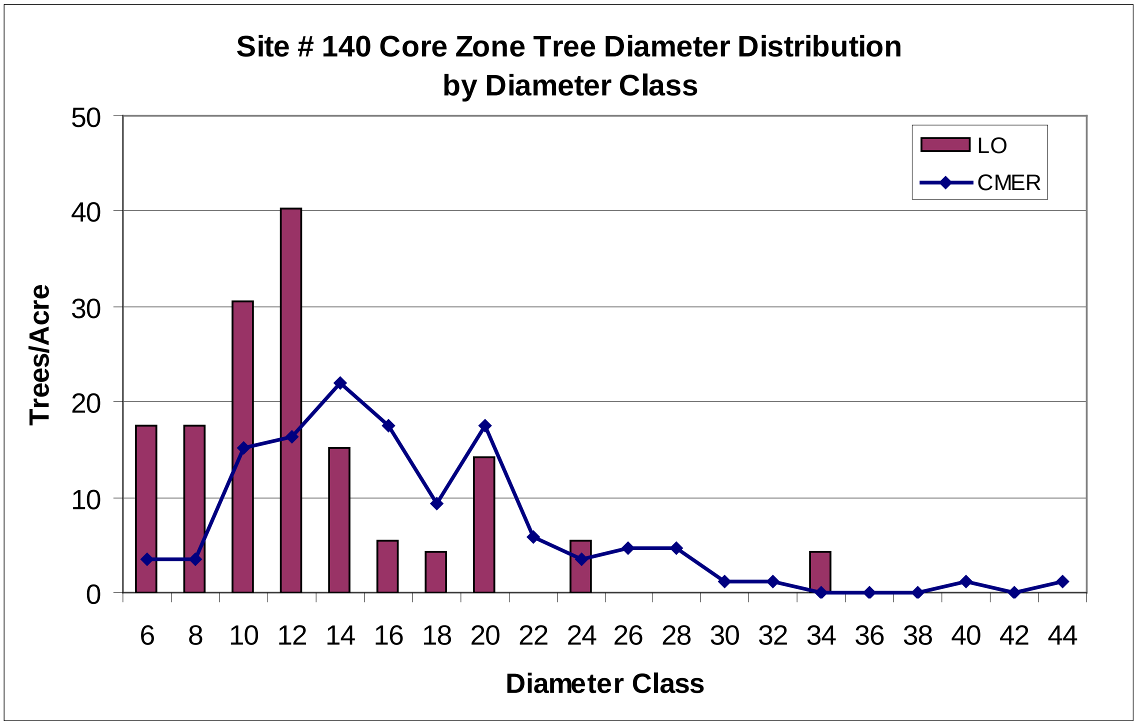


Figure D14 – Tree diameter distributions for site #130.



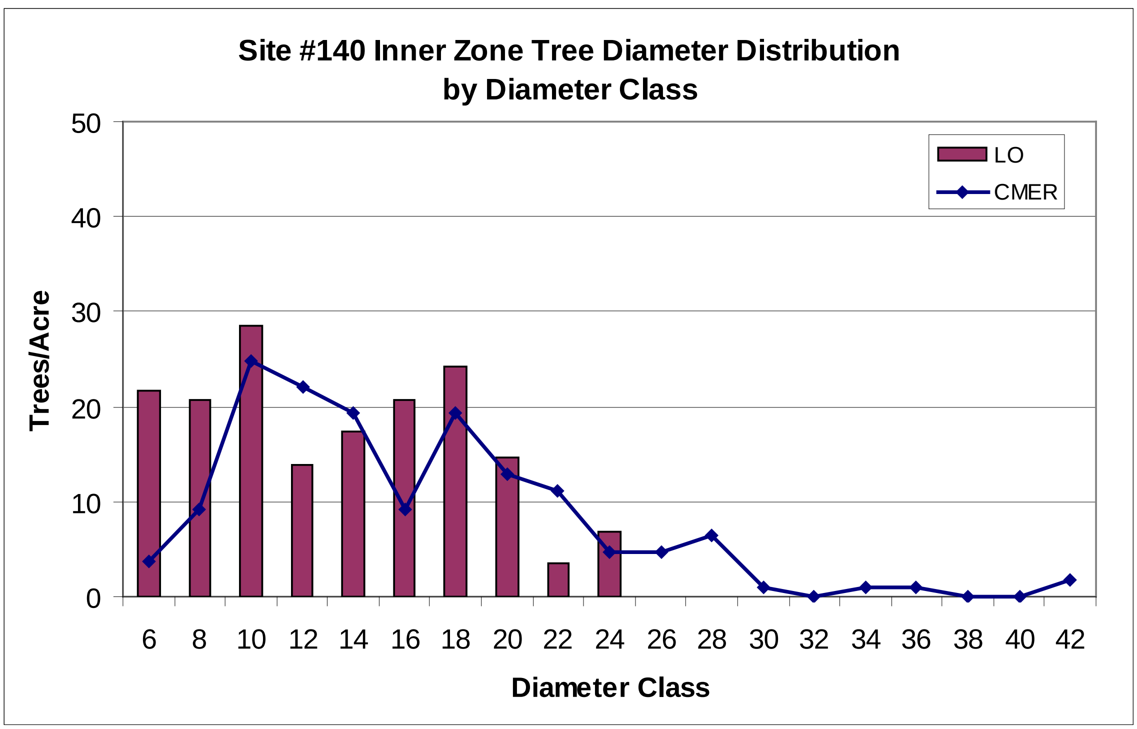


Figure D15 – Tree diameter distributions for site #140.