Report to AFGO Members from the Strata Subcommittee

On work conducted from September 2012 to October 2014

November 3, 2014

EXECUTIVE SUMMARY

The Alberta Forest Growth Organization (AFGO) Strata Subcommittee was formed in September 2012 to answer questions about the accuracy of the photo interpreted labels developed through Reforestation Standard of Alberta (RSA) performance survey programs, and whether the rules used to assign sampling units into strata were suitable for use in landbase stratum assignment. The Subcommittee's Terms of Reference asked a series of technical questions that were intended to break the larger question into smaller technical questions that could be more readily addressed.

The subcommittee's work focused on the following:

- Assessment of variability within RSA sampling units assigned to strata using both true color and color infrared aerial photography.
- Alternate methods of stratifying stands, including use of density caps and thresholds, and different break points for both density and stocking.
- Discussion of questions around the link between RSA and growth and yield.
- Discussion of appropriate uses of RSA data and how they can be used to assign post-performance aged stands to strata for timber supply analysis and landbase reconciliation purposes.

The subcommittee produced a series of recommendations that have been submitted to the RSA Management Committee, entitled:

- Current and potential uses of RSA data and limitations;
- Use of MAI as a link between early stand performance and stand yield;
- Differentiating use of aerial stratification data for MAI assessment and for stratum assignment for timber supply analysis and strata reconciliation; and
- Use of stocking to assign RSA sampling units to strata.

Additionally, the subcommittee identified a number of questions that were considered either outside its scope or which could not be resolved:

- A series of questions around growth models and their performance were developed for the GYPSY Advisory and MGM Strategic Direction Team.
- A discussion paper on development of successional yield curves was produced and the AFGO Plenary Committee has indicated that it feels development of a process for including successional changes into mixedwood yield curves needs to be further pursued.
- The ESRD Strata Reconciliation Process is under development and has the potential to affect the process for strata assignment that is ultimately developed.

A new subcommittee will be formed to address the outstanding issues and questions.

Strata Subcommittee Members

Darren Aitkin – Alberta Environment and Sustainable Resource Development (ESRD)
Jeremy Beal – Tolko, High Level Lumber Division (January 2014 – July 2014)
Ken Greenway – ESRD (September 2012 – June 2013)
Gitte Grover – Alberta-Pacific Forest Industries
Bob Held – Sundre Forest Products
Terry Kristoff – Alberta Plywood Ltd.
Tim McCready – Millar Western Forest Products
John MacLellan – Tolko, High Level Lumber Division (August 2014 – October 2014)
Sharon Meredith – Alberta Forest Growth Organization
Al Plantinga – Tolko, High Level Lumber Division (September 2012 – December 2013)
Shane Sadoway – Blue Ridge Lumber Inc.

Acknowledgements

In addition to the time spent by Subcommittee members in attending meetings and reviewing reports and analyses, members also contributed data to support analysis. Additionally, re-interpretation of air photos to assess use of stocking was paid for directly by Al-Pac, Alberta Plywood and Blue Ridge. Alberta Environment and Sustainable Resource Development conducted analyses on alternative stratification schemes, which is included as Appendix 4. Katrina Froese of Froese Forestry Consulting provided analytical support and technical expertise to the Subcommittee.

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Introduction

The Alberta Forest Growth Organization (AFGO) initiated a subcommittee in September 2012 in response to concerns raised by Alberta-Pacific Forest Industries (Al-Pac) relating to assigning labels to regenerated stands for timber supply analysis. Al-Pac's specific concerns were about the accuracy of the photo interpreted labels developed through Reforestation Standard of Alberta (RSA) performance survey programs and whether the rules used to assign sampling units into strata were suitable for use in landbase stratum assignment.

The so-called Strata Subcommittee developed a terms of reference (Appendix 1) to outline the scope of its work by identifying a series of questions to answer. This report describes the work of the Strata Subcommittee as it relates to each of the terms of reference questions. Detailed reports and analysis summaries that were produced are included as appendices. First, some details about the terms of reference and background on the RSA process are provided for context.

Strata Subcommittee Terms of Reference

As stated in the terms of reference, the purpose of the AFGO strata subcommittee was to determine how to assign a single stratum to individual post-performance age stands for purposes of:

- Yield curve development;
- Landbase assignment; and
- Strata reconciliation.

Because of the complexity of the issues, the subcommittee identified a series of technical questions in the terms of reference. The intent was to break the larger issues into smaller technical questions that could be more readily addressed.

After completing an initial terms of reference, the Subcommittee was asked by the RSA Management Committee to answer some additional questions around the link between RSA and growth and yield. A terms of reference that had been revised to include these questions (Appendix 1) was approved by the AFGO Plenary Group in June of 2013. Four main questions, each having a number of subsidiary questions, were identified:

1. *Are the sampling unit labels accurate enough to carry forward?*
2. *How do we use RSA data for timber supply analysis, landbase assignment and yield curve development?*
3. *What is the implication to strata reconciliation and broader management issues?*
4. *Are current RSA methods appropriately linked to growth and yield?*

The Subcommittee has answered all the detailed technical questions in the terms of reference, but stopped short of developing a process for assigning strata to individual post-performance aged stands, as was outlined in the Subcommittee's original intent, since it proved to be more difficult than anticipated

RSA Background

Reforestation Standard of Alberta (RSA) performance surveys collect detailed ground survey data suitable for making yield projections using the Growth and Yield Projection SYstem (GYPSY). Yield projections are used to determine predicted mean annual increment (MAI) at either deciduous or coniferous culmination age (depending on the stratum being sampled). MAIs are reported by companies into the Alberta Reforestation Information System (ARIS), which are then used to evaluate reforestation performance relative to target MAIs contained within the system.

Under RSA, companies with a performance survey program that meets a specified minimum size are required to use an aerial approach in which aerial photos are used to identify eligible survey areas and to:

1. Divide openings into smaller areas, or sampling units (SUs) based on differences in species composition and density; and
2. Assign labels to each SU based on the overall proportion of coniferous and deciduous densities using the rules shown in Table 1.

Interpreters determine total density of the regenerating layer and then create a species call that is intended to describe the proportion of density by species. For example, Aw5Pl3Sw2 would mean 50% of the total stems per hectare are aspen, 30% are lodgepole pine and 20% are white spruce.

Table 1. Rules for assigning strata to sampling units.

RSA Stratum	Coniferous Percent (Density Based)	Leading Coniferous Species (Density Based)
Hw	0-20	NA
HwPl	30-50	Pine
HwSx	30-50	Spruce
SwHw	50-70	White spruce
PlHw	50-70	Pine
SbHw	50-70	Black spruce
Sw	80-100	White spruce
Pl	80-100	Pine
Sb	80-100	Black spruce
Fd	80-100	Douglas-fir

Once this call is made, an RSA label is assigned to each sampling unit based on proportion of coniferous density. A density-based label (low, medium, high, dense) is also assigned to each SU.

These strata or "bins" are then used to group SUs for subsampling. Previously, rare sampling strata which comprise small areas overall could be combined with other sampling strata for these purposes if they were similar (e.g., PlHw and HwPl, SbHw and SwHw). A minimum of 15 SUs for Pl and mixed strata, and 10 for pure species Hw and Sw are selected from each bin for ground sampling; results of ground sampling are averaged within each bin and applied back to all SUs with the same label.

This process was developed in part to achieve two objectives:

- To divide more heterogeneous openings into smaller SUs that are more homogeneous in nature, in order to provide improved model projections; and
- To create "bins" (i.e. sampling strata) for grouping similar SUs for purposes of subsampling, to ensure confidence that averaging the results is appropriate for that population.

Non-photo programs are implemented for smaller populations. Non-photo surveys do not require aerial photography, and stratification into SUs is ground-based. Mixedwood strata are also compressed under this protocol (e.g., MxSx instead of separate HwSx, SbHw and SwHw strata). A final key difference is that all sampling units are ground surveyed, rather than a subsample.

For additional details, please refer to the current *Reforestation Standard of Alberta*.

Questions Addressed

The questions addressed by the subcommittee are listed below, along with a description of the work undertaken to answer them. In some cases, the questions have been simplified or shortened for the purposes of this report; the detailed questions and additional context are presented in Appendix 1.

1) Are the SU labels accurate enough to carry forward?

1.1 Interpreted labels show high variability when compared to ground data by bin.

Note that the Strata Subcommittee used "bin" to mean the stratum assigned for RSA sampling.

a. Will interpretation improve with new digital imagery?

RSA data from 10 companies with survey dates from 2009 to 2011 were examined. Using species proportions from ground survey data, the variability within each stratum for each company was analyzed graphically. Results across the companies generally showed a high level of variability in the Hw, HwSx, SwHw and Sw bins. A detailed report on the analysis is provided in Appendix 2.

After having a demonstration of new 4-band digital IR photography from Greenlink, the opinion of the Subcommittee was that the new photography could reduce variability within bins and that further analysis should be deferred until survey data using new photography is available.

Analysis using new photography was completed in August 2014. New digital photography shows some improvements, particularly with identification of coniferous species and conifers under deciduous overstory, but several difficulties remain:

1) Quantifying deciduous in leaf-off condition, particularly when less than ~4m.
2) Identifying presence and density of smaller coniferous ingress.
3) Differentiating Sb from Sw and therefore reliance on silviculture records.
4) Accurate interpretation of density where there is patchy spatial distribution or high densities.

Details of the analysis are contained in Appendix 3.

b. Why not use silviculture information / declaration instead?

Using four companies' data, a "rebinning" exercise was conducted to determine if grouping SUs based on silviculture regime could help reduce variability within bins. Improvements were seen for some companies, such as Al-Pac and Weyerhaeuser where more silviculture information was available spatially (e.g., planting, tending and site preparation). For other companies, minimal or no improvements were seen. It appeared that using more silviculture treatment information could improve results (Appendix 2), however, this was not investigated further because most companies do not retain the level of spatial treatment information required for rebinning to reduce variability.

1.2 Parameters used to define strata may not be appropriate for juvenile stands.

Beginning in January of 2013 and ending in July 2013, ESRD conducted analyses to answer terms of reference questions 1.2 and 1.3. A detailed report has been prepared and is included in this report as Appendix 4. The subcommittee also undertook additional analyses to assess the use of stocking for RSA stratification (Appendices 5 and 6). A brief summary of findings for each is provided here.

a. Can use of stocking information for stratum assignment reduce variability in results, and would these strata line up better with how one would stratify using AVI rule sets?

The ESRD analysis using ground survey information showed that using stocking proportions did not significantly reduce the within bin variability.

Analysis done by ESRD looking at the suite of MAI targets in the province found a reasonably consistent relationship between MAI proportion (based on the defined targets) and crown closure proportion (based on broad cover group definitions). Using GYPSY, ESRD showed that there is a good link between MAI and stocking using a 20/50/80 breakpoint for stocking or a 20/50/90 breakpoint for density.

The subcommittee conducted additional analysis to assess the use of aerially interpreted stocking to assign strata. Four companies (Blue Ridge, Alberta Plywood, Sundre Forest Products and Al-Pac) have had photo interpreters make stocking calls on SUs that have been ground surveyed. The results (Appendix 5) show that using percent stocking to assign sampling strata gave more consistent results and that interpreted stocking is better aligned with ground sampled stocking than interpreted density is with ground sampled density. However there was an overall trend towards under-calling both stocking and density, particularly in the case of deciduous content.

As presented in Appendix 6, a number of alternative stratum assignment scenarios were assessed to determine whether moving to a stocking-based scheme would improve stratum assignments, with the objective of minimizing within-stratum variability, defined in terms of predicted culmination MAIs (coniferous, deciduous and proportion). Both a 20/50/90 split based on density and a 20/50/80 split based on stocking resulted in fewer SUs being assigned to pure deciduous but both very little impact on variability for the primary species of interest. However, 20/50/80 stocking is better aligned with AVI break points for defining broad cover groups and is more repeatable during photo interpretation.

The subcommittee recommends adopting use of stocking or at minimum beginning to make stocking calls as part of the RSA aerial stratification process. The Subcommittee's recommendations regarding stratification with stocking are in Appendix 7 and summaries of the supporting analyses are in Appendices 5 and 6.

b. Should the "break points" currently used to assign broad cover group be adjusted to account for higher deciduous densities at performance age?

Yes, the analysis suggests that using a 20/50/90 density split would better link performance age conditions and expected strata at rotation, if density remains the metric for RSA stratum assignment. Supporting analysis can be found in Appendix 4.

However, if the recommendation to use stocking as the metric is adopted, a 20/50/80 split should be used, a discussed in Appendices 6 and 7.

c. Do minimum conifer thresholds have a role in describing future stand condition, and if so, how should these be incorporated into the stratum assignment process?

The analysis showed that conifer thresholds in some cases reduced and in some cases increased variability, suggesting that it would not improve stratum assignment in the RSA context. However, strata were better aligned with declarations which allowed a significant deciduous content at Performance Survey age.

d. *Since high deciduous densities are difficult to interpret for density (and often overshadow even high levels of conifer presence), should deciduous density calls be capped at a certain sph?*

The analysis suggested that this would have limited utility because few of the surveys assessed showed densities higher than 6,000 based on ground survey information. Supporting analysis can be found in Appendix 4.

1.3 What is the correct metric for evaluating "best" parameters? …break points are intended to link conditions at performance age to crown closure at maturity, does it make sense to use backwards modelling to attempt this linkage?

Analysis completed by ESRD showed that thresholds can be drawn for MAI proportion based on MAI targets that reasonably consistently divide the broad cover group strata. Further analysis was conducted using GYPSY to determine the link between culmination MAI and performance age stocking or density. Modelling in the way this question was originally envisioned was not completed.

The expectation that stand conditions at age 14 reflect stand conditions at maturity may not be appropriate for boreal mixedwoods where successional changes will impact composition significantly. This led to the development of a discussion paper (Appendix 8) on developing successional yield curves. The approach discussed would significantly change how strata would be assigned at performance survey age. Although this paper was discussed and brought to ESRD for feedback, it was not finalized and should not be considered recommendations from the Subcommittee. However, it should serve as a starting point for developing recommendations on successional yield curve development, a problem that could be addressed by a new subcommittee.

2) How do we use RSA data for TSA, landbase assignment and yield curve development?

2.1 How is RSA data currently used and expected to be used in forest management planning?

Based on their collective experience, the Subcommittee developed recommended uses for RSA data (Appendix 9). This list is intended to provide guidance for forest managers. It was approved by the AFGO Plenary Group at the October 30, 2013 AGM and presented to the RSA Management Committee by Gitte Grover in November, 2013.

2.2 Is the label to be retained at the SU level or rolled up to the opening level?

ESRD has given direction that SU-level spatial boundaries should be retained for timber supply analysis; therefore the Subcommittee was not required to address this question. Based on this direction, the following answers to the subsidiary questions were determined. The Subcommittee's discussion of this process is found in Appendix 10.

a. *Does the labelling process for post-performance surveys need to be at the same scale as other cutblocks, both older and younger?*

   This question was raised before direction was provided from ESRD to use SU boundaries for performance-surveyed blocks and is no longer relevant now that the decision has been made. However, some concerns were raised by subcommittee members, but it was decided that it was outside the scope of the subcommittee. Older cutblocks would be at the scale determined by AVI standards and the scale of newer cutblocks would be based on opening boundaries defined by silviculture staff.

b. *Is the expectation that the SU level linework be incorporated into the inventory and/or landbase for timber supply analysis?*

   SU-level line work will be used in landbase for timber supply analysis. New inventories will retain cutblock boundaries. SU linework would not be retained in a new inventory unless it was consistent with where lines would be drawn when following AVI standards.

c. *What happens when a new AVI is created (since RSA photo interpretation does not use the same ruleset as AVI 2.1)?*

   AVI rules will be followed and line work and attribute information will be updated as appropriate. However, cutblock boundaries will be used as the basis for new AVI.

2.3 What method is used to assign the label for landbase assignment? Questions will depend on whether you are using SU or opening labels:

a. If at the SU level, is it assumed that the interpreted label will be used (since aerial information is the only census information – ground data is from a subsample of SUs only)?

Because SU-level line work will be used, SU-level labels are required. However, the idea of using the RSA "bin" assignment raised concerns about the label not being representative of future strata and associated problems with yield curve development. This issue was not resolved by the subcommittee but is presented in the discussion paper on successional yield curves contained in Appendix 8.

2.4 How are the labels used for yield curve development?

The subcommittee agreed that it makes sense to use aerial data collected through RSA to assign SUs to company-specific yield curve strata based on these attributes. The FMP-specific assignments would not necessarily be equivalent to base 10 RSA bins. Examples of attributes that might need to be included for yield curve development that are not captured by RSA are use of enhanced stock and inclusion of natural subregions. It was noted that the Forest Management Planning Standard requires that FMP strata be compatible with the base 10 strata.

The subcommittee's recommendations for how to differentiate the use of RSA data for MAI assessments and its use in FMPs and strata reconciliation (Appendix 11) has been vetted through AFGO plenary and will be brought to the RSA Management Committee in fall 2014.

3) What is the implication to strata reconciliation and broader management issues?

3.1 How does the linkage work between initial declaration, labelling after performance survey, and (potentially) use of this label for strata reconciliation?

The discussion of successional yield curves in Appendix 8 was one attempt to describe this relationship. The recommendations for differentiating between various uses of RSA data mentioned above (Appendix 11) will also address this question.

The subcommittee feels that this question cannot be answered completely at this time due to uncertainty around the strata reconciliation process. This is one outstanding question that should be answered if the subcommittee's mandate is renewed.

3.2 If SUs are used for labels:

a. How can SUs be linked to establishment surveys and subsequent treatments?

This question is not relevant now that the decision has been made to use SUs. Establishment surveys and subsequent treatments will be applied at the opening level. There was discussion around the concept of managing silviculture at an SU level, as it was suggested that SUs should generally line up with opening boundaries since if large areas were planned/managed differently within an opening, they could be separated into discrete openings at the declaration stage. However, silviculturists did not feel this was always operationally feasible.

b. How could SU labels be linked to landbase ownership (e.g. a block is declared to DC and belongs at the opening level to the D operator. At the SU level there is a D piece and a C piece; does the C piece now belong to the C operator?).

Ownership of SUs is defined in the FMA. The stratum an SU is assigned to for RSA purposes will not determine which landbase it is a part of. The landbase assignment many change when a new inventory is done.

4) Are current RSA methods appropriately linked to growth and yield?

4.1 Is MAI the 'best' data to be used as a regeneration standard for the standards to link early performance to the DFMP/AAC/TSA?

This question was addressed through discussions at Subcommittee meetings between July and September of 2013. The result of the discussion was a document (Appendix 12) with three recommendations:

1. Culmination MAI should continue to be used as a regeneration standard to link early performance to the DFMP.
2. Culmination of <u>total</u> MAI should be an option to set targets in mixedwoods.
3. Where later rotation harvesting is planned, a minimum harvest age should be allowed when selecting culmination MAI.

This recommendation was provided to the AFGO plenary and subsequently presented to the RSA Management Committee by Gitte Grover on November 13, 2013.

4.2 In aerial surveys, is stocking a better metric than density? What are the correct proportions for mixedwoods, e.g. 20/50/80 versus 30/60/90?

Analysis by ESRD (Appendix 4) indicated that changing density proportions to 20/50/90 at performance age would align assignment to strata more closely with predicted MAI proportions at culmination.

However, subsequent analysis undertaken by Blue Ridge, Al-Pac and Alberta Plywood found that photo-called stocking was a more repeatable metric than density. Further analysis (Appendix 5) showed that using percent stocking provided comparable results to density when used to assign bins to SUs. Since stocking may be better aligned conceptually with AVI and is more repeatable, the subcommittee recommends that stocking be collected as part of the RSA data beginning with the next programs and the ESRD consider moving to using stocking to assign strata to SUs in RSA (Appendix 7).

4.3 Are the correct data being collected by the RSA survey procedures to 'best' make the link between early performance and DFMP objectives…?

See discussion under 4.4.

4.4 Do GYPSY and MGM 'accurately' predict the linkage between early performance and DFMP objectives…?

The Subcommittee discussed questions 4.3 and 4.4 and decided that the best venue for answering these questions was the GYSPY Advisory Committee and the MGM Strategic Development Team. Before referring these questions to those groups, the Subcommittee identified additional questions that would need to be addressed in the process of answering these higher level questions

(Appendix 13). These questions have been referred to the Advisory Committee and Strategic Development Team. They were tabled at meetings of both groups.

OUTSTANDING QUESTIONS

Throughout its mandate, the Strata Subcommittee has discussed a number of questions that fall outside of the scope of its terms of reference. Because they were outside of scope for the group, it has not conducted analyses or developed recommendations relating to them. However, the subcommittee feels that these are important questions to highlight as they will need to be addressed in the future.

AFGO members have decided that two of these questions warrant further discussion by an AFGO Technical Subcommittee. These questions are:

- How does the TBA ESRD Strata Reconciliation Process affect recommendations made by the Strata Subcommittee?
- What process should be used for developing successional yield curves?

It should be noted that the question of assigning strata to performance aged stands for purposes of timber supply analysis and stratum reconciliation, although included in the mandate of the committee, was not included in the list of technical questions to be addressed. Although this issue was discussed by the subcommittee at length, it does not have formal recommendations for a process to follow for stratum assignment.

Now that the Strata Subcommittee has completed its mandate, it recommends that a new subcommittee be struck to address the above questions, as well as the following outstanding questions:

- What yield strata classes can be assigned to allocate performance survey age stands to a stratum for yield curve development and stratum reconciliation?
- Guidelines for how (if) to use RSA data for FMP-specific TSA strata, assuming that the recommendation to use the data differently for that purpose is accepted.
- Limitations in how strata are assigned for yield curve development and strata reconciliation due to tenure.

APPENDICES

Appendix 1: AFGO Strata Subcommittee Terms of Reference

AGFO Strata Subcommittee Terms of Reference

June 25, 2013

Background

The AFGO strata subcommittee was initiated to address how to integrate new Regeneration Standard of Alberta (RSA) performance survey data into the landbase assignment (assigning polygons to yield groups) and yield curve development process. These two activities provide the underpinning of timber supply analysis for Detailed Forest Management Planning. In addition, the linkage between landbase assignments and their use for strata reconciliation must be addressed.

Landbase Assignment

Currently, landbase assignment for cutblocks is at the opening level, with silviculture and/or Alberta Vegetation Inventory (AVI) information being used to provide a stratum label[1]. ASRD's 2009 document entitled "Regenerating Landbase – ARIS Records Validation Procedures" indicates that RSA performance survey data must be incorporated into this process. Appendix I contains relevant excerpts of this document. At this time, no procedure exists for incorporating RSA performance survey data, which exists at the sub-opening (sampling unit, or SU) level.

Yield Curves

Yield curves for natural stands are most often developed using ground-based data from a subset of natural stands, stratified by yield group, and used as inputs to either regression-based or growth modelling approaches. Yield stratum is generally determined by spatially linking ground plots to the landbase assignment to maintain consistency in stratum assignment.

In the past, yield curves for managed stands have often been developed using either a "back to natural" assumption, or a modification of natural stand yield curves. Companies are now being encouraged to use their RSA performance survey data to support development of managed stand yield curves via a growth modelling approach. In order to use these data, strata must be assigned to the data, and the strata assignments must again be consistent with the landbase assignments.

Strata Reconciliation

It is likely that strata reconciliation (the comparison between pre and post-harvest composition at the landscape level) will be done using this same stratum assignment (label). Decisions regarding scale (opening vs. SU level) and labelling method can have significant implications to the success of the strata reconciliation process. As

[1] Until cutblocks are declared "Performance Survey Complete", they are assumed to be on the yield trajectory indicated in the ARIS declaration, or an alternate yield trajectory based upon establishment survey findings. For cutblocks with a performance survey completed, the yields as demonstrated from the performance survey are used until an AVI for the area is completed. For pre-91 cutblocks AVI labels are used to assign areas to yield curves, or where new survey data are available, they may be used to assign cutblocks to yield curves, where approved by Alberta..

such, a recommendation on how (or whether) these labels should be used for strata reconciliation is also required.

RSA Review

The strata subcommittee was asked by the RSA Management Committee to expand its mandate to address some questions around the growth and yield link to RSA. These questions focus on the appropriateness of the measures used and data collected for making the link between early performance and the DFMP objectives, and on use of models to make this link. They are growth and yield questions, not biometrics questions, and will inform the RSA biometrics review.

Purpose

The purpose of the AFGO strata subcommittee is to determine how to assign single stratum to individual post-performance age stands for purposes of:

- Yield curve development;
- Landbase assignment; and
- Strata reconciliation.

The guiding principle for the Subcommittee is to develop a process that meets the requirements of the Alberta Planning Standard. Excerpts from the Alberta Planning Standard are provided in Appendix II. Important concepts are highlighted in red.

Mandate

The mandate of the AFGO strata subcommittee is to:

1. Provide review and guidance for technical tasks.
2. Provide a set of recommendations to ESRD pertaining:
    a. SU label revision recommendations for the RSA review process; and
    b. Methods for assigning labels for use in landbase / yield curve development;
    c. Implications to the strata reconciliation process (how and whether to use these labels).
3. Provide advice to the RSA Management Committee regarding the link between RSA and growth and yield.
4. Provide updates to the AGFO general membership (with the goal of achieving this quarterly).

Subcommittee members are responsible for participating in AFGO strata subcommittee meetings, providing recommendations and, as needed, data to address technical tasks.

Technical Issues/Questions to be Addressed

Stratum assignment is not straightforward, due to a number of technical issues and potential implications to other processes such as strata reconciliation. The strata subcommittee needs to address the following questions (roughly in the order presented on this list):

1. Are the SU labels accurate enough to carry forward?
2. How do we use RSA data for TSA, landbase assignment and yield curve development?
3. What is the implication to strata reconciliation and broader management issues?
4. Are current RSA methods appropriately linked to growth and yield?

Question 1) Are the SU labels accurate enough to carry forward?

1. Interpreted labels show high variability when compared to ground data by bin.
    a. Will interpretation improve with new digital imagery?
    b. Why not use silviculture information / declaration instead?
2. Parameters used to define strata may not be appropriate for juvenile stands.
    a. Can use of stocking information for stratum assignment reduce variability in results, and would these strata line up better with how one would stratify using AVI rulesets?
    b. Should the "break points" currently used to assign broad cover group be adjusted to account for higher deciduous densities at performance age?
    c. Do minimum conifer thresholds have a role in describing future stand condition, and if so, how should these be incorporated into the stratum assignment process?
    d. Since high deciduous densities are difficult to interpret for density (and often overshadow even high levels of conifer presence), should deciduous density calls be capped at a certain sph?
3. What is the correct metric for evaluating "best" parameters? The goal is to reduce variability within bins used for sampling, BUT:
    a. Since break points are intended to link conditions at performance age to crown closure at maturity, does it make sense to use backwards modelling to attempt this linkage?

Question 2) How do we use RSA data for TSA, landbase assignment and yield curve development?

1. How is RSA data currently used and expected to be used in forest management planning?
    a. What are the implications of using it in these ways?
    b. Are there any ways in which it should not be used?
2. Is the label to be retained at the SU level or rolled up to the opening level?
    a. Does the labelling process for post-performance surveys need to be at the same scale as other cutblocks, both older (pre-91 and AVI-interpreted blocks), and younger (declaration based)?
    b. Is the expectation that the SU level linework be incorporated into the inventory and/or landbase for timber supply analysis?
    c. What happens when a new AVI is created (since RSA photo interpretation does not use the same ruleset as AVI 2.1)?
3. What method is used to assign the label for landbase assignment? Questions will depend on whether you are using SU or opening labels:
    a. If at the SU level, is it assumed that the interpreted label will be used (since aerial information is the only census information – ground data is from a subsample of SUs only)?
    b. If at the Opening level, how is a single Opening level label created?
4. How are the labels used for yield curve development?

a. If labels are created at the SU level, how are they used for yield curve development? E.g. a "piece" of a block is labelled as pure deciduous; should data from this "piece" be used to develop yields that are then applied at the opening level?
b. At either the SU or Opening level, what is the role of composite weights in the yield curve development process?

Question 3) What is the implication to strata reconciliation and broader management issues?

1. How does the linkage work between initial declaration, labelling after performance survey, and (potentially) use of this label for strata reconciliation?
2. If SUs are used for labels:
    a. How can SUs be linked to establishment surveys and subsequent treatments?
    b. How could SU labels be linked to landbase ownership (e.g. a block is declared to DC and belongs at the opening level to the D operator. At the SU level there is a D piece and a C piece; does the C piece now belong to the C operator?).

Question 4) Are current RSA methods appropriately linked to growth and yield?

1. Is MAI the 'best' data to be used as a regeneration standard for the standards to link early performance to the DFMP/AAC/TSA?
    a. If yes, then is culmination MAI the right MAI to set as a standard given culmination is not always where harvesting will occur? For example, late harvesting of C in mixedwoods may be a FMP imposed harvest limitation to achieve other values.
2. In aerial surveys, is stocking a better metric than density? What are the correct proportions for mixedwoods, e.g. 20/50/80 versus 30/60/90?
3. Are the correct data being collected by the RSA survey procedures to 'best' make the link between early performance and DFMP objectives, or should different and/or additional data be collected to 'better' make the link?
    a. Is the selection of top height tree adequate when there are no dominant layers in regenerating stands and suppressed trees could be selected?
4. Do GYPSY and MGM 'accurately' predict the linkage between early performance and DFMP objectives, and if not, what are the modeling concerns that will need to be addressed to increase the accuracy to a necessary level?
    a. Should models include advanced trees?
    b. Should average density be used? Should density be used since large density plots skew the mean?

Expected Outcome of the AFGO Strata Assignment Subcommittee

The anticipated deliverables at the end of this process are:

1. Recommended revisions to the methodology for SU stratification and label assignment during RSA performance surveys, to be forwarded to the RSA Review Committee;
2. Recommendations on the scale of labelling (SU and/or opening) and methodology for landbase assignment;
3. Recommendation for a process of assigning and using data for yield curve development; and
4. A discussion document outlining the potential implications of the above to the strata reconciliation process.

Appendix I. Regenerating Landbase ARIS Records Validation Procedures: Excerpts

Reference: Alberta Sustainable Resource Development. 2009. Regenerating Landbase – ARIS Records Validation Procedures. Edmonton, AB. 3p.

The Alberta Forest Management Planning Standard, standard 3.11, Annex 1, requires that areas harvested after March 01, 1991 be assigned to a yield stratum as defined in the Alberta Regeneration Information System (ARIS).

ARIS Broad Cover Group data (e.g. "C") and yield group assignment (e.g. "Pine closed") relationships are clearly documented, and consistent with treatment records and regeneration survey information for each opening.

All openings are assigned to a yield group consistent with the most recent of the following ARIS data:

a) declared stratum,

b) stratum resulting from an establishment survey finding, or

c) stratum resulting from a performance survey finding.

All openings in an "NSR" condition as found in an establishment survey, or currently with an "RTD" status (ReTreateD), but without a performance survey finding, are assigned a yield group consistent with the original declaration.

All openings with an "NSR" condition resultant from a performance survey shall be assigned to one of two classes based upon ARIS performance survey data.

All openings harvested prior to 1991, for which AVI information is either unavailable, or in Alberta's opinion outdated or inappropriate (as per Standard 3.11 ii., Annex 1, Alberta Forest Management Planning Standard), have attributes consistent with the ARIS record of harvested area and age. Assignment of these areas to appropriate yield strata has been made based upon additional pre-approved survey information (Standard 3.11, ii).

Appendix II. Alberta Forest Management Planning Standard: Excerpts

Reference: Alberta Sustainable Resource Development. 2006. Alberta Forest Management Planning Standard version 4.1. Edmonton, AB. 114 p.

3.10 Processed attributes approved by Alberta have been included in the classified landbase file.

Certain attributes used in timber supply analysis result from processing or manipulating basic inventory data. The rationale and methodology for creating these attributes must be provided. The processed attributes that must be included in the classified landbase attribute file include:

i. Yield stratum assignment

ix. Classification of reforested areas is consistent with reforestation records.

3.11 Harvested areas have been classified using the most current information on the harvest area.

The degree to which reforestation has been successful is a critical matter. The accurate classification of harvested areas is essential for management. Increasing amounts of the net landbase are being harvested and the management of these areas is a significant issue in forest management. Alberta's view is that the stand development trajectory can be established through reforestation survey information. The classification of harvest areas must be consistent with reforestation records and plans for the area.

The requirements are as follows:

i. Areas harvested after March 1, 1991, shall be assigned to the yield stratum based on the regeneration stratum for the harvest area as defined in the Alberta Regeneration Information System (ARIS) and the most current information on the harvest area and its associated regeneration stratum in ARIS.

Harvest areas may be in one of the following phases:

a. Harvest Stratum Assignment - harvest area is less than 2 years old and has not received a stratum declaration (reforestation target) or initial establishment regeneration survey.

b. Stratum Declaration - area has been harvested, a reforestation stratum target has been declared, but harvested area has not received an initial establishment regeneration survey.

c. Establishment Surveyed - This is the first regeneration survey on an area. If the area is satisfactorily restocked (SR) to the stratum declaration, or not satisfactorily restocked (NSR) to any stratum, the stratum shall be the stratum declaration. If the area is NSR to the stratum declaration, but SR to alternate stratum it may be changed to the new stratum which becomes new reforestation target.

d. Performance Surveyed - This is the final regeneration survey and marks the end of the reforestation phase of a harvested area. The final stratum is determined, and may be different from the original stratum declaration, unless the performance survey result is NSR to any available stratum.

ii. Should AVI information not be available, or in Alberta's opinion, the survey information is outdated and inappropriate, Alberta will require that a conservative yield assumption be applied to pre-1991 harvest areas. Areas harvested prior to March 1, 1991 shall be assigned to a yield stratum based on the vegetation inventory in place on the effective date of the inventory, unless an alternate field survey approved by Alberta prior to the effective date demonstrates that an alternate yield curve is more appropriate. In this case, the Organization may also utilize an approved alternate survey to demonstrate a more appropriate yield curve and stratum assignment.

4.0 Yield Projection Standards

Alberta expects significant refinements of a limited number of growth models (i.e., Mixedwood Growth Model (MGM), Growth and Yield Projection System (GYPSY), and Tree and Stand Simulator (TASS). Monitoring mature intact and thinned natural stands to develop empirical yield projections will give way to monitoring managed regenerating stands with a strong reliance on modelling for growth projection.

4.1 The yield strata used have been approved by Alberta.

A standardized approach to yield strata is required for growth comparisons across administrative boundaries (FMA, FMU, defined forest area (DFA), SYU), cost-effectiveness and efficiency of monitoring programs, and to facilitate credible relationships between regeneration standards and growth and yield projections.

4.2.1.1 Development and review of yield projections has been completed using a data set approved by Alberta.

Yield projections may be developed based on permanent or temporary sample plots, or some combination of the two, plus associated data.

4.2.4 Yield projections have been calibrated to local forest conditions.

c. Managed stand yield projections must be supported with analysis of reforestation results and PSPs applicable to the DFA.

4.2.6 The modeling procedures evaluated and the rationale for selecting the yield projections have been described.

b. Inventory stand descriptions and origins must be maintained throughout the yield projection development process.

4.2.7 The complete documentation required to support the proposed yield projections has been submitted.
The documentation requirements are:
e. The methods used to assign yield plots to their respective yield class. This process must be identical to the one used to stratify the net landbase into the yield strata.

4.2.11 All clearcut harvest areas, and partial cut harvest areas (following the first harvest entry) have been assigned to a yield projection based on the results of an objective assessment survey approved by Alberta.

Appendix 2: Evaluation of RSA Photo Interpreted Labels, 2012-13

AFGO Strata Subcommittee

Evaluation of RSA Photo Interpreted Labels, 2012-13

Prepared by:

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Prepared for:

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Alberta Forest Growth Organization

February 10, 2014

This document is formatted for double sided printing.

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1.0 OVERVIEW

The scope of this work focused on evaluating the accuracy of stratification (labelling) as it relates to aerial Regeneration Standard of Alberta (RSA) performance surveys. Work commenced in fall 2012 and was completed in summer 2013 under the direction of the AFGO Strata Subcommittee.

1.1 RSA Performance Surveys

Aerial performance surveys are undertaken by all companies with programs of sufficient size. The first step is obtaining aerial photography and using this information to subdivide openings into sampling units (SUs) based on species composition and density class.

The second step is to assign a label ("bin" or stratum) to each SU. Total density is recorded for each SU, and proportion of density by species is also determined (e.g., Pl8Aw2 means pine represents 80% of total density and aspen represents 20% of total density). Based on these proportions, each sampling unit is assigned to an RSA stratum according to the rules in Table 1; a subsample of SUs are then selected for ground sampling (with a minimum number targeted in each stratum).

Table 1. Rules for assigning strata to sampling units.

RSA Stratum	Coniferous Percent (Density Based)	Leading Coniferous Species (Density Based)
Hw	0-20	NA
HwPl	30-50	Pine
HwSx	30-50	Spruce
SwHw	50-70	White spruce
PlHw	50-70	Pine
SbHw	50-70	Black spruce
Sw	80-100	White spruce
Pl	80-100	Pine
Sb	80-100	Black spruce
Fd	80-100	Douglas-fir

1.2 Scope of Work

Some concerns were raised regarding the accuracy of photo-interpreted labels when initial comparisons between photo-interpreted and ground-based attributes were undertaken. As shown in the example in Figure 1, photo-interpreted densities could vary widely as compared to ground survey results. There were also concerns relating to assigning sampling units (SUs) into the correct broad cover group. As an example, in Figure 2, red dots represent all blocks that, based on ground data, should have been assigned to a pure hardwood stratum, but based on photo interpretation ranged from 0 to 100% deciduous composition.

The AFGO Strata Subcommittee undertook several activities in order to understand the nature of the issue, the results of which are documented here.

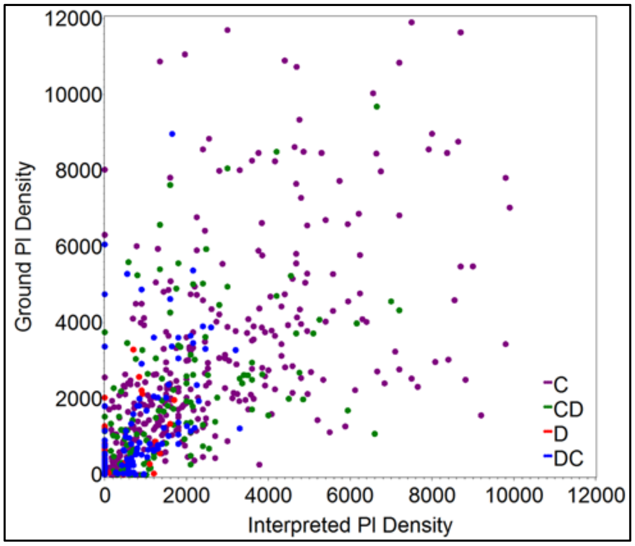


Figure 1. Ground pine density compared to interpreted pine density, RSA data.

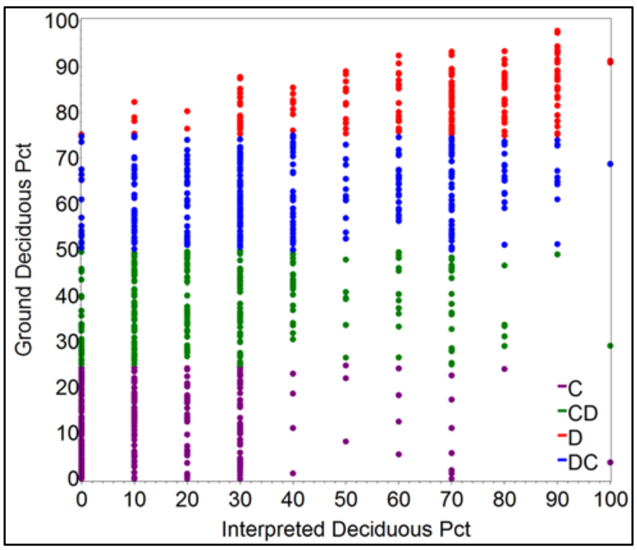


Figure 2. Ground deciduous percent compared to interpreted deciduous percent, RSA data.

1.3 Caveats on Content

This work was completed with input from the Strata Subcommittee over the span of several meetings. During analysis, a very large number of graphics were created. The majority of concerns discussed in this document related to hardwoods and spruce-leading mixedwoods. In order to minimize the size of this document, only selected (and generally, problematic) examples are presented. Unless specifically mentioned, RSA labels for pine and pine mixedwoods worked well for many companies.

2.0 EVALUATION OF RSA LABELS AND REBINNING EXERCISES

2.1 RSA Strata (Bins)

The first exercise that the Strata Subcommittee undertook was a graphical exercise intended to look at the overall variability within these RSA sampling "bins", to try to gain an understanding of potential underlying issues. The questions to be addressed were 1) is the label representative, and 2) is the variability within sampling bins acceptable?

Analysis was undertaken in September 2012, and a meeting was held in October 2012 to discuss the results of analysis.

RSA data from 10 companies (Alberta-Pacific, Alberta Plywood, Blue Ridge Lumber, Hinton Wood Products, Millar Western Forest Products, Sundance Forest Industries, Sundre Forest Products, Tolko, Weyerhaeuser Grande Prairie and Weyerhaeuser Pembina) were obtained, with survey dates ranging from 2009 to 2011. Data were extracted from the Empirical Post-Harvest database[1] for use in the analysis, with the exception of Tolko data which were added after the fact. Only selected results are presented in this document.

The first three figures present results from Alberta-Pacific data. Figure 3 presents the proportion of ground-based (RSA survey) density by species group for SUs assigned to the pure hardwood (Hw) stratum based on photo interpretation. Figure 4 and Figure 5 show the results for the hardwood-spruce (HwSx) and white spruce-hardwood (SwHw) strata, respectively.

Given that the goal of these bins is to put similar SUs together for purposes of subsampling, these three bins looked very similar in composition, although the HwSw showed a higher proportion of white spruce overall. Two additional observations were made: 1) all three bins show high deciduous densities, indicating that photo interpretation was doing a poor job of accurately determining density; and 2) there are occasional outliers with very high coniferous densities, implying that on occasion, there is a high density coniferous component that is missed by interpretation.

Figure 6 presents the results for the pure black spruce (Sb) bin for Blue Ridge Lumber. In 7 out of 9 SUs, the deciduous component was less than 20% (the RSA cutoff defining a pure conifer stand), but in two cases the deciduous exceeded that amount (in one case, over 40% deciduous by density). Also, one SU showed more pine than black spruce content, and another SU was found to be white rather than black spruce.

Figure 7 presents results for the Millar Western white spruce (Sw) stratum. In many SUs, a large deciduous component was observed on the ground, which was not interpreted from the photos. In addition, there is a significant component of pine in many of these SUs, often exceeding the white spruce component.

[1] The Empirical Post-Harvest database was a FRIAA (Forest Resource Improvement Association of Alberta) funded project intended to bring together data from post-harvest stands in order to address the data gap for these stand types.

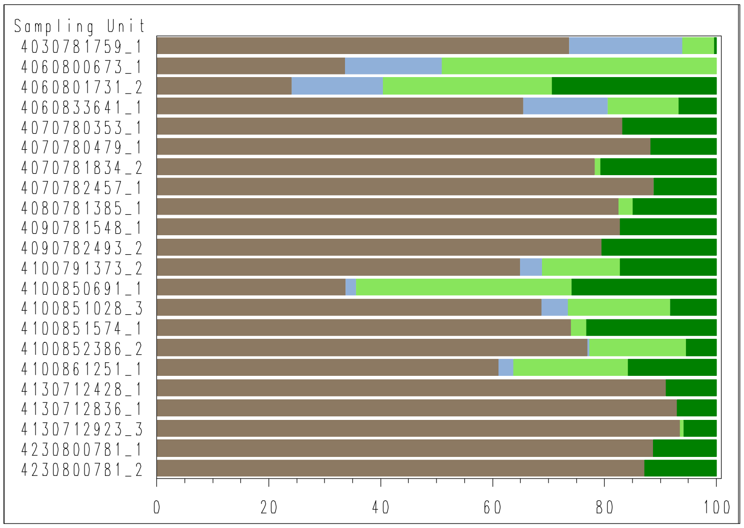


Figure 3. Alberta-Pacific RSA data: proportion of SU density, interpreted Hw.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

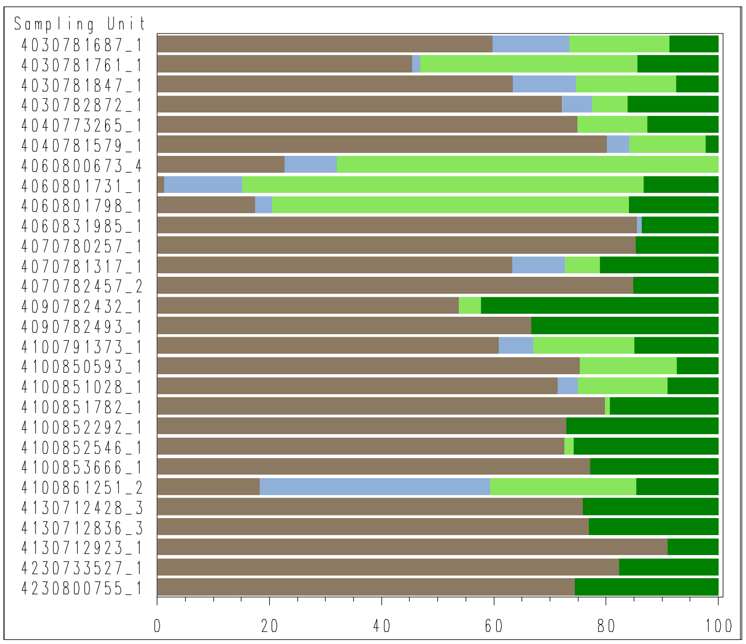


Figure 4. Alberta-Pacific RSA data: proportion of SU density, interpreted HwSx.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

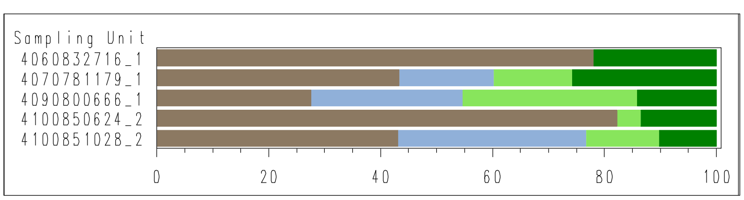


Figure 5. Alberta-Pacific RSA data: proportion of SU density, interpreted SwHw.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

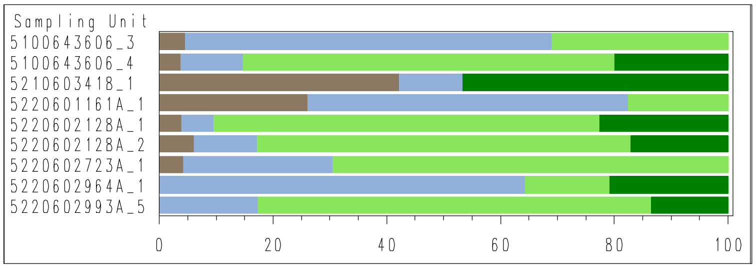


Figure 6. Blue Ridge Lumber RSA data: proportion of SU density, interpreted Sb.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

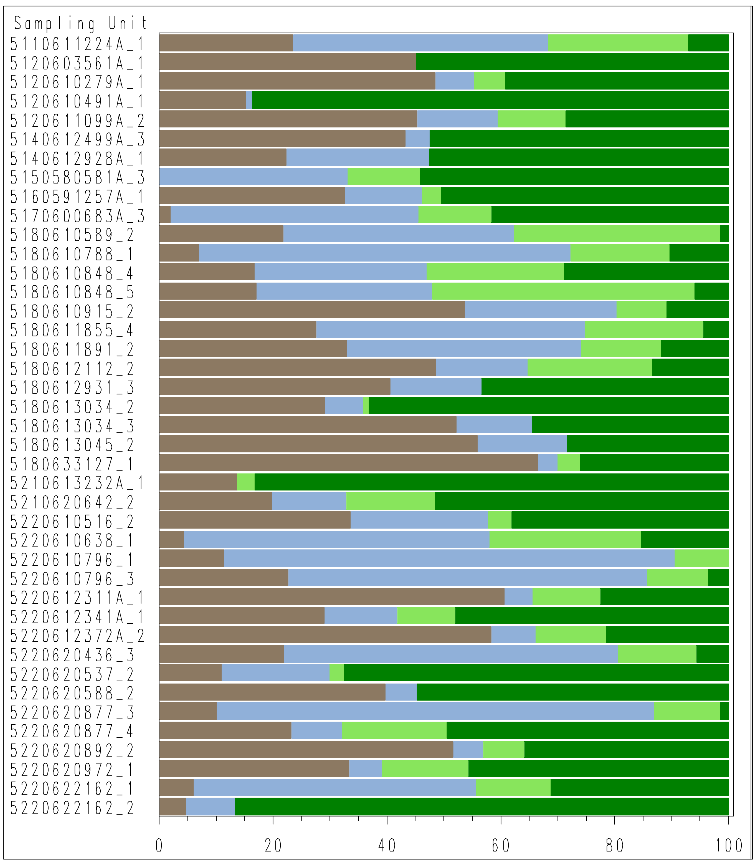


Figure 7. Millar Western RSA data: proportion of SU density, interpreted Sw.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

Figure 8 and Figure 9 present the results from Weyerhaeuser Grande Prairie's white spruce and pine strata, respectively. The white spruce bin showed more consistency in results than the Millar Western white spruce stratum, but pine results were variable, with a large white spruce component in many cases. Deciduous densities also could be variable, more so in the case of white spruce than for pine, which was a trend observed in many companies' data.

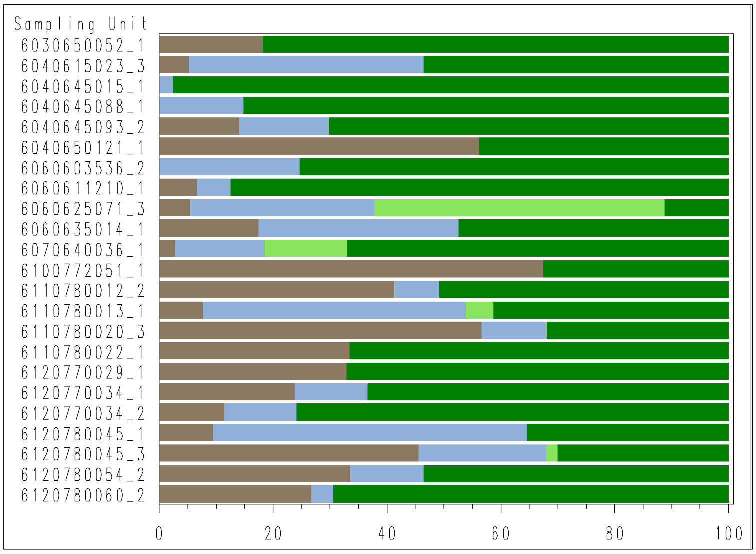


Figure 8. Weyerhaeuser Grande Prairie RSA data: proportion of SU density, Sw.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

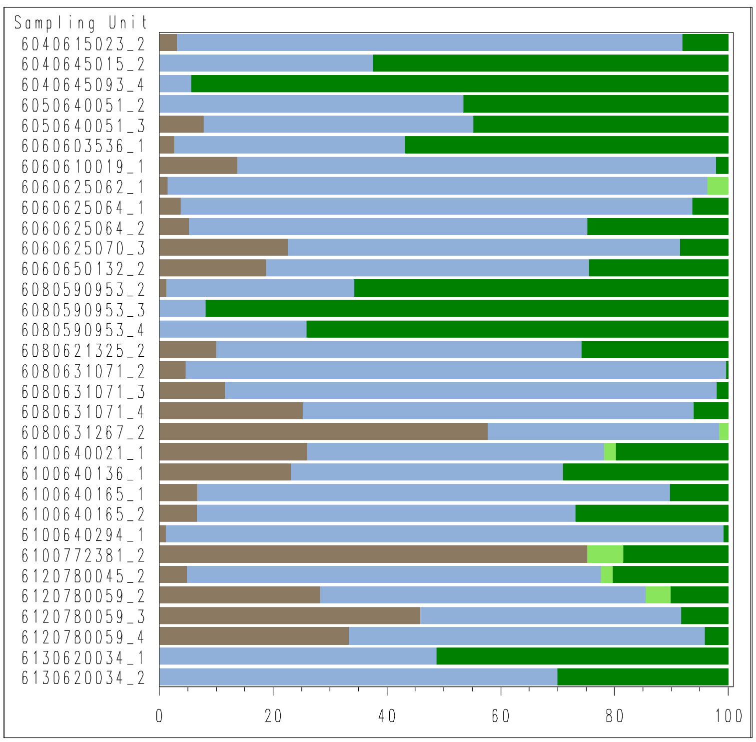


Figure 9. Weyerhaeuser Grande Prairie RSA data: proportion of SU density, interpreted Pl.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

2.2 Rebinning Exercises

The rebinning exercise was intended to examine whether silviculture regime could provide a better method for grouping SUs in terms of similarity in species composition. Four datasets were used for this analysis:

- Alberta-Pacific: rebinned based on planted species and tending treatment.
- Millar Western: rebinned based on declaration and leading conifer.
- Blue Ridge Lumber: rebinned based on declaration and planted species.
- Weyerhaeuser Grande Prairie: rebinned based on site preparation treatment, tending and planted species.

Figure 10 presents the results for the Alberta-Pacific hardwood bin based on original photo interpretation for comparison purposes. This bin is termed "unintentional deciduous" since no deciduous cutblocks were performance surveyed under RSA. There was considerable variability in the proportion of deciduous density relative to coniferous density. Figure 11 to Figure 13 show selected results for rebinned data. In Figure 11, three SUs (portions of cutblocks) were identified as "intentional deciduous" as these and were neither tended nor planted (consistent with silviculture targeting a pure deciduous condition); note the consistency in results. Similar improvements are found in Figure 12 and Figure 13 when strata are reassigned based on silviculture treatment (with the exception of one outlier).

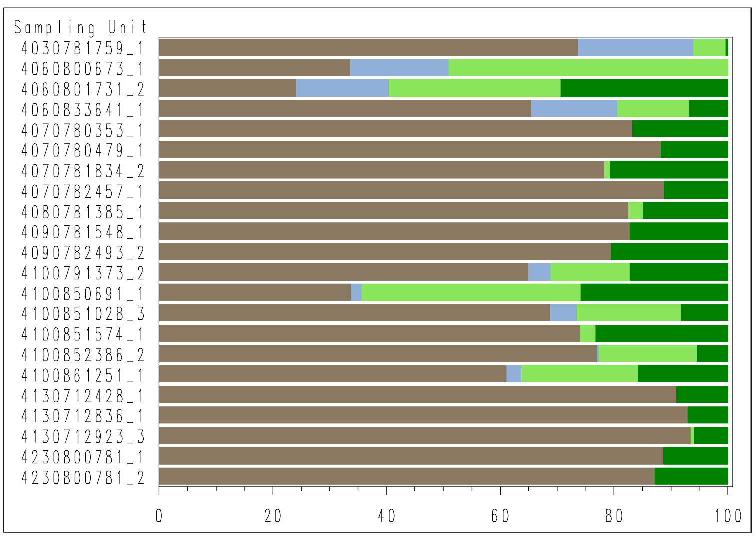


Figure 10. Alberta-Pacific RSA data: interpreted as Hw (unintentional "D").
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

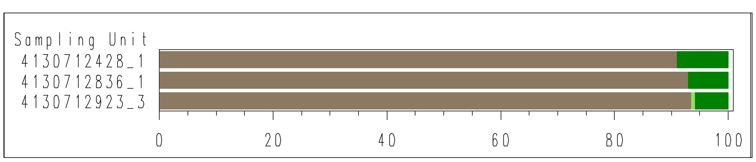


Figure 11. Alberta-Pacific rebinned data: no tend + no plant ("intentional D")
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

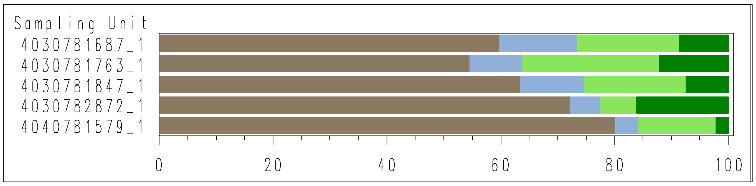


Figure 12. Alberta-Pacific rebinned data: tend + plant Pj + Sw/Sb.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

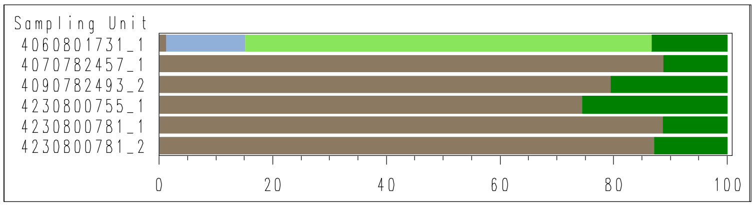


Figure 13. Alberta-Pacific rebinned data: no tend + plant Sw.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

Figure 14 shows results of rebinning for Blue Ridge Lumber's pine stratum. Rebinning based on silviculture plus leading coniferous species resulted in more SUs being assigned to the same bin, and overall fewer bins, for the company's data. The rebinning also resulted in an increase in within-bin variability.

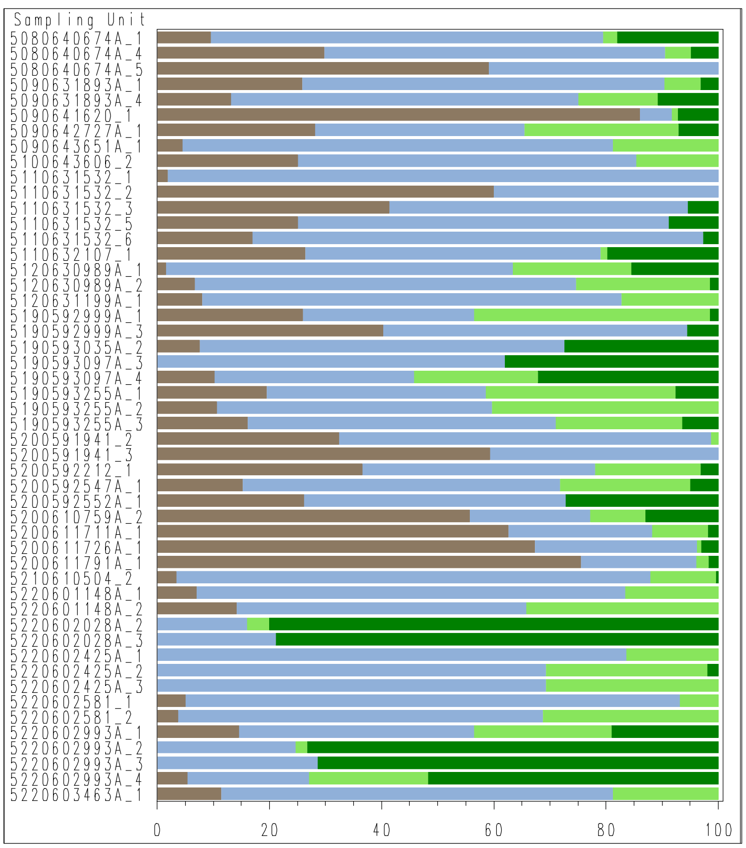


Figure 14. Blue Ridge Lumber rebinned data: pine (Pl).

Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

Results are similar for the Millar Western data. Figure 15 shows the results for the white spruce stratum. In this case, many of the pine-leading "outliers" observed under the original RSA stratification scheme were moved into the new pine stratum, improving overall results. However, results were not improved with respect to variability in deciduous species composition within bins.

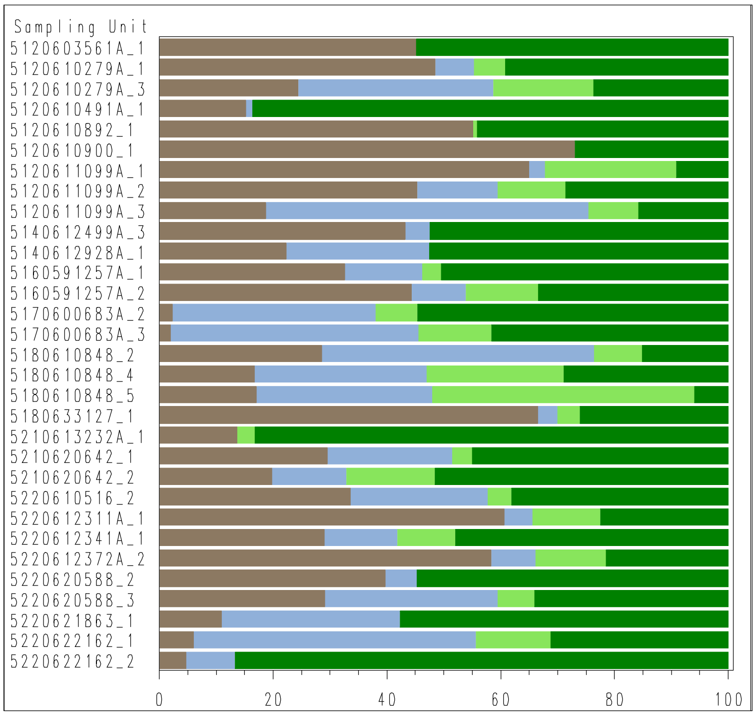


Figure 15. Millar Western rebinned data: white spruce (Sw).
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

Rebinning of the Weyerhaeuser Grande Prairie data, which included consideration of planted conifer species, site preparation and tending treatment, showed better results for certain strata (primarily pine), but less clear trends for spruce-dominated strata. Selected results for pine-leading strata are presented in Figure 16 and Figure 17; results for white spruce-leading strata are shown in Figure 18 and Figure 19.

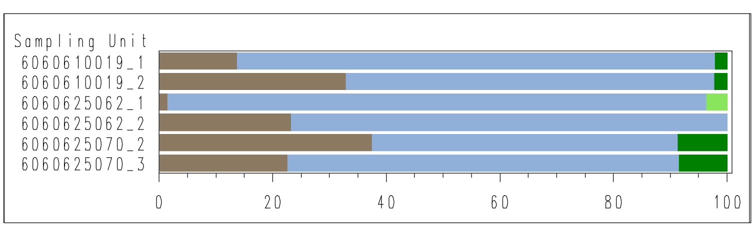


Figure 16. Weyerhaeuser Grande Prairie rebinned data: Pl + prep + no tend.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

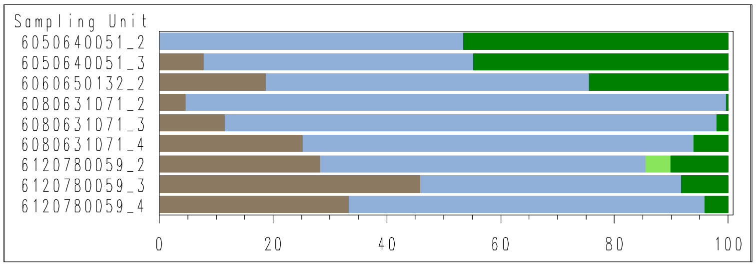


Figure 17. Weyerhaeuser Grande Prairie rebinned data: Pl + prep + tend.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

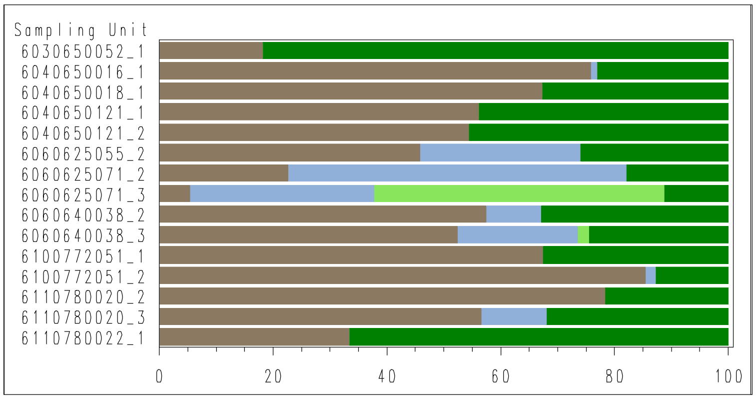


Figure 18. Weyerhaeuser Grande Prairie rebinned data: Sw + prep + no tend.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

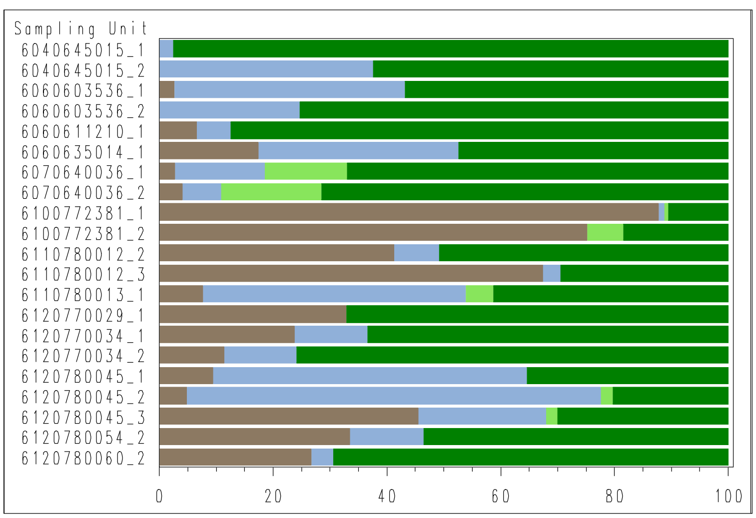


Figure 19. Weyerhaeuser Grande Prairie rebinned data: Sw + prep + tend.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

2.3 Stocking vs. Density

Following the initial evaluations and rebinning exercises, feedback from both photo interpreters and members of the Strata Subcommittee indicated that in many cases, outages could be affected by spatial patterning. This patterning could affect results in two ways (directions):

1) Photo-interpretation, where clumpy distribution of species must be averaged across the block when determining overall density. For example, fringes or patches of deciduous species left after herbiciding.
2) Ground sampling, where a single plot falls in a high-density (atypical) area and is averaged across the block. For example, clusters of birch, where all birch stems are counted within the plot, or patches of high density fir ingress.

This averaging of spatially discrete, high density areas across the entire block to create an SU-level label may present an inaccurate picture of species composition, particularly of future species composition in terms of canopy closure (the metric used to describe species composition for the Alberta Vegetation Inventory).

It was also observed that very high densities of deciduous species can often occur after manual tending, which often results in the majority of strata being assigned to hardwood or hardwood-leading strata, regardless of coniferous densities.

As such, an additional investigation was made into whether using percent stocking rather than density proportions could result in improved results (reduction in within-bin variability). Stocking may better reflect future species composition since it describes occupancy of growing space spatially across a stand.

Rather than proportion of ground-based densities, graphs were generated using ground-based stocking percentages. Figure 20 shows the original (density proportion) results from the Weyerhaeuser Grande Prairie rebinning exercise; note that both deciduous and white spruce appear quite variable. Figure 21 presents data from the same SUs, but with results based on percent stocking. Based on percent stocking, white spruce composition is quite consistent across all SUs; the variability in RSA the results is based primarily on the deciduous component.

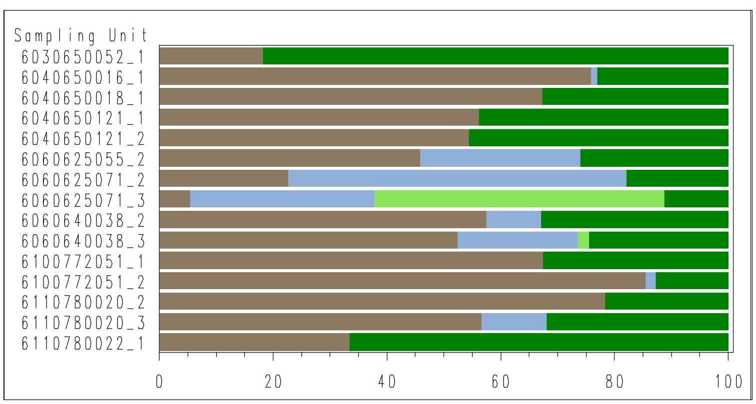


Figure 20. Weyerhaeuser Grande Prairie rebinned data: Sw + prep + no tend, proportion of density.

Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

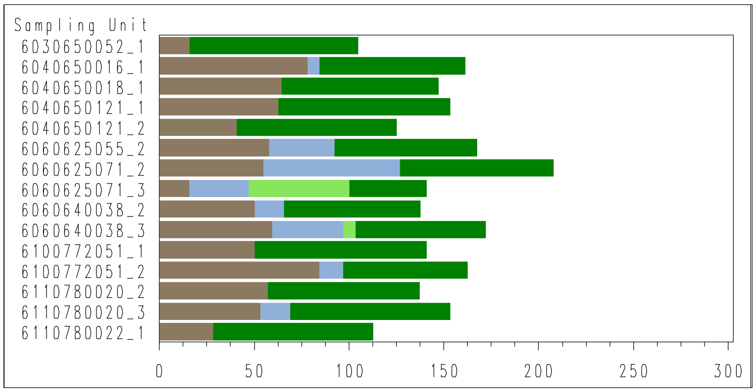


Figure 21. Weyerhaeuser Grande Prairie rebinned data: Sw + prep + no tend, stocking %.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

Results are similar for other companies, such as Millar Western. Figure 22 and Figure 23 show results based on density proportion and stocking percent for Millar Western's pine stratum. Under the percent stocking scenario, it becomes obvious that pine stocking is very consistent across all SUs, however deciduous and spruce stocking varies.

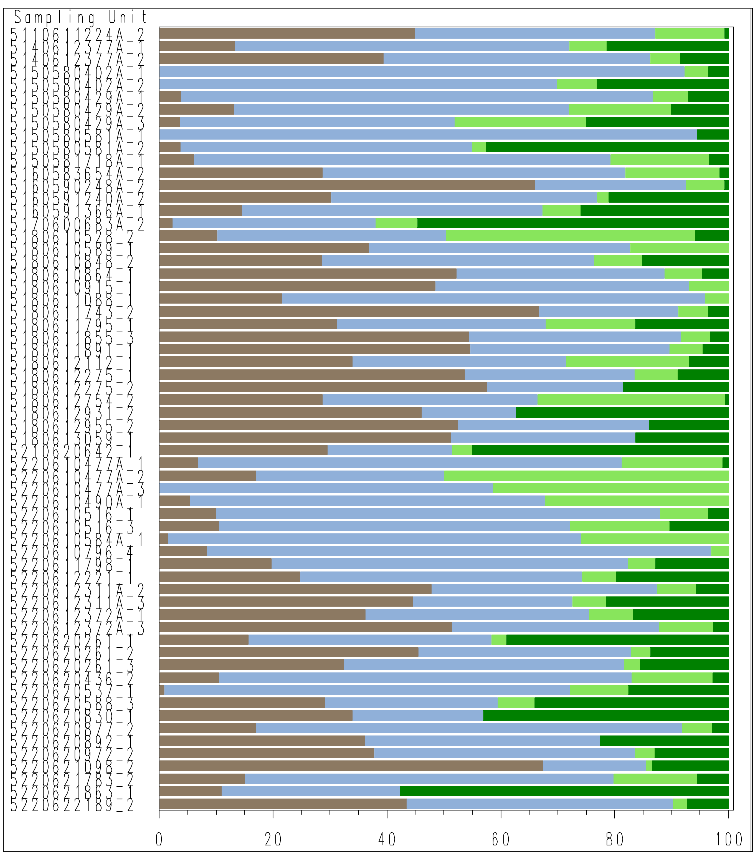


Figure 22. Millar Western rebinned data: Pl, proportion of density.
Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

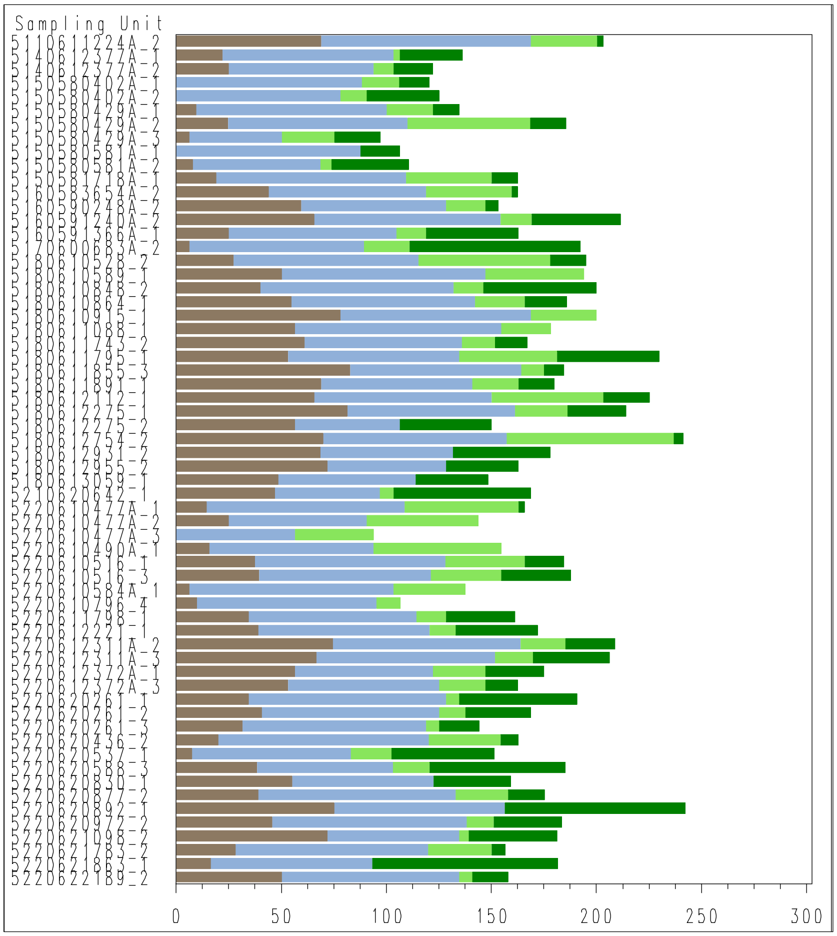


Figure 23. Millar Western rebinned data: Pl, stocking %.

Brown = deciduous, blue = pine, light green = black spruce, green = white spruce.

2.4 Observations and Conclusions

Based on this work and subsequent discussions with photo interpreters and members of the Strata Subcommittee, several key observations were be made:

- Variability within strata appears to be high based on the existing RSA data/ruleset;
- In certain cases, different strata appear to be similar in terms of species composition;
- Outages between ground data and photo interpretation may be due to the influence of spatially discrete, high density areas in one of two ways:
  - o Ground sampling (e.g., photo interpretation cannot see small birch or fir, but plots capture 1 or 2 high density plots which are averaged across the block); or
  - o Photo interpretation (e.g., density of patchy areas or fringes of deciduous left after herbiciding must be averaged across the block, but plots do not fall into these areas;

- Outages may also be due to the inability of photo interpretation to capture smaller conifers, or shorter (leaf-off) deciduous species;
- Outages can also occur because there is often a full growing season between photo capture and ground sampling, allowing trees to grow into the minimum height threshold.

The conclusion of the Strata Subcommittee was that some inaccuracies will always occur when aerial photos are used to infer attributes for a stand or opening, in the same way that this occurs with the Alberta Vegetation Inventory. It is the opinion of the committee that alignment between aerial photos and ground-based attributes will improve with the transition to 4-band digital photography. Supplemental analysis is planned for spring 2014 to evaluate new photography.

Alberta-Pacific rebinning, and to some extent the Weyerhaeuser Grande Prairie rebinning, did appear to reduce variability within bins. However, for two other companies, Millar Western and Blue Ridge Lumber, results were not improved, and in fact resulted in a reduced number of strata for sampling (which could potentially result in more within-bin noise). It appears that rebinning based solely on declaration and leading conifer may not yield improved results, but further division based on tending/site preparation information (as was the case for Alberta-Pacific and Weyerhaeuser) may do so. However, not all companies have accurate spatial silviculture records extending back 14 years to when these stands were initially treated, which could impede application of such a stratification scheme.

The AFGO Strata Subcommittee decided not to pursue further investigation of the use of silviculture information as a labelling method, pending the outcome of evaluation of new aerial photography. If new 4-band photography improves results, labels based on photo-interpreted attributes will be sufficient for assigning strata to sampling units.

Using assignment rules based on proportion of density averaged across a sampling unit allows spatially discrete, high density areas to influence the final stratum assignment which may not be representative of future species composition. Using stocking percentage may better describe the future crown closure (species composition under an AVI-based ruleset).

Because density drives the GYPSY model more than stocking, the AFGO subcommittee felt that density was likely a superior metric for describing strata. However, the option was left open to revisit this question as part of the 2014 analysis.

Regardless of the revised metric, outliers will still persist due to the outages described here; AVI inventories have similar inaccuracies because ultimately aerial photography is a remote sensing approach which is subject to a certain level of error.

3.0 YIELD CURVES AS A METHOD TO EVALUATE LABELS

After initial work with RSA data in Section 2.1, a follow-up question arose. The Alberta-Pacific Hw, HwSx and SwHw strata appeared to have very similar composition (proportion of spruce and deciduous densities). The question was asked, if these three bins (below) were used to create yield curves, would the Hw, HwSx and SwHw curves all be similar or even the same? The decision was made to create stratum-specific yield curves based on each company's RSA data.

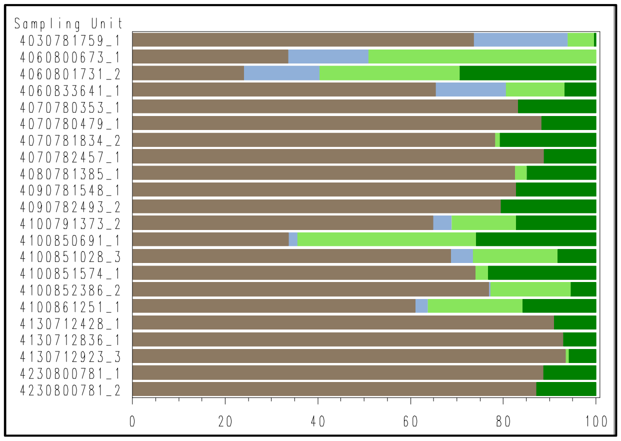


Figure 24. Alberta-Pacific sampling units assigned to pure hardwood (Hw).

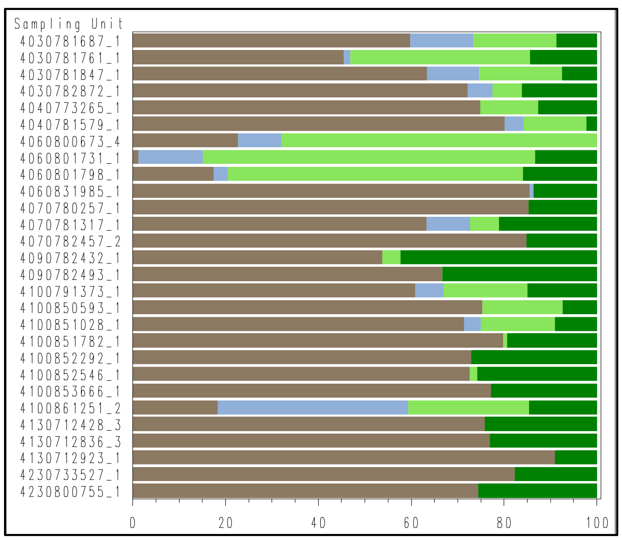


Figure 25. Alberta-Pacific sampling units assigned to aspen-spruce mixedwood (HwSx).

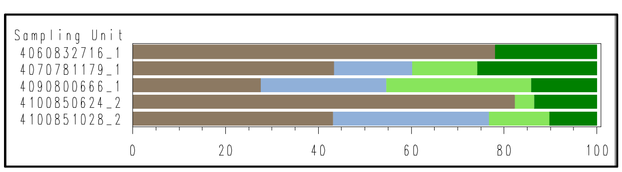


Figure 26. Alberta-Pacific sampling units assigned to spruce-aspen mixedwood (SwHw).

3.1 Yield Curves

The same data used for the original RSA stratum evaluation (Section 2.1) were used to generate yield curves for all companies' data. Each SU with ground data was projected using GYPSY to create a curve for deciduous and coniferous volume. These individual projections were then averaged to create a stratum-level curve. Composite weightings from RSA programs were not applied, since the intent was also to create "rebinned" yield curves for subsequent comparison (using the information from Section 2.2) which would not allow use of these weightings.

Resulting yield curves for spruce-leading strata (plus pure hardwood) for Alberta-Pacific, Alberta Plywood, Hinton Wood Products and Tolko are shown in Figure 27 to Figure 30.

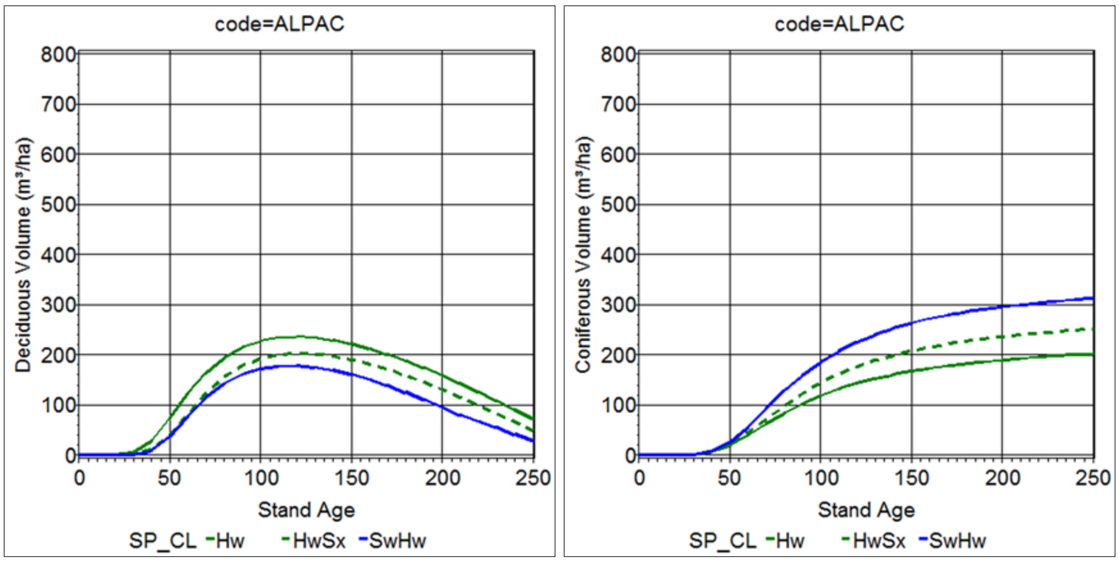


Figure 27. Alberta-Pacific yield curves (Hw, HwSx and SwHw) based on RSA strata.

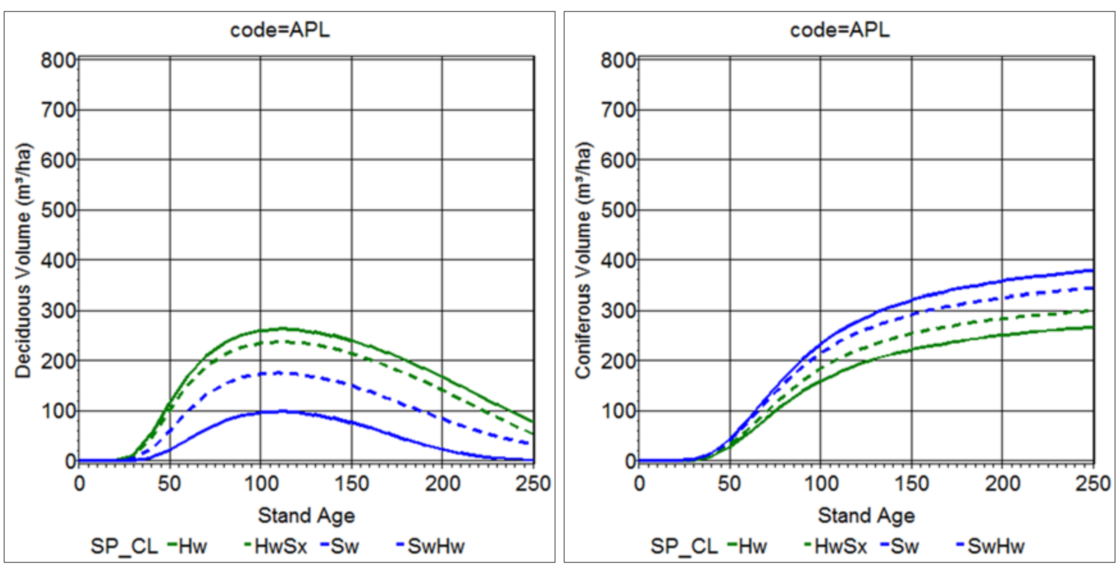


Figure 28. Alberta Plywood yield curves (Hw, HwSx, SwHw and Sw) based on RSA strata.

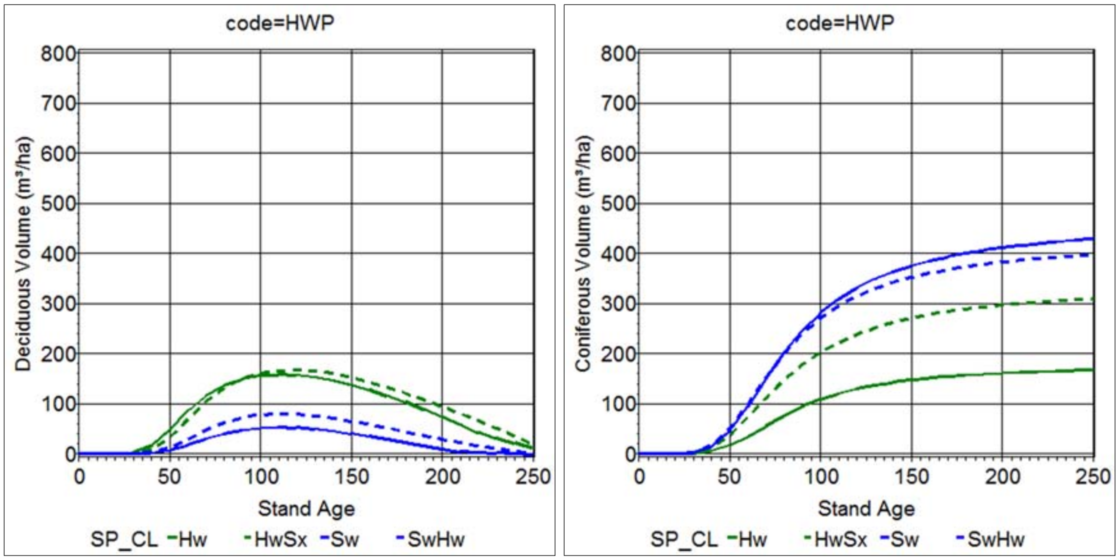


Figure 29. Hinton Wood Products yield curves (Hw, HwSx, SwHw and Sw) based on RSA strata.

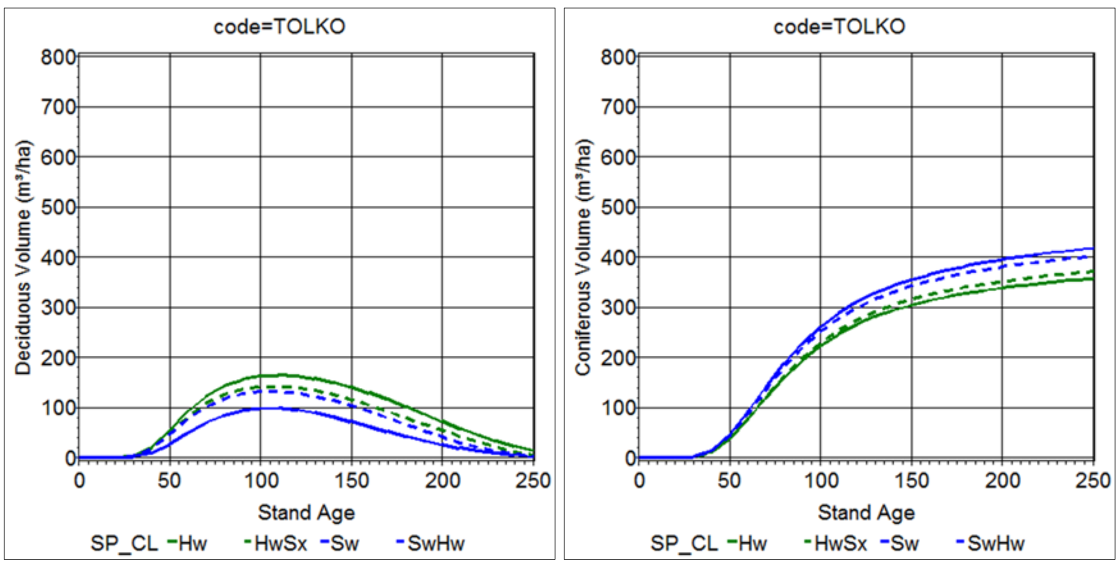


Figure 30. Tolko yield curves (Hw, HwSx, SwHw and Sw) based on RSA strata.

In the majority of cases, yield curves exhibit the patterns expected (e.g., the Hw stratum has more deciduous volume than the HwSx stratum, which has more deciduous volume than the SwHw stratum, etc.) but in some cases, the curves can be quite similar. For example, for Tolko, there is almost no difference in deciduous volume between the HwSx and SwHw strata. For coniferous volumes across the Hw-HwSx-SwHw-Sx sequence of strata (which spans all four broad cover groups), at 100 years the range of differences is less than 40 m^3/ha.

Figure 31 to Figure 34 show yield curves for pine-leading strata for Blue Ridge Lumber, Hinton Wood Products, Millar Western and Sundre. The pine vs. pine hardwood range from well differentiated (e.g. for Blue Ridge, Hinton and Sundre) to less differentiated (as in the case of Millar Western). In general, as with all analyses, pine/pine mixedwood labels performed better than spruce/spruce mixedwood labels.

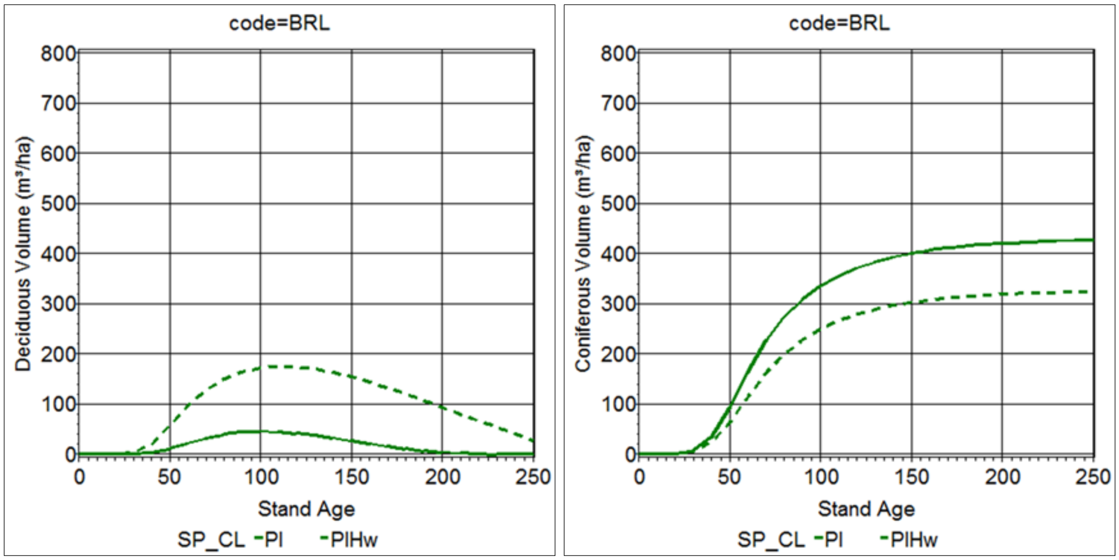


Figure 31. Blue Ridge Lumber yield curves (Pl, PlHw) based on RSA strata.

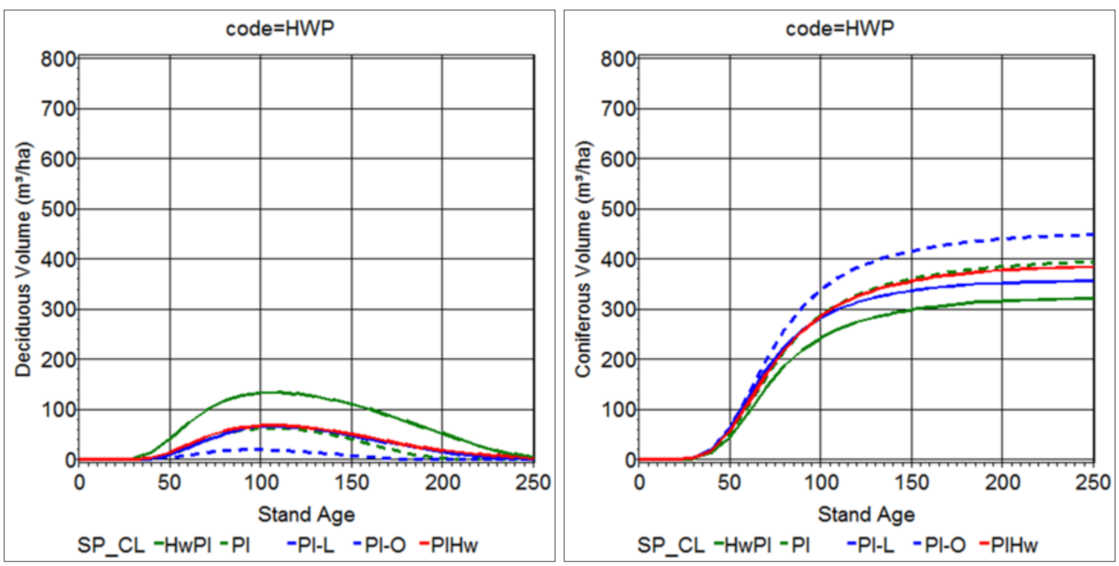


Figure 32. Hinton Wood Products yield curves (Pl, PlHw) based on RSA strata.

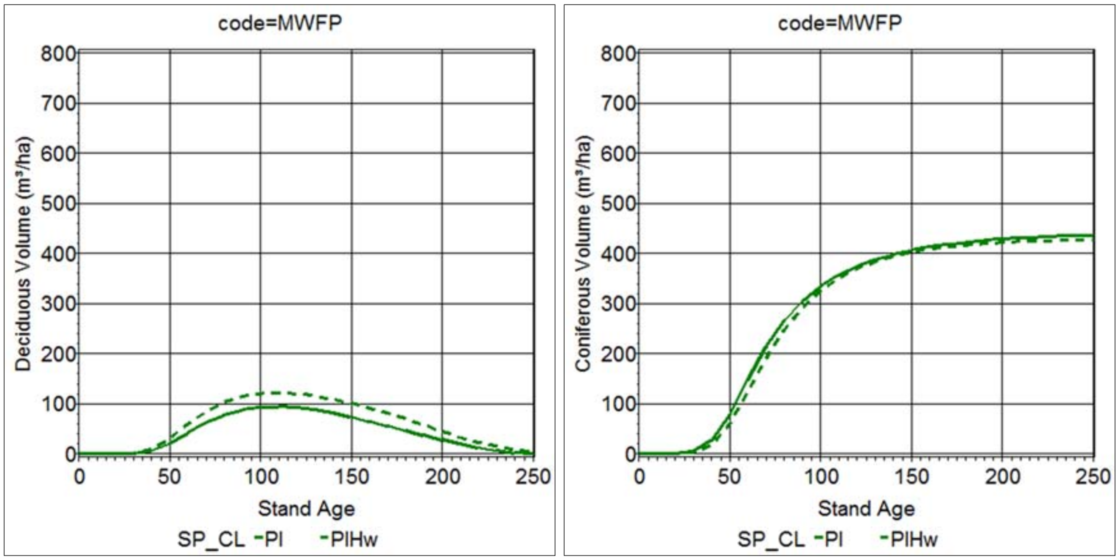


Figure 33. Millar Western yield curves (Pl, PlHw) based on RSA strata.

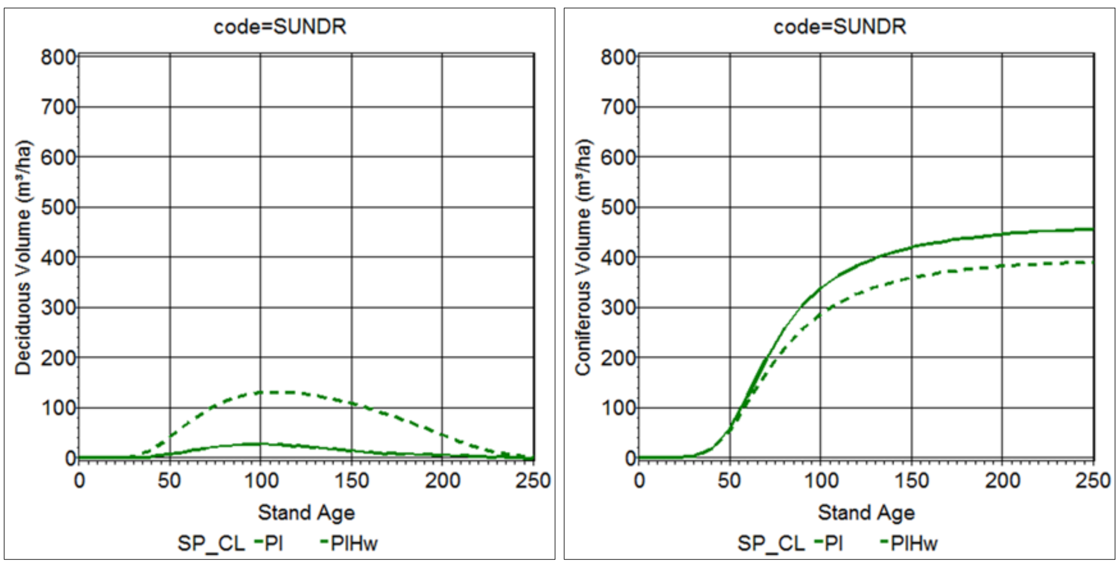


Figure 34. Sundre yield curves (Pl, PlHw) based on RSA strata.

3.2 Deciduous Volumes

The following 4 graphs show coniferous yields from four of the participating companies. During this exercise, it was observed that hardwood strata contain a significant proportion of coniferous volume (over 100 m^3/ha at age 100 for all four companies, and over 200 m^3/ha for Tolko). This provided another indication that perhaps either 1) conifers were not being identified during photo interpretation, 2) deciduous densities were causing SUs with a significant conifer component to be assigned to the hardwood stratum, or 3) the RSA "breakpoint" for assigning SUs to the hardwood stratum was in the wrong place .

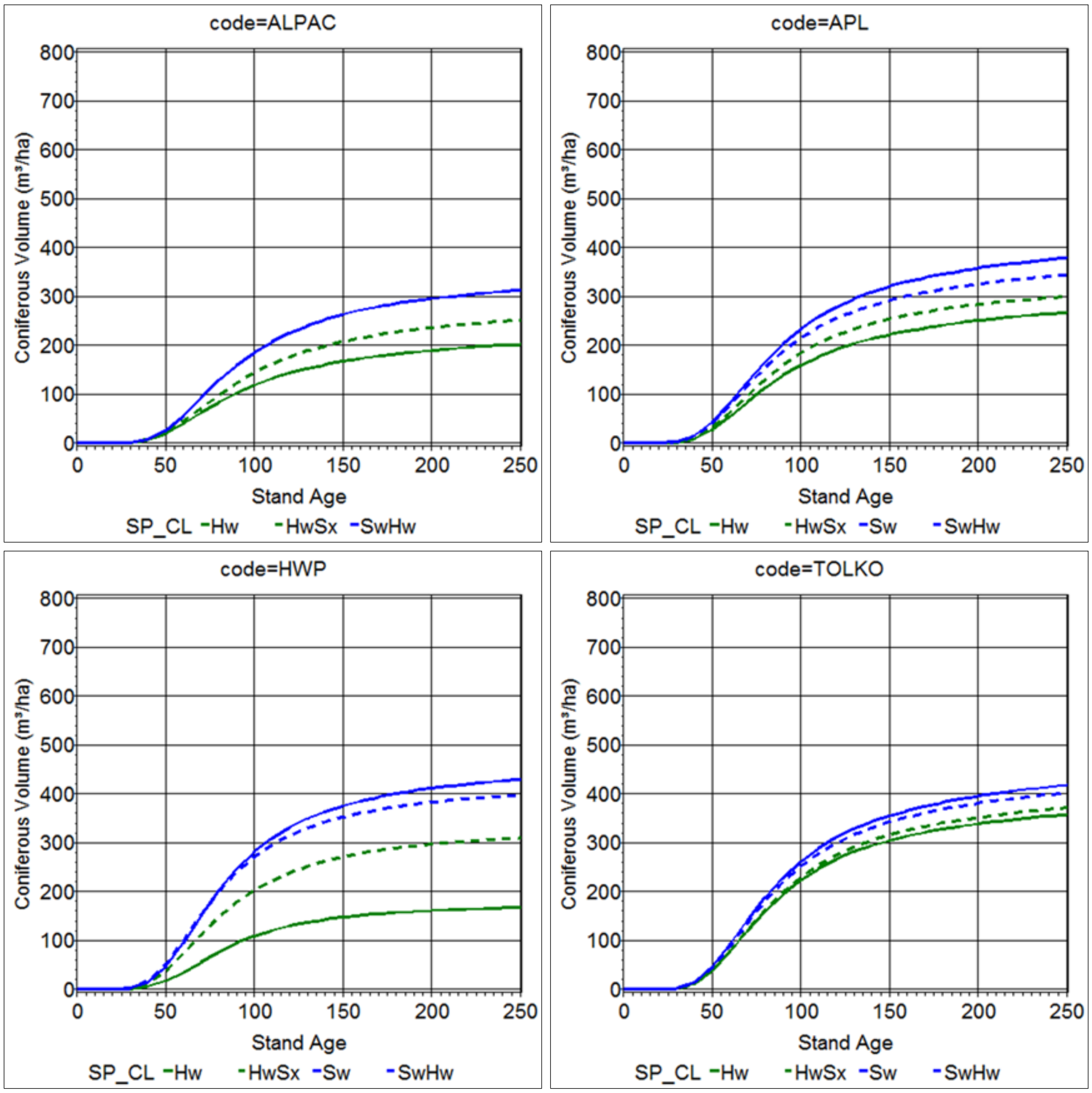


Figure 35. Coniferous yield curves (Hw, HwSx, SwHw and Sw) from four companies' data.

3.3 Rebinning Impacts

Yield curves were also developed using the rebinned data where available. As an example, Alberta-Pacific yield curves for hardwood, hardwood-spruce and white spruce-hardwood strata were initially quite similar, and were only differentiated to a modest extent (approximately 20 m^3/ha difference) for deciduous volume at age 100 (Figure 36). Using the revised stratum assignments from Section 2.2, the Hw yield curve improved considerably, particularly with respect to coniferous content (Figure 37). Note, however, that there were only 3 SUs assigned to Hw after rebinning (since no declared hardwoods were required to be performance surveyed at that time). For the other companies, rebinning moved all Hw SUs into coniferous strata.

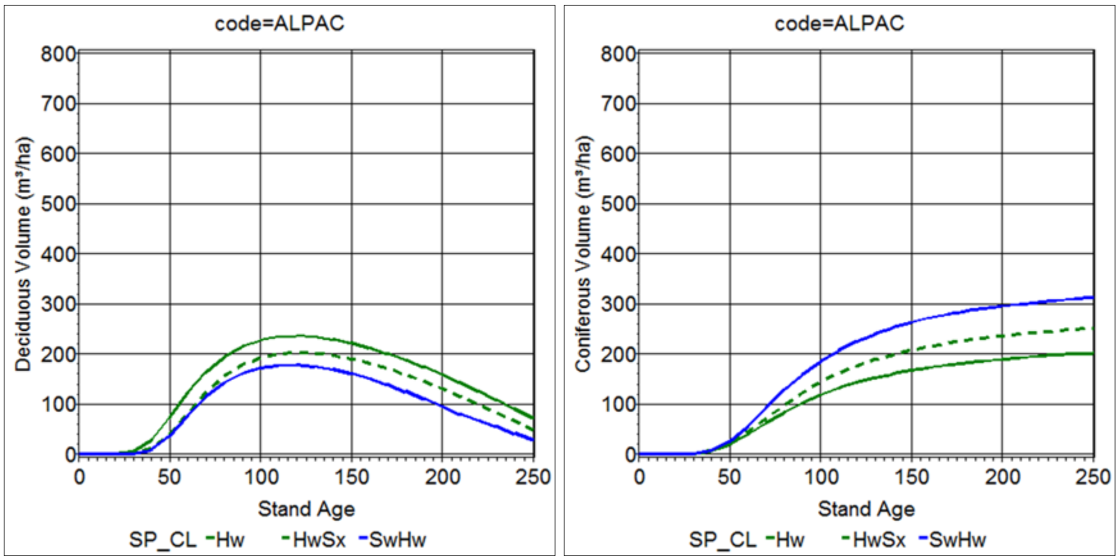


Figure 36. Alberta-Pacific yield curves (Hw, HwSx and SwHw) based on original RSA strata.

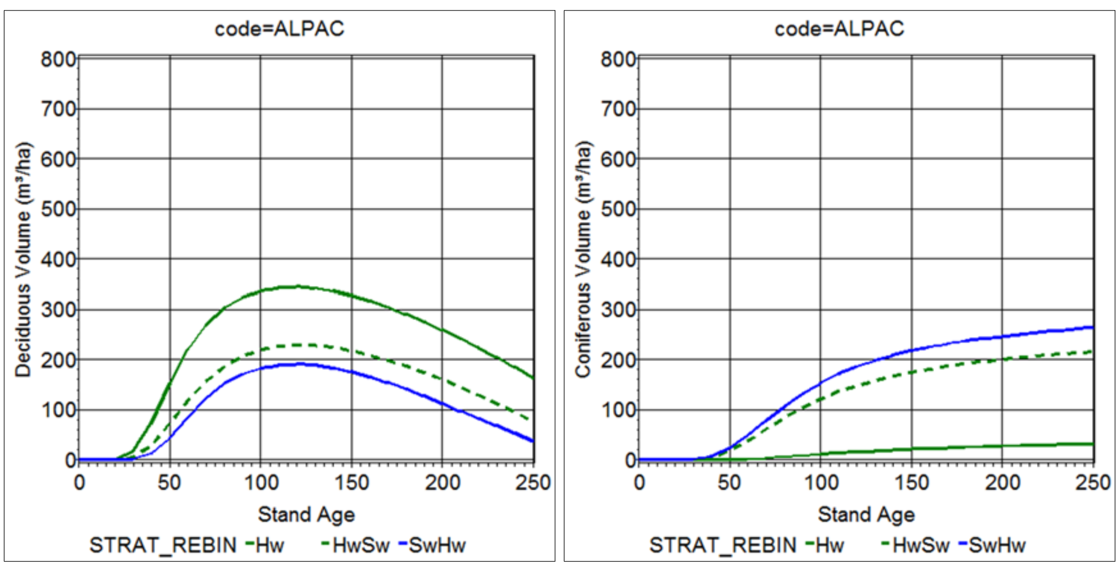


Figure 37. Alberta-Pacific yield curves (Hw, HwSx and SwHw) after rebinning.

Note that improvements relate primarily to the hardwood stratum; changes to mixedwood yields are relatively minor. The impacts of rebinning are in line with work completed by ESRD, where, rather than rebinning, the definition of a hardwood stratum was shifted from ≥80% deciduous density to ≥ 90% deciduous density. This identifies that although there is an issue with the hardwood stratum, rebinning based on silviculture is not the only method to address this issue.

3.4 Observations and Conclusions

This work reinforced the concern that current stratum assignments were inaccurate, either due to issues with photo interpretation of attributes or the break points used to assign SUs to RSA strata. Overall, however, yield curves follow the biological expectations in terms of trends (i.e., deciduous strata have more deciduous volume than coniferous strata, coniferous strata have more conifer volumes than deciduous strata), which indicates that with improvements to the two aforementioned aspects of the process, better results are achievable.

4.0 IMPACTS OF IMPROVEMENTS TO PHOTO-INTERPRETATION

4.1 Issues

Key concerns with photo-interpretation, as identified by the Strata Subcommittee during initial investigations, were the ability of interpreters to identify shorter coniferous or deciduous trees and to correctly interpret deciduous densities in manually tended stands.

4.2 Evaluation

The AFGO Strata Subcommittee attending a meeting with Greenlink Forestry in December 2012, to discuss the perceived issues with photo-interpretation and the RSA stratum assignment process. Greenlink provided a demonstration of new digital photography with four-band infrared capabilities.

Greenlink's opinion was that with the new digital photography, combined with improvements to hardware (monitor quality) over the last several years, photo-interpretation quality would improve sufficiently to address the majority of concerns. However, three unresolvable issues were identified:

1) Spatially discrete, high density areas must still be averaged across the SU, in some cases placing the SU in what would likely be the wrong stratum if the intent is to represent future species composition. For example, high deciduous densities at the edges of herbicided blocks, or localized groupings of species such as fir or birch.
2) Manually tended stands with deciduous regrowth in the 2-3 m height range are difficult to interpret. Because of the short height and leaf-off condition of these SUs, interpreters can identify when densities are high, but interpretation of actual numbers become an educated guess.
3) Photo capture often occurs one growing season prior to ground sampling; outages due to smaller deciduous and conifers growing into the minimum height threshholds in the interim cannot be addressed under the current protocols.

4.3 Observations and Conclusions

*As an outcome of this meeting, and the issues as described in Section **Error! Reference source not found.**, the Strata Subcommittee agreed that further evaluation of results be undertaken in 2013, following receipt of new RSA data collected using new digital 4-band photography.*

APPENDIX 3: EVALUATION OF NEW DIGITAL AERIAL PHOTOGRAPHY

13056 Sherbrooke Ave, Edmonton, AB T5L 4E9 · Tel (780) 705-2077 · Email: kat@froeseforestry.ca

update

froese forestry consulting inc.

Company: Alberta Forest Growth Organization, Strata Subcommittee
From: Katrina Froese
Date: June 23, 2014 Revised October 20, 2014
Re: Evaluation of New Digital Aerial Photography

Objective

Evaluate whether new digital photography results in reduced variability within sampling strata.

Approach

The initial approach was to follow the same descriptive methodology used in the original exploratory analysis.

Analysis

A total of 17 datasets from 10 companies were used for analysis. Data from combined programs were split by disposition holder. Rocky Wood Preservers were excluded from results due to small sample size.

Graphs represent percent of ground-sampled density within each sampling unit. Sampling units are grouped by company and interpreted sampling stratum. Minor sampling strata (e.g., strata with single observations) are excluded. Outputs are provided on pages 4-20.

Boxplots were also created. These compare ground-sampled density to interpreted density, where total interpreted density split into species group densities based on proportion of attribute label (e.g. 1,000 sph, Aw8Sw2 = 800 sph Aw and 200 sph Sw).

Question

If we capped plot-level deciduous densities (or used ground-based stocking proportions rather than density proportions), would results line up better with inventory calls?

Addition August 27, 2014

At the June 23, 2014 meeting, a request was made to re-create the analysis with two changes:

- Group the data across companies (one "bin" for Hw, HwPl, etc.)
- Create similar graphics for the original (true colour) photography for comparison purposes

In order to keep results roughly comparable, only companies that contributed data to both analyses (Alberta-Pacific, Alberta Plywood, Blue Ridge Lumber, Millar Western Boyle, Sundre, Vanderwell and Weyerhaeuser Pembina) were included in round 2 analysis.

Two additional handouts were distributed at the August 27th meeting showing graphical depictions of within-bin variability for (new) colour infrared and (previous) true colour photography, and are provided as an addendum to this document. Within-bin variability did not show appreciable improvements (reductions) based on a visual comparison between the two datasets.

Addition October 20, 2014

At the August 27, 2014 meeting, a further request was made to generate some descriptive statistics, to provide a more quantitative means of comparing the two datasets. The dataset used for the August 28, 2014 update was used for this analysis.

Table 1 provides descriptive statistics on within-bin variability in ground sampled densities by photo-interpreted RSA stratum. Primary species of interest are highlighted in blue. In general, relative to true colour photography, colour infrared photos show:

- Lower standard deviation and coefficient of variation in the aspen species group;
- Higher average coniferous densities, which may reflect the improved ability to see conifers;
- Increased variability (standard deviation and coefficient of variation) in pine and black spruce densities within pine and black spruce strata (again possibly related to increased ability to see smaller conifers); and
- Similar trends for white spruce density in the majority of white spruce-leading strata.

Table 2 provides descriptive statistics on within-bin variability in ground sampled proportions by photo-interpreted RSA stratum. Trends are similar, however the magnitude of differences between true colour and colour infrared are smaller. For example, the standard deviation of pine density in the HwPl stratum changes from 1945 stems/ha to 4018 stems/ha (CV%=87 and 110, respectively), but the standard deviation of pine stocking only changes from 18 to 23% (CV%=30 and 34, respectively.

Table 3 provides descriptive statistics on within-bin variability in ground sampled density by photo-interpreted RSA stratum, where density is expressed as a percent of total density (similar to the graphical approaches implemented in previous analysis. As a proportion of the total SU density, the magnitude of differences are again smaller than when compared to absolute densities.

Table 1. Average, standard deviation and coefficient of variation for ground-sampled densities by photo-interpreted stratum and type of photography.

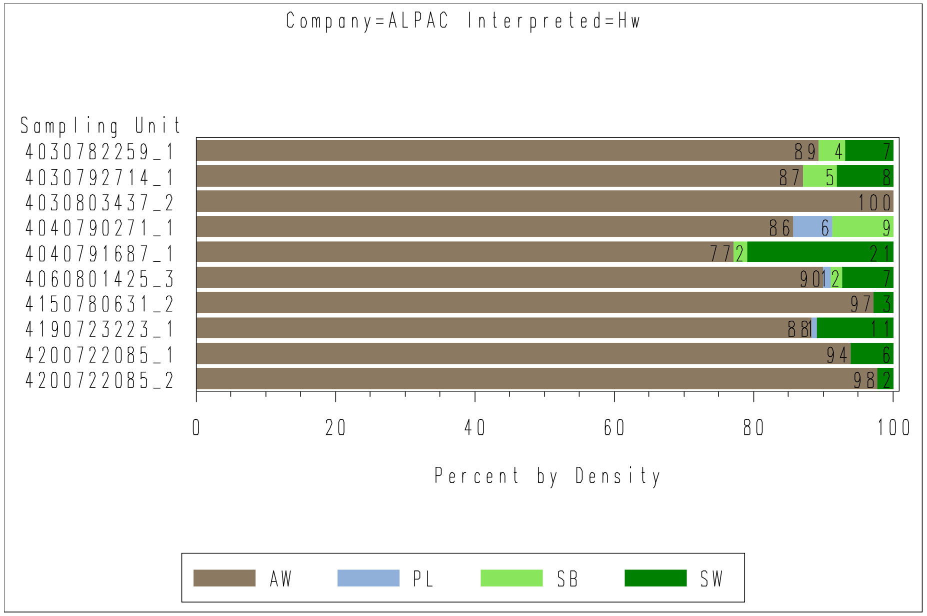
Photo-Interp Stratum	Photo Type	# of SUs	Density											
			Average				Standard Deviation				Coefficient of Variation			
			AW	PL	SB	SW	AW	PL	SB	SW	AW	PL	SB	SW
Hw	TC	89	7576	243	371	1363	4365	631	983	787	58	259	265	58
	CIR	30	8869	870	277	1167	3392	2026	466	1591	38	233	168	136
HwSx	TC	150	6700	419	406	1831	4317	1007	1043	1222	64	240	257	67
	CIR	84	7531	467	376	2445	3357	747	1411	2171	45	160	375	89
SwHw	TC	141	4420	371	339	1976	4036	911	955	1739	91	245	282	88
	CIR	58	4170	596	99	1866	3181	738	261	1055	76	124	265	57
Sw	TC	145	2036	475	238	2099	1954	702	481	2030	96	148	202	97
	CIR	58	2048	662	280	2169	1605	991	581	2513	78	150	207	116
HwPl	TC	25	4279	2223	509	802	2022	1945	846	802	47	87	166	100
	CIR	31	5668	3662	239	1658	2775	4018	405	1866	49	110	170	113
PlHw	TC	55	3604	3344	509	796	3132	3408	875	1139	87	102	172	143
	CIR	59	3609	3920	544	852	2630	4459	1870	1325	73	114	344	155
Pl	TC	155	1516	3920	586	942	1896	4077	920	1266	125	104	157	134
	CIR	76	1757	5997	513	1000	1733	8911	713	1578	99	149	139	158
SbHw	TC	3	2802	285	2587	365	2427	316	2180	527	87	111	84	145
	CIR	2	6110	485	266	3157	641	685	375	2740	10	141	141	87
Sb	TC	19	1227	1999	2054	549	1358	2279	1259	957	111	114	61	174
	CIR	7	1391	1019	1567	435	2201	1298	1281	374	158	127	82	86

Table 2. Average, standard deviation and coefficient of variation for ground-sampled percent stocking by photo-interpreted stratum and type of photography.

Photo-Interp Stratum	Photo Type	# of SUs	Percent Stocking											
			Average				Standard Deviation				Coefficient of Variation			
			AW	PL	SB	SW	AW	PL	SB	SW	AW	PL	SB	SW
Hw	TC	89	83	9	8	62	15	19	17	29	18	221	210	46
	CIR	30	89	20	10	42	10	28	13	32	11	142	124	77
HwSx	TC	150	76	12	11	75	20	20	21	22	27	162	188	29
	CIR	84	85	16	9	73	10	21	18	22	12	128	201	30
SwHw	TC	141	62	10	9	80	21	17	20	18	34	168	223	23
	CIR	58	67	23	5	75	22	25	11	19	33	107	236	25
Sw	TC	145	41	19	9	75	24	24	17	25	60	124	179	33
	CIR	58	45	22	11	74	27	26	19	19	60	115	164	25
HwPl	TC	25	64	58	15	38	20	18	22	28	31	30	153	74
	CIR	31	76	68	10	43	16	23	13	26	21	34	128	62
PlHw	TC	55	54	69	15	33	26	22	23	27	48	32	150	83
	CIR	59	59	75	14	28	31	19	20	26	52	25	139	95
Pl	TC	155	31	76	20	34	22	18	24	30	71	24	121	87
	CIR	76	37	82	19	26	30	18	24	30	82	22	125	114
SbHw	TC	3	45	19	58	14	40	19	34	16	88	99	58	118
	CIR	2	90	19	9	84	8	27	13	1	9	141	141	1
Sb	TC	19	31	46	68	21	26	31	25	26	82	68	37	126
	CIR	7	24	27	58	25	34	25	31	25	140	93	53	101

Table 3. Average, standard deviation and coefficient of variation for proportion (percent) of ground-sampled densities by photo-interpreted stratum and type of photography.

Photo-Interp Stratum	Photo Type	# of SUs	Percent Density (Species Density / Total Density)											
			Average				Standard Deviation				Coefficient of Variation			
			AW	PL	SB	SW	AW	PL	SB	SW	AW	PL	SB	SW
Hw	TC	89	77	3	4	16	17	9	10	12	22	277	258	73
	CIR	30	80	7	2	10	14	12	4	11	18	182	162	109
HwSx	TC	150	68	4	5	23	19	9	11	15	28	209	249	64
	CIR	84	71	5	3	22	15	8	6	13	22	163	251	58
SwHw	TC	141	59	5	4	32	18	9	12	17	31	189	270	52
	CIR	58	57	10	1	31	18	14	3	15	32	135	242	49
Sw	TC	145	39	12	6	43	23	17	11	22	59	147	201	50
	CIR	58	39	15	5	41	24	21	9	23	62	143	167	56
HwPl	TC	25	55	28	6	11	17	19	10	11	32	66	153	101
	CIR	31	53	28	2	16	15	17	4	14	28	60	168	87
PlHw	TC	55	41	42	6	11	23	23	12	14	55	56	179	127
	CIR	59	41	43	4	11	23	24	8	15	57	57	174	128
Pl	TC	155	21	54	9	15	18	22	13	17	86	40	135	112
	CIR	76	23	56	7	14	22	26	10	19	95	47	141	134
SbHw	TC	3	33	19	45	4	30	27	5	5	91	146	11	136
	CIR	2	66	4	2	28	23	5	3	15	35	141	141	53
Sb	TC	19	18	30	40	12	19	23	22	16	108	78	56	134
	CIR	7	21	20	42	17	31	21	23	18	143	108	55	107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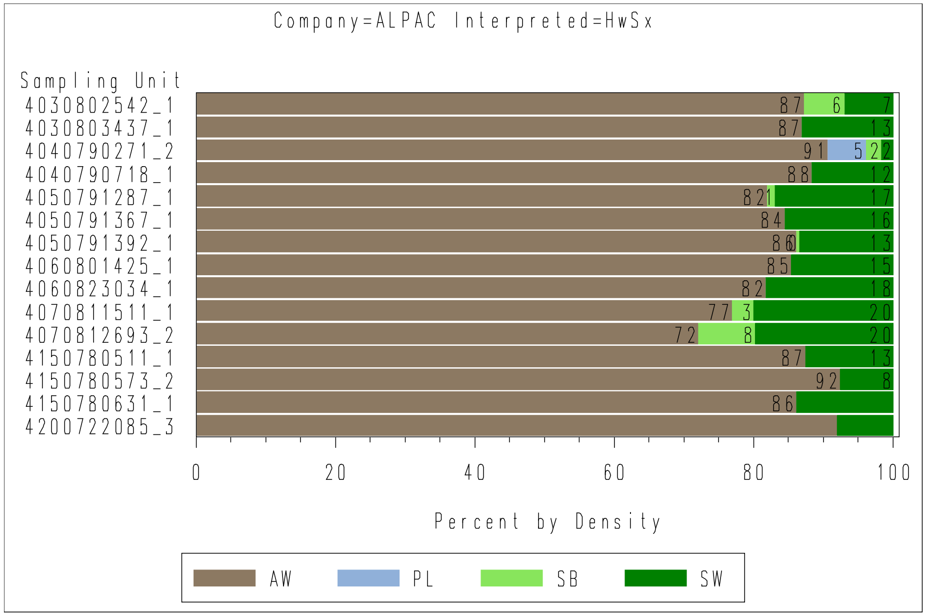
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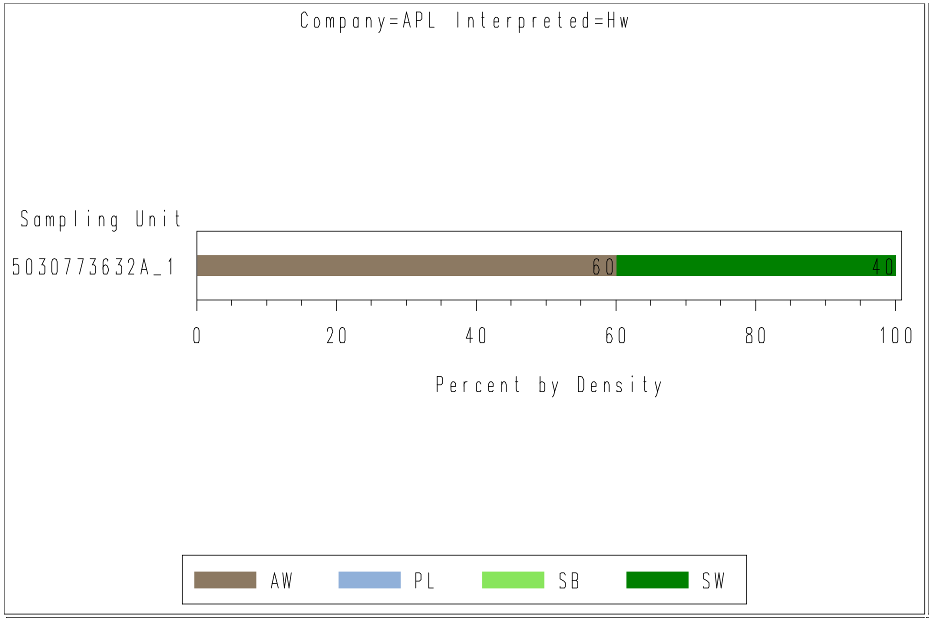
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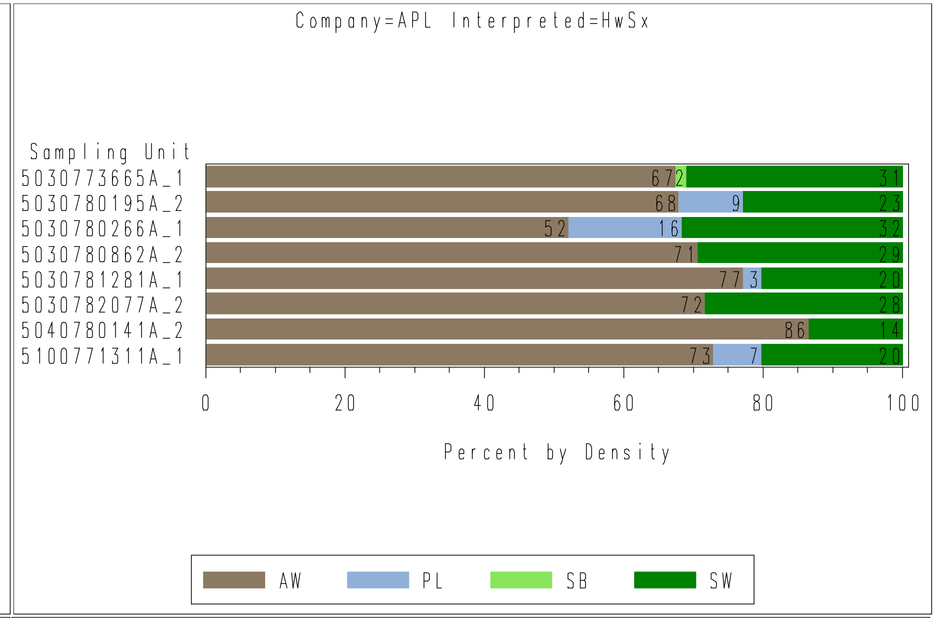
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68 9 23
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72 28
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AW
PL
SB
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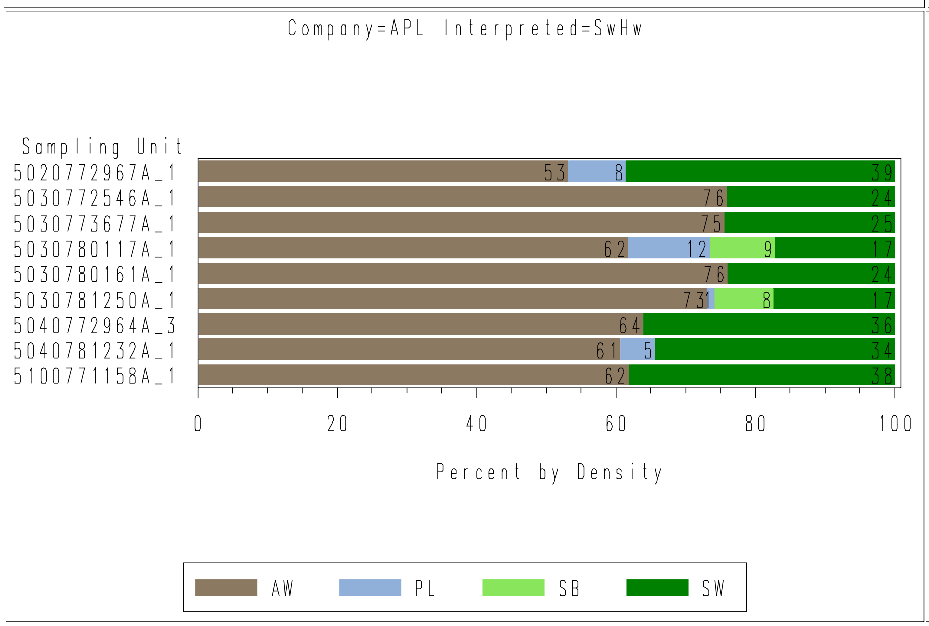
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76 24
75 25
62 12 9 17
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Percent by Density
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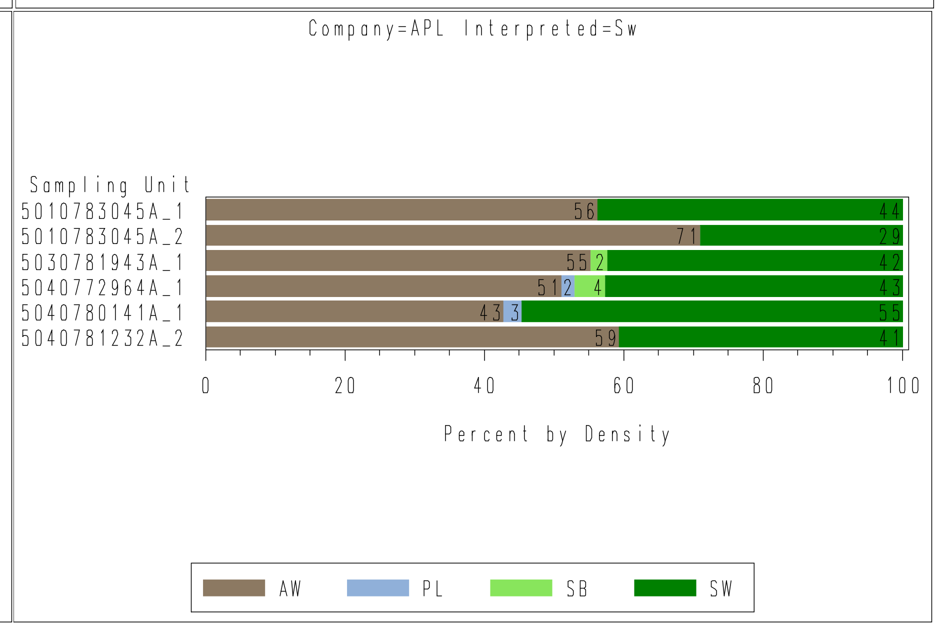
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56 44
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43 3 55
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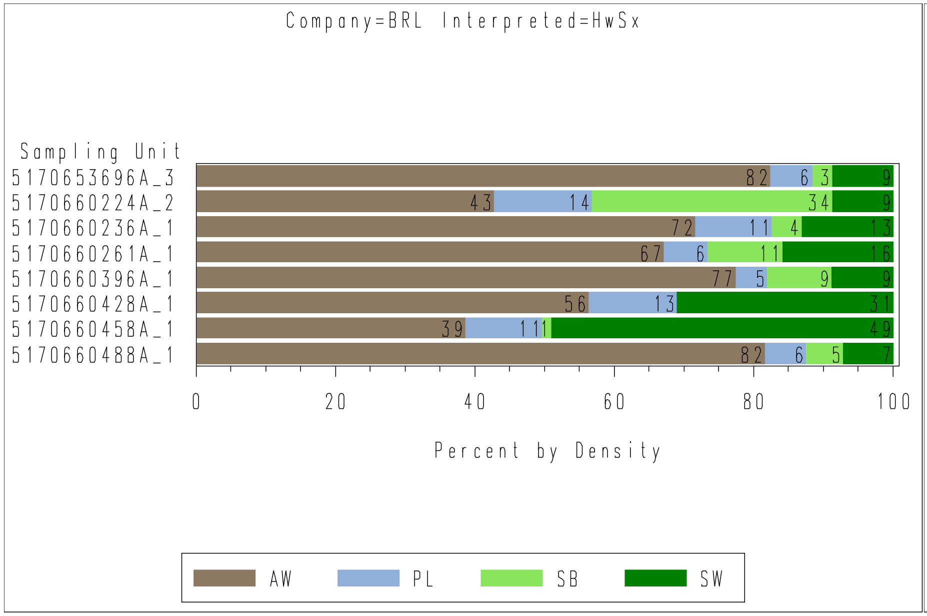
Percent by Density
AW
PL
SB
SW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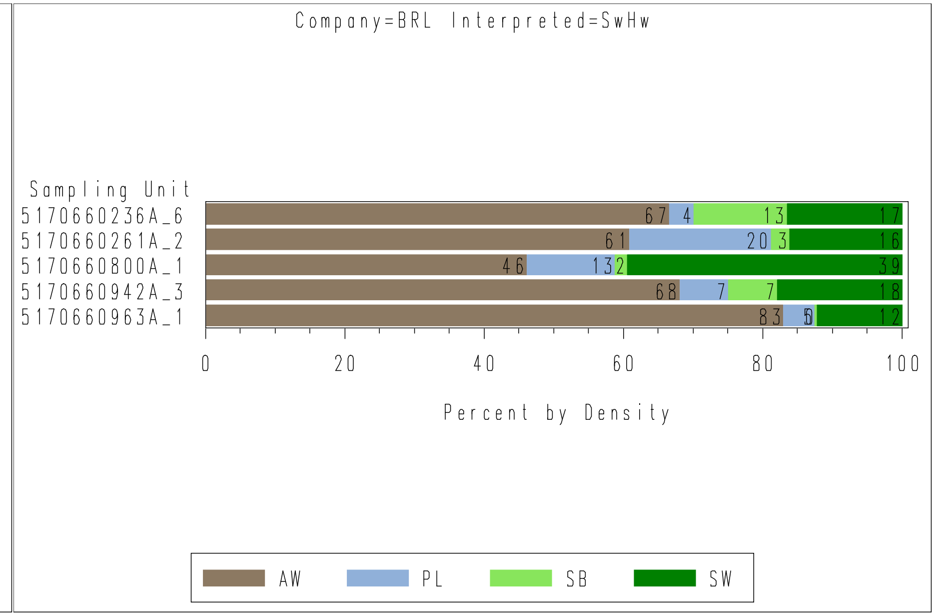
Percent by Density
AW PL SB SW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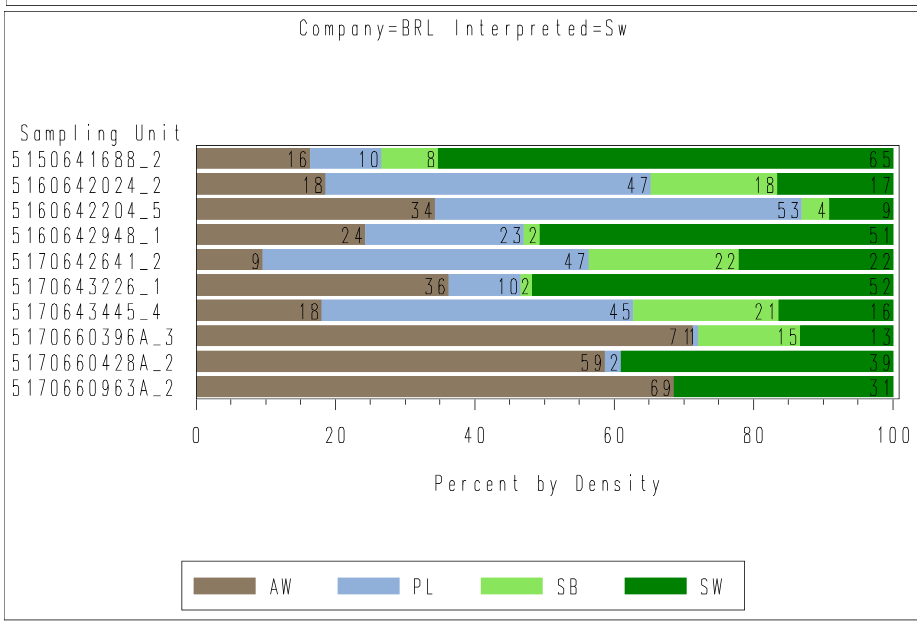
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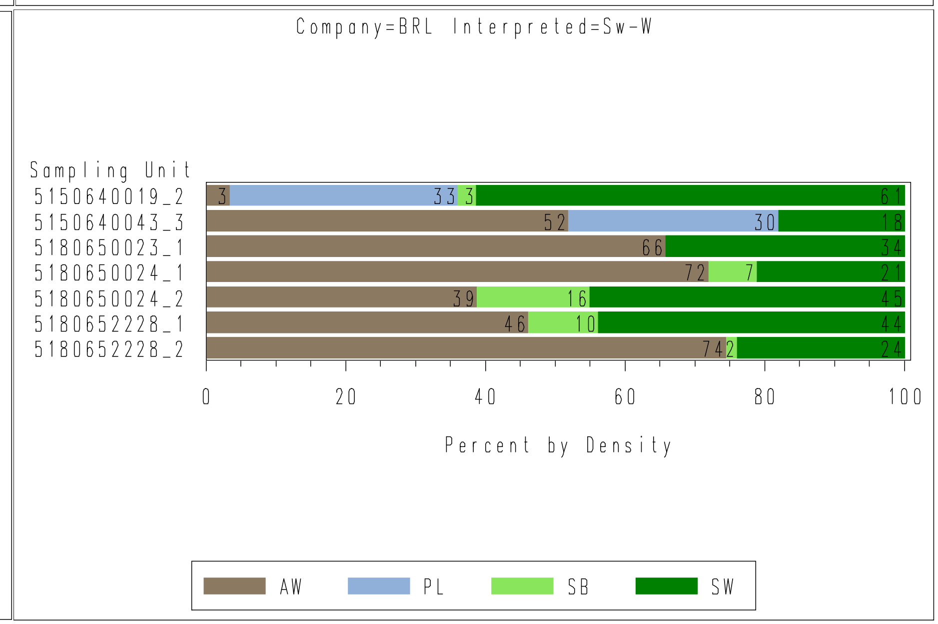
Percent by Density
AW PL SB SW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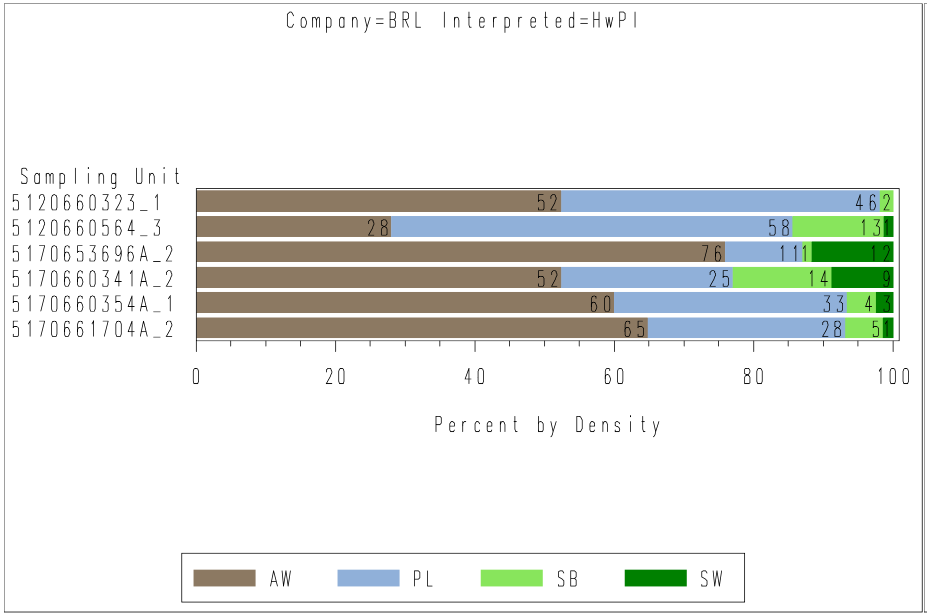
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Percent by Density
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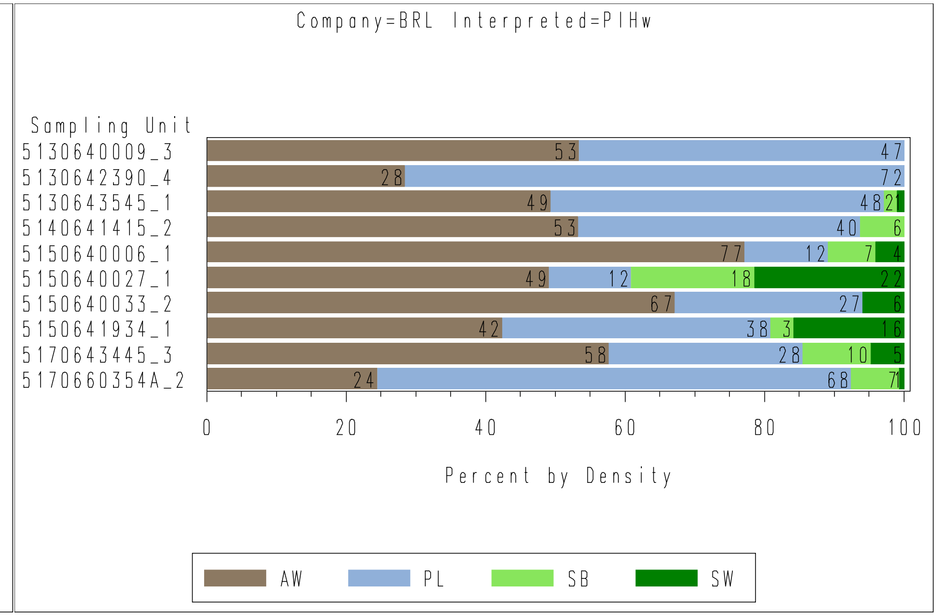
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Percent by Density
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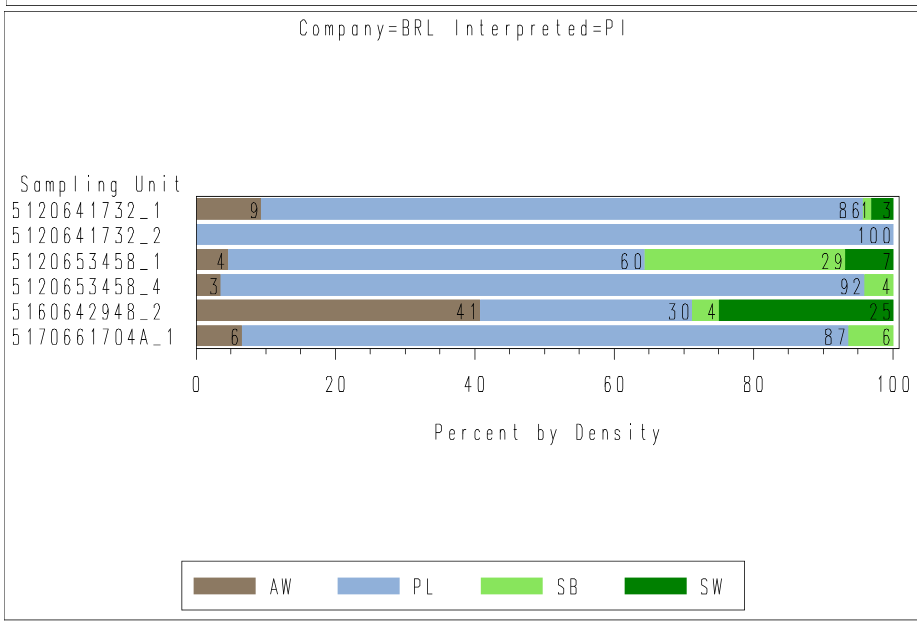
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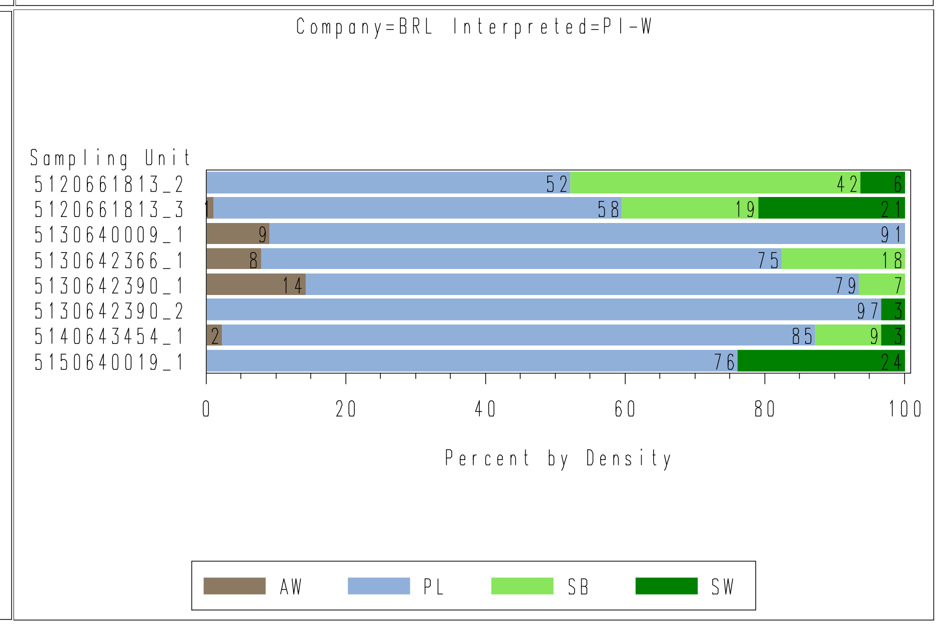
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Percent by Density
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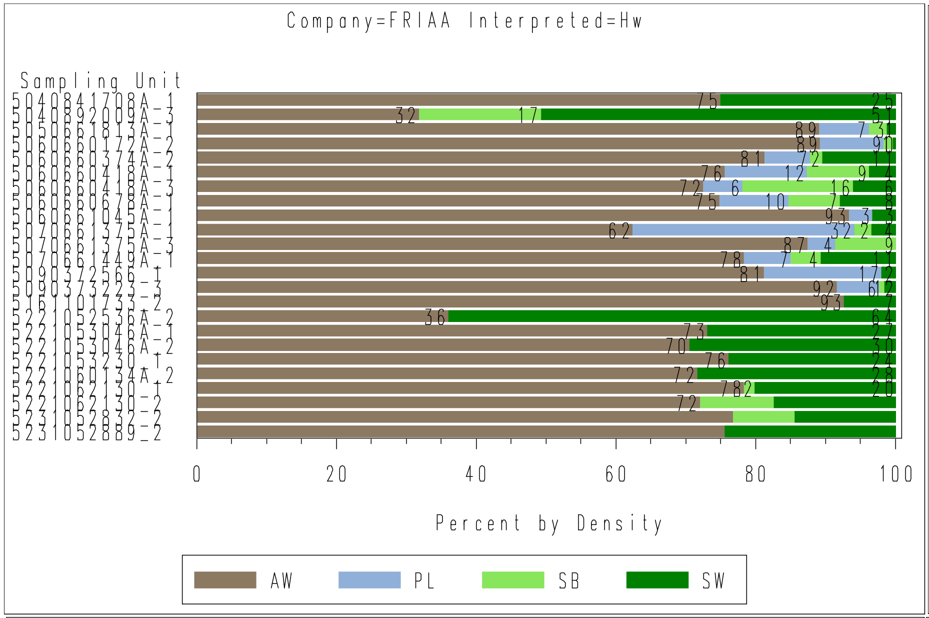
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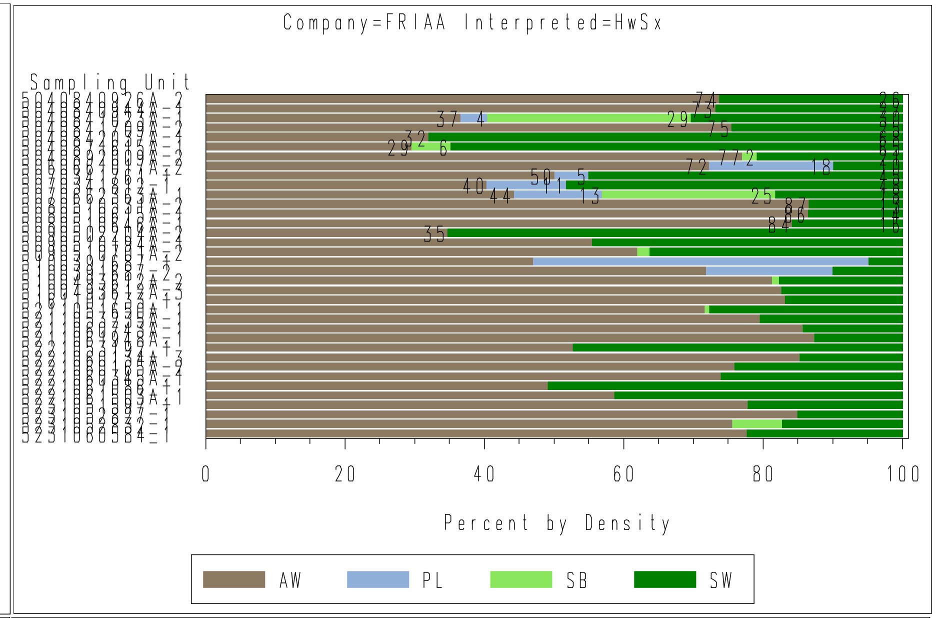
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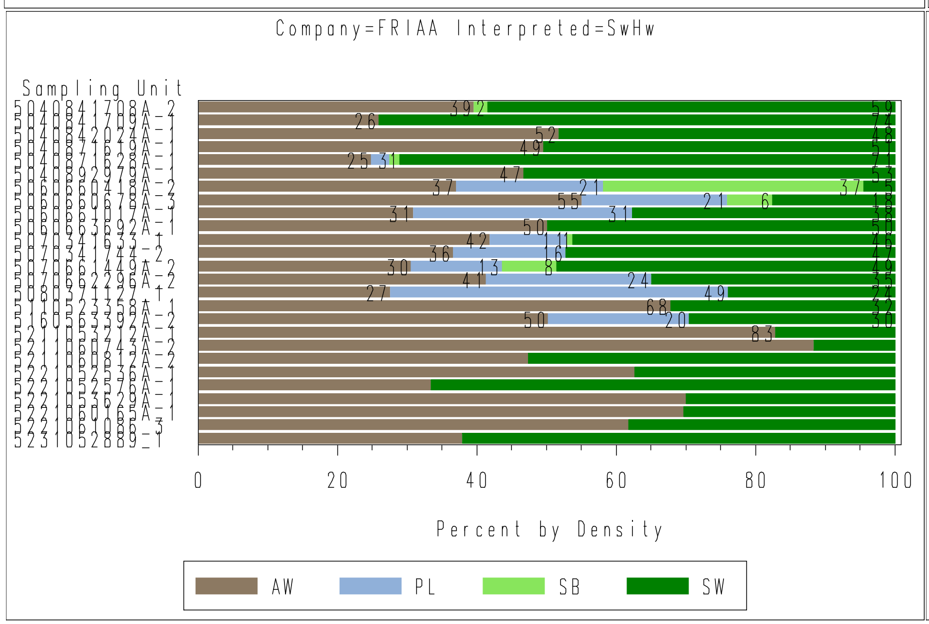
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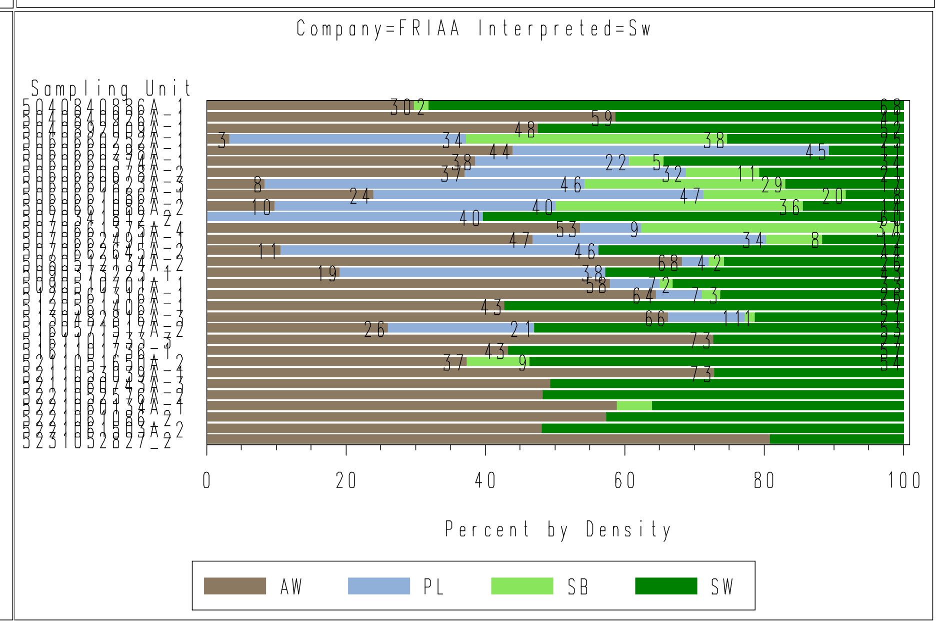
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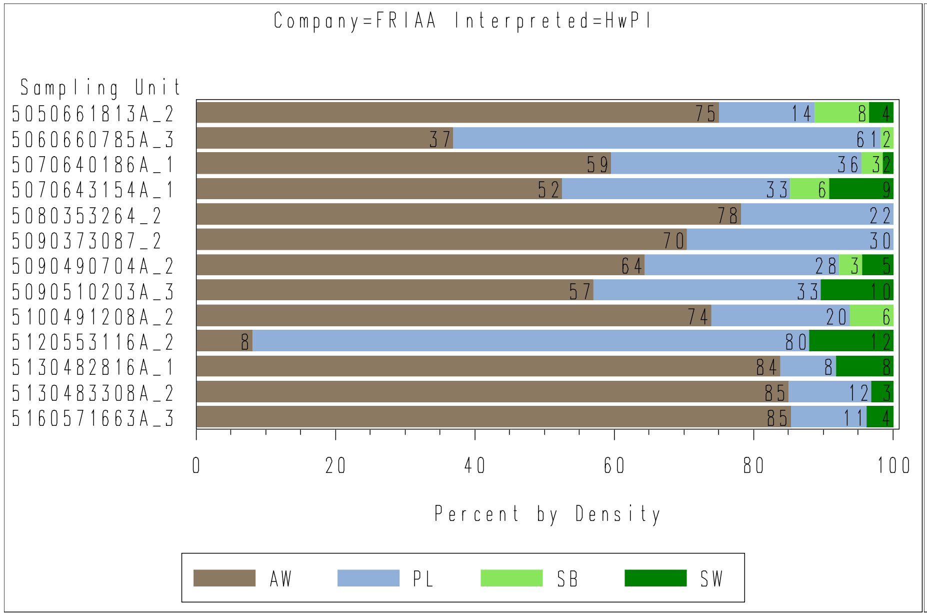
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Percent by Density
AW
PL
SB
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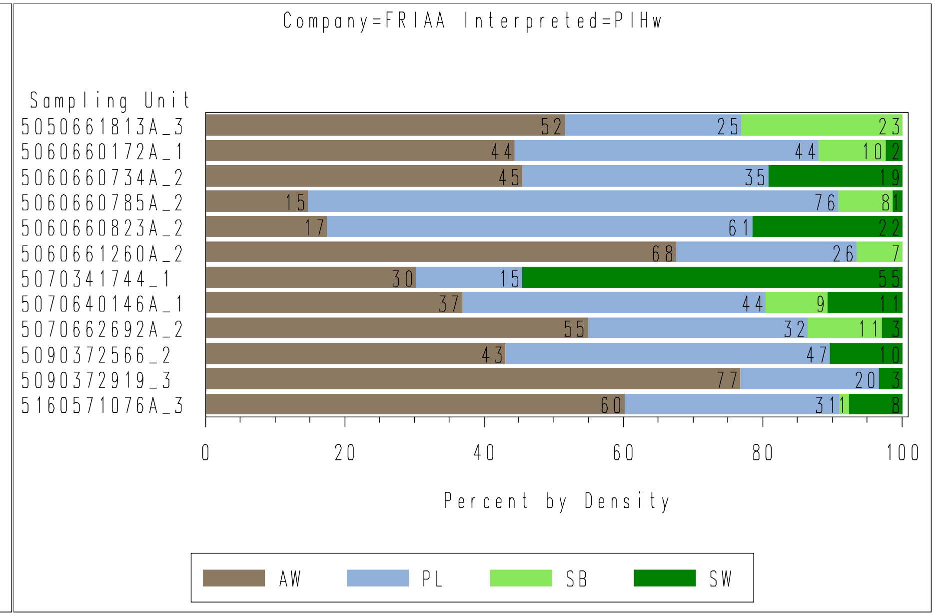
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Percent by Density
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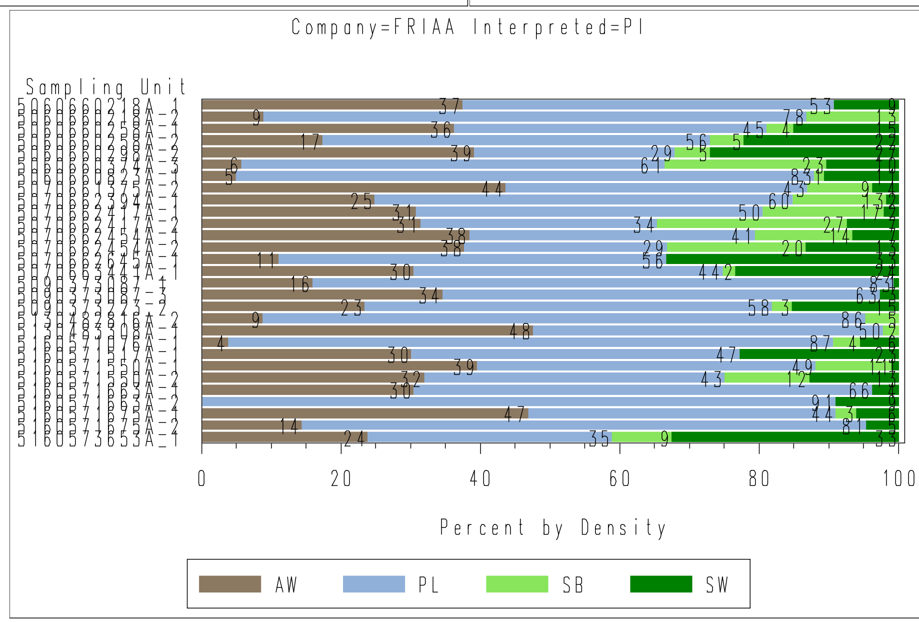
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Percent by Density
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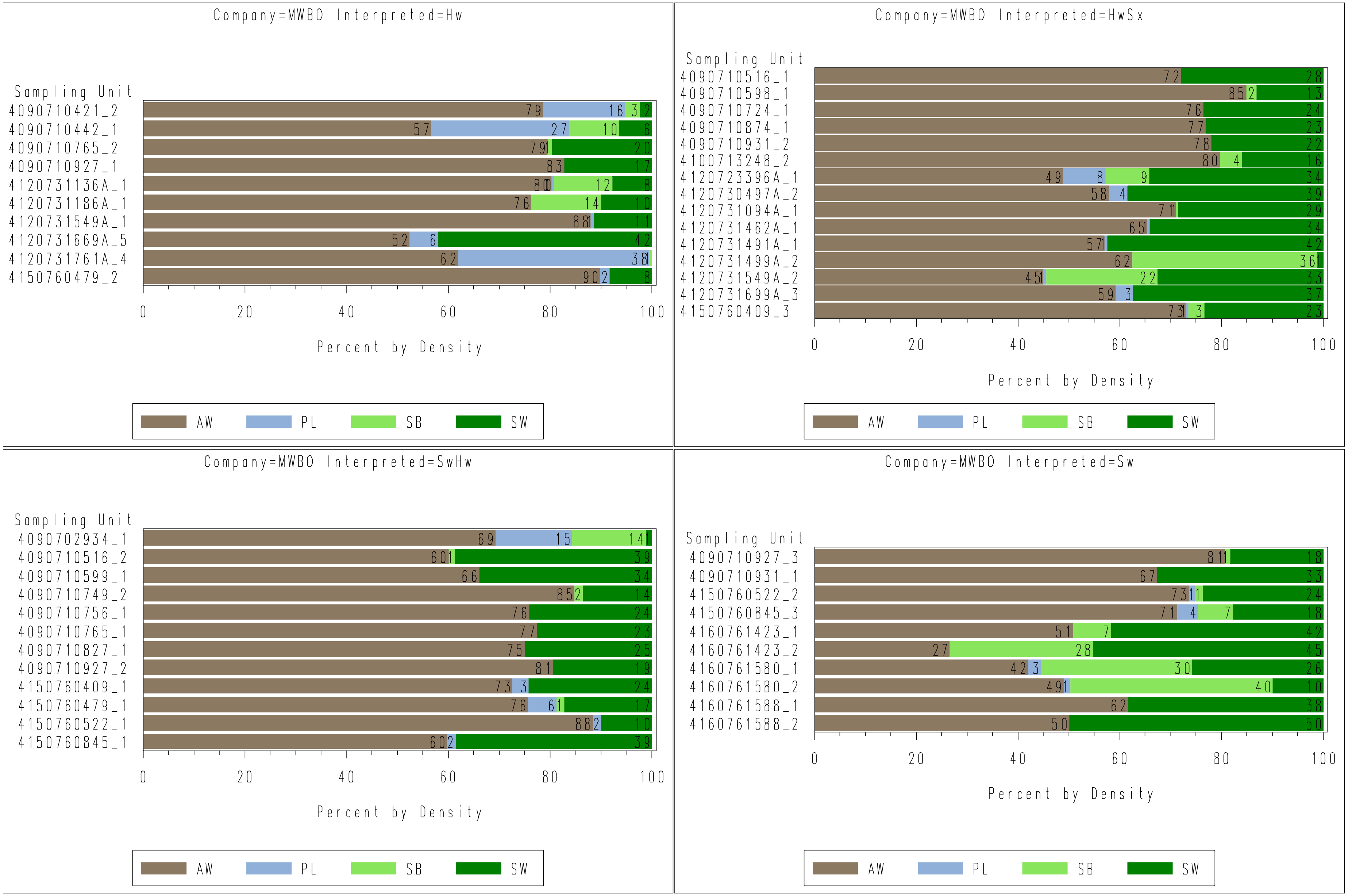
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Company=MWBO Interpreted=HwSx
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Sampling Unit
Percent by Density
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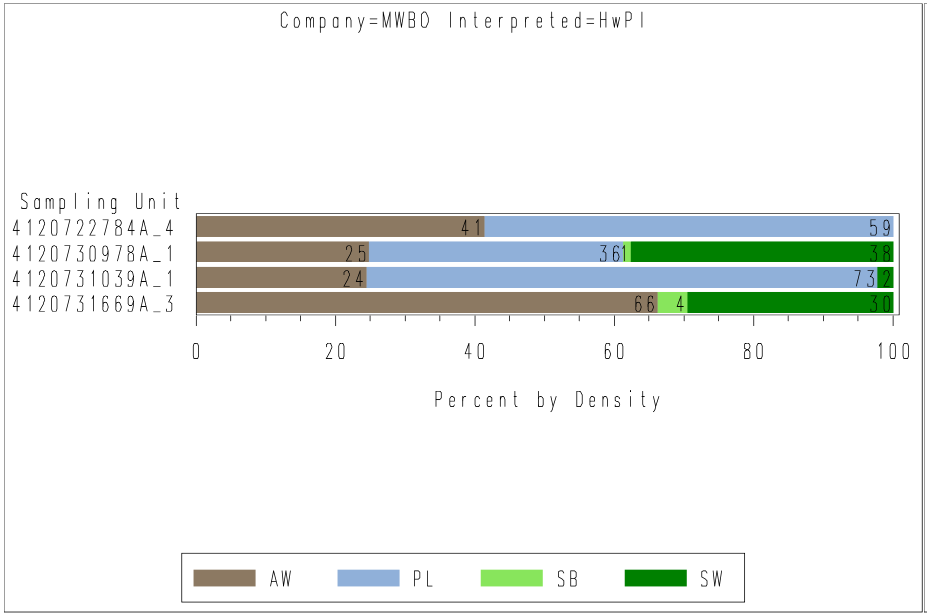
PL
SB
SW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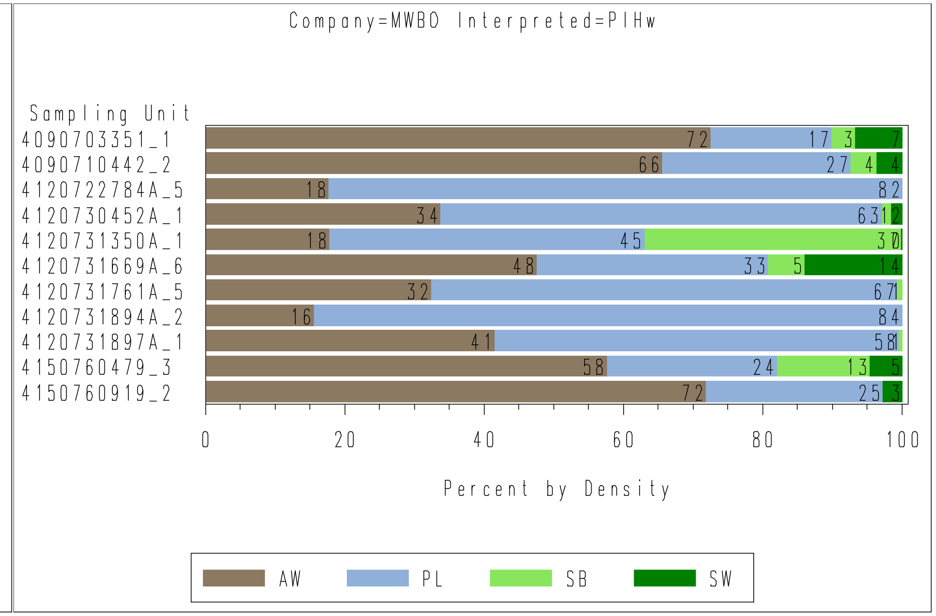
Percent by Density
AW
PL
SB
SW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82
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32
67
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84
41
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Percent by Density
AW
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SB
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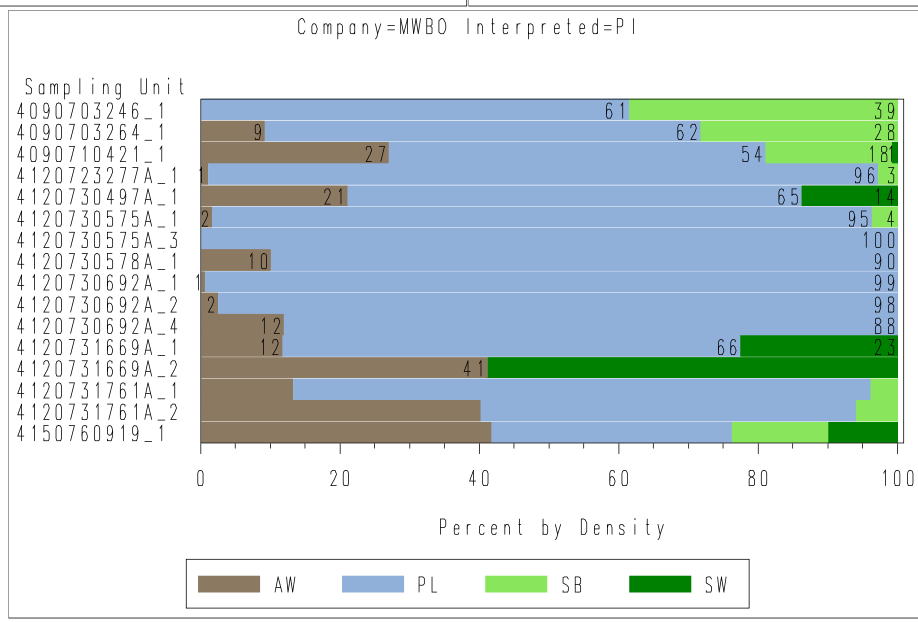
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Percent by Density
AW
PL
SB
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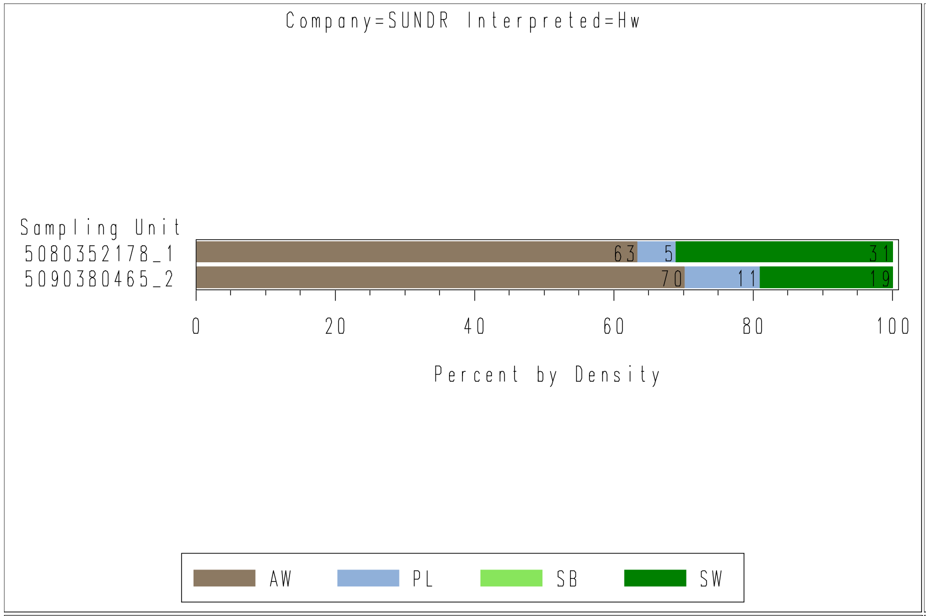
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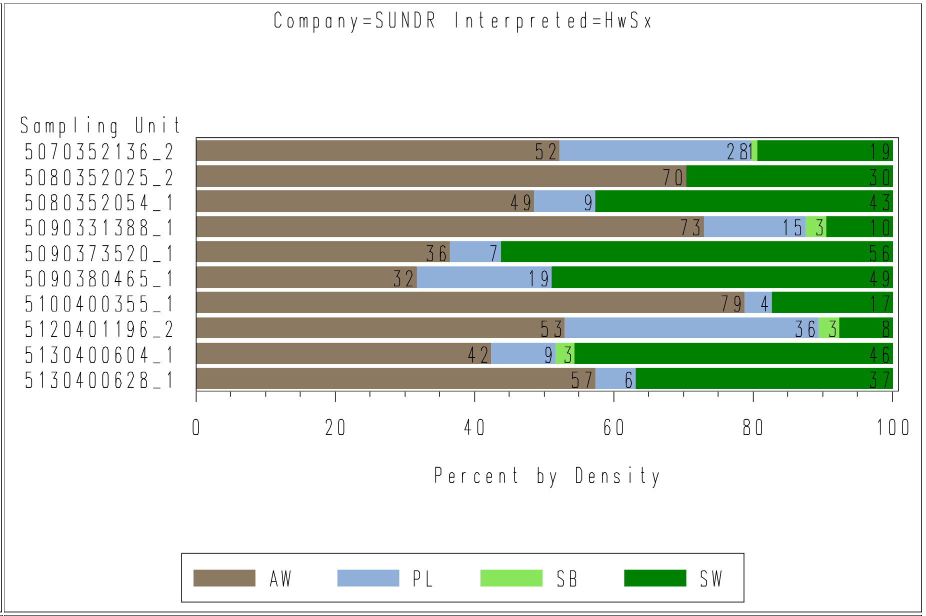
Percent by Density
AW PL SB SW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70 30
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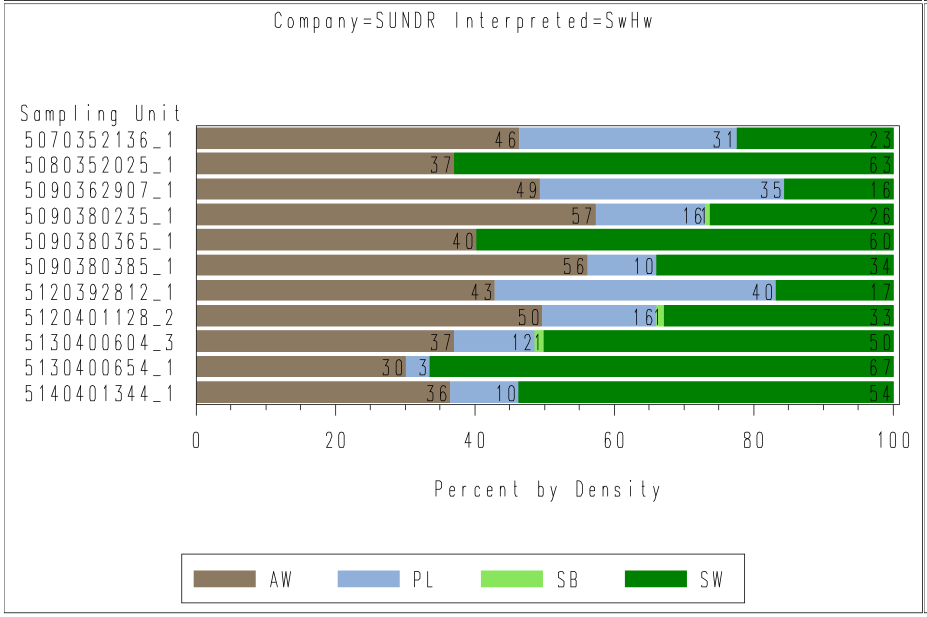
Percent by Density
AW PL SB SW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37 63
49 35 16
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Percent by Density
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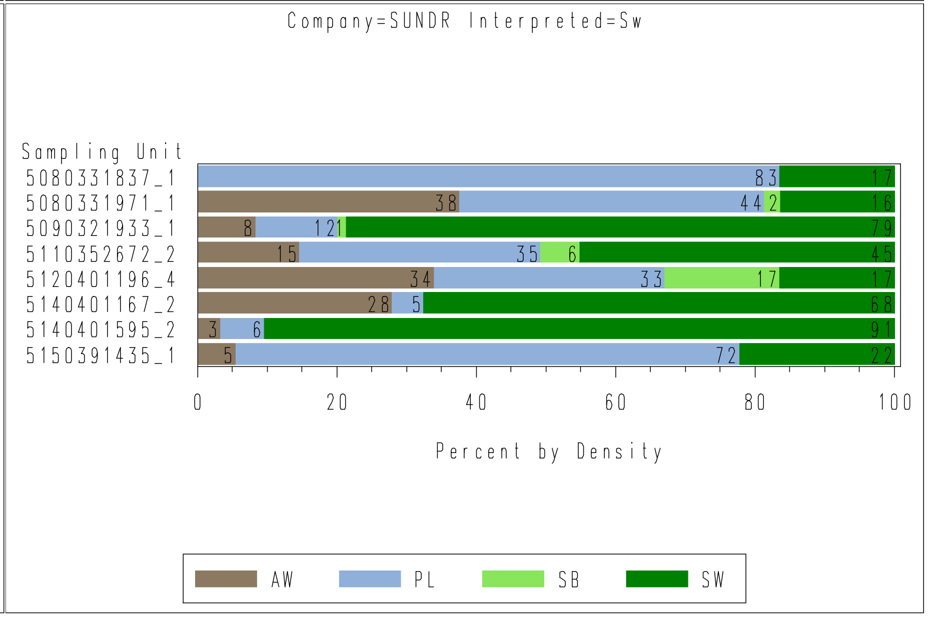
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Percent by Density
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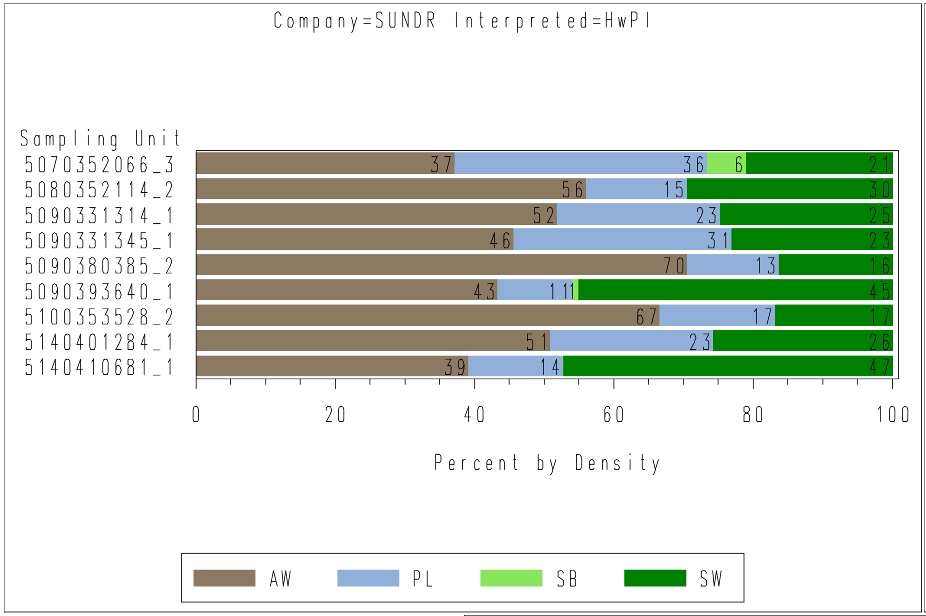

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Percent by Density
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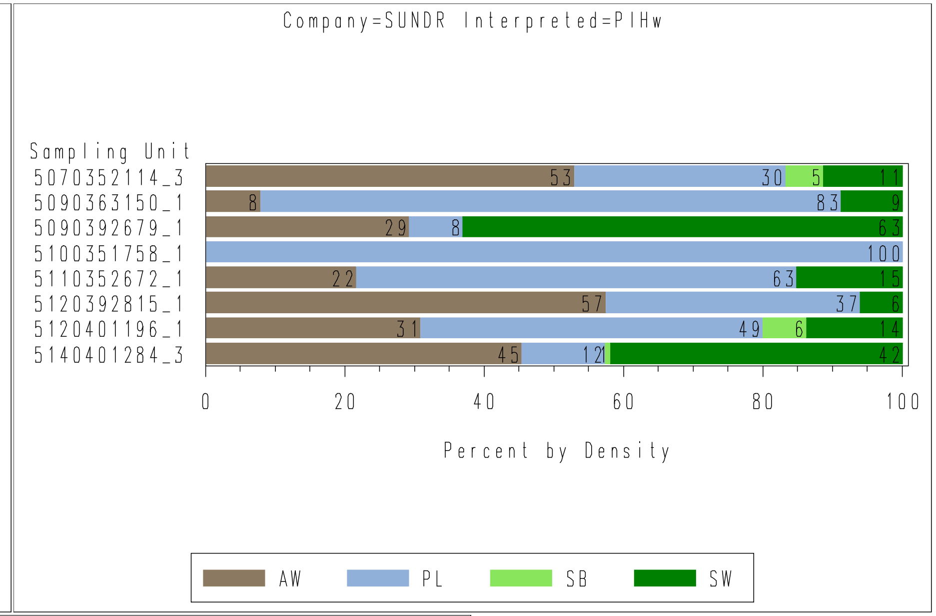

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Percent by Density
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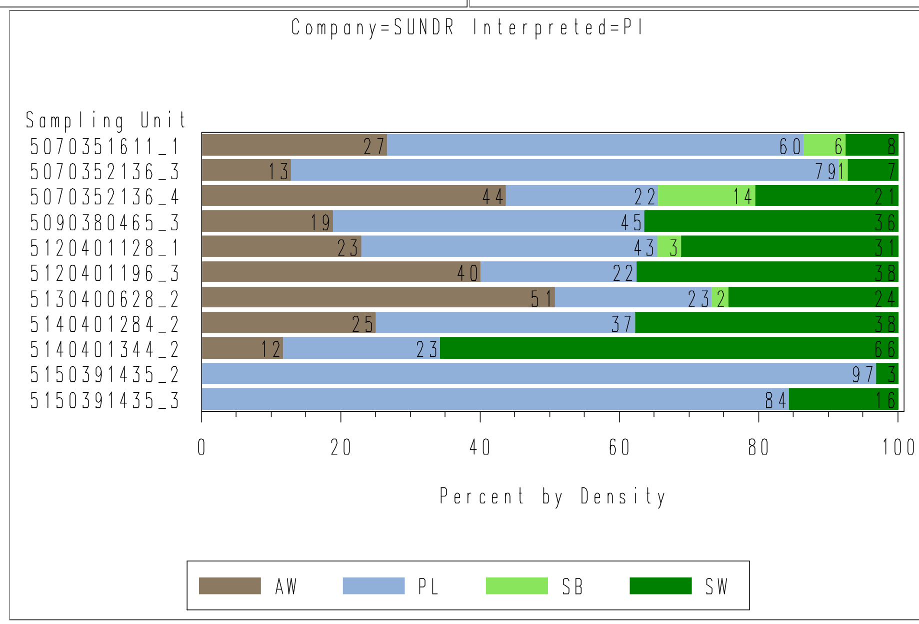

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Percent by Density
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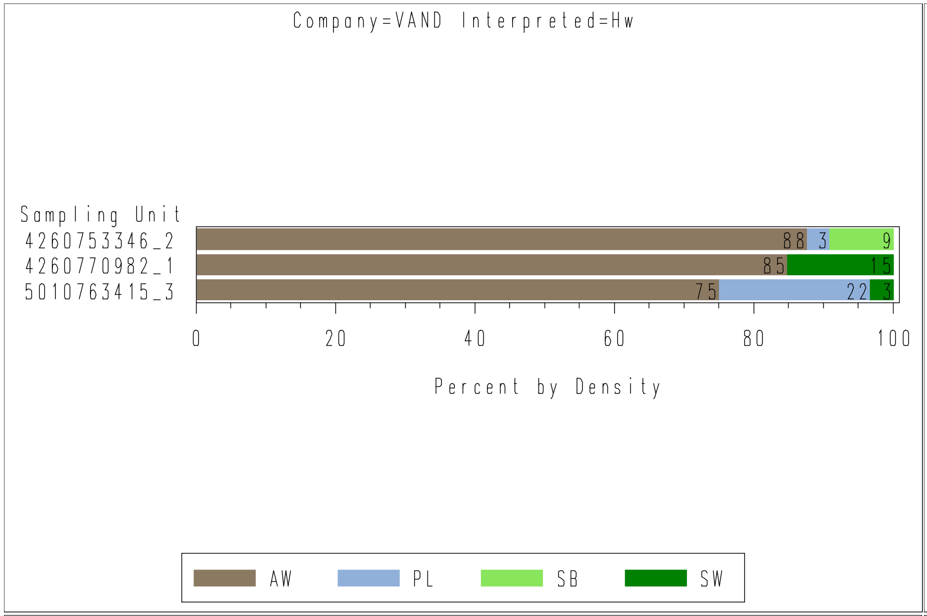
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Percent by Density
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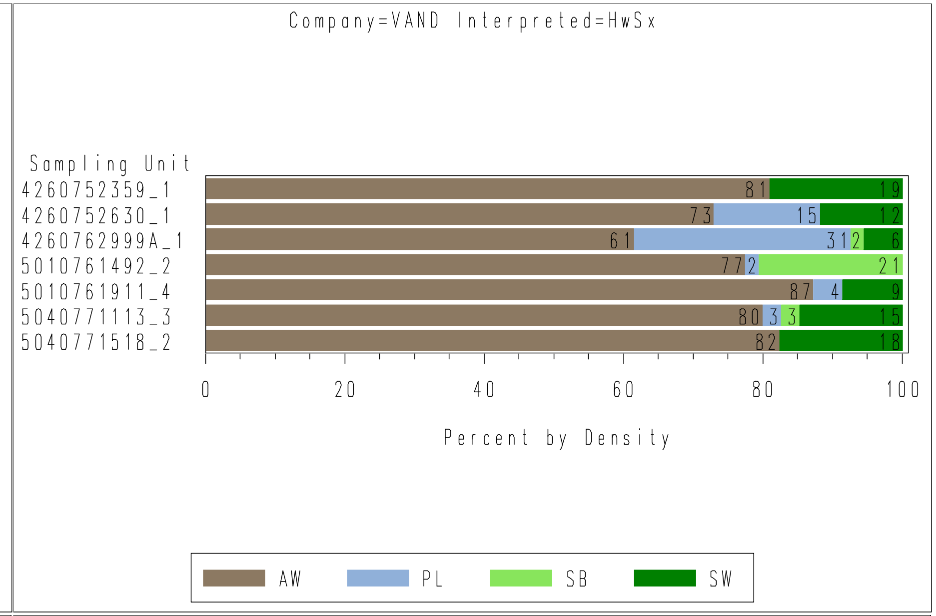
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Percent by Density
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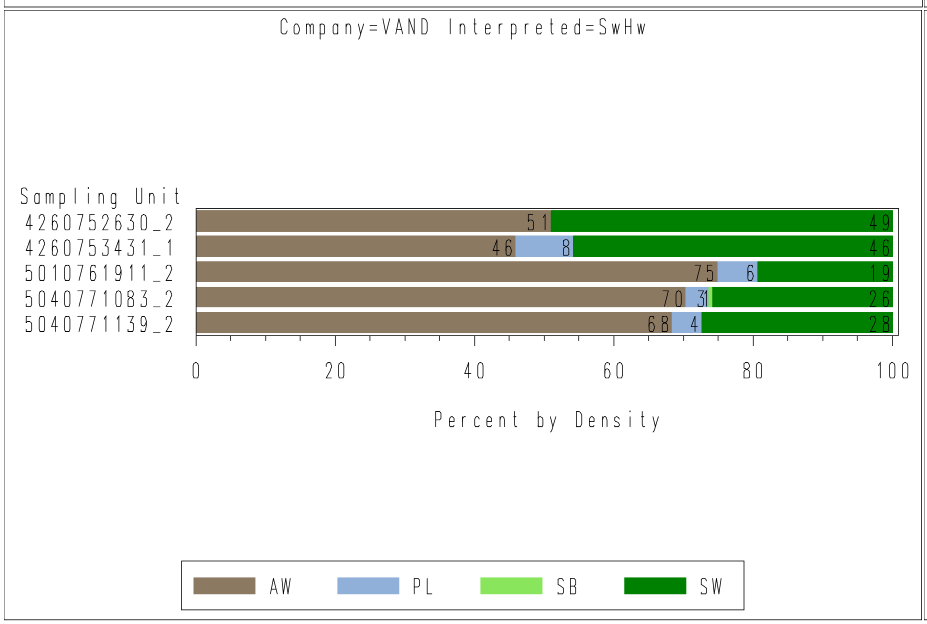
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Percent by Density
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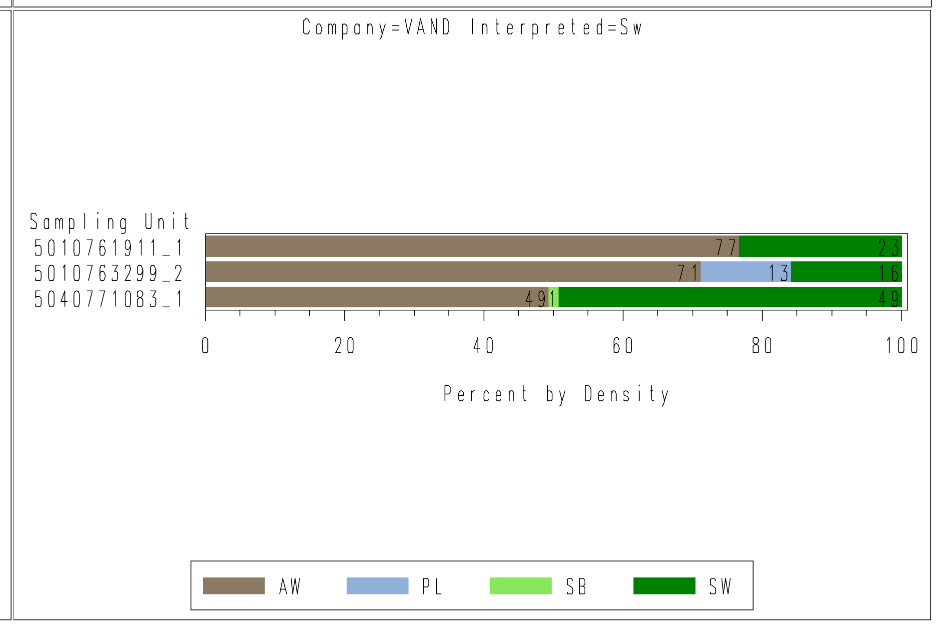
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Percent by Density
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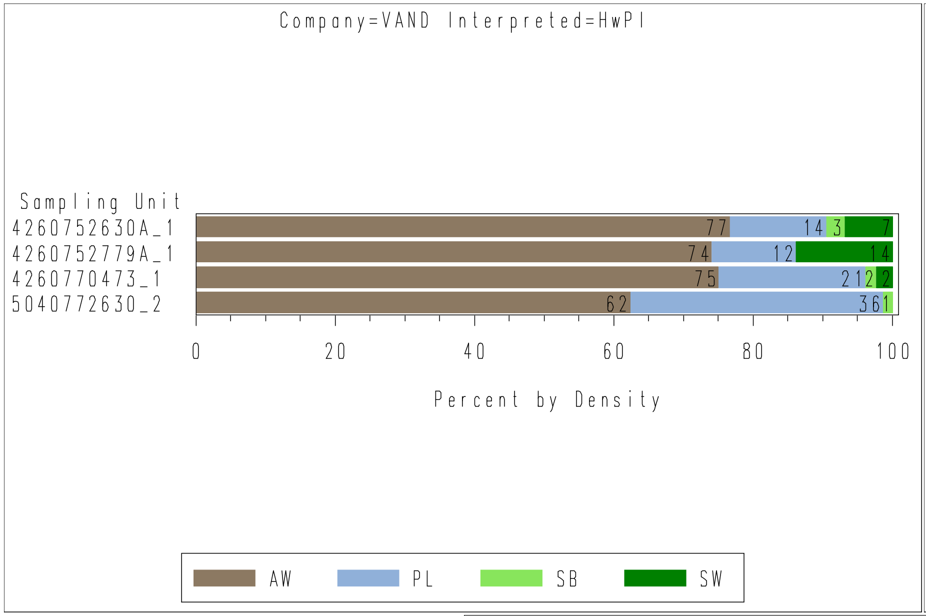
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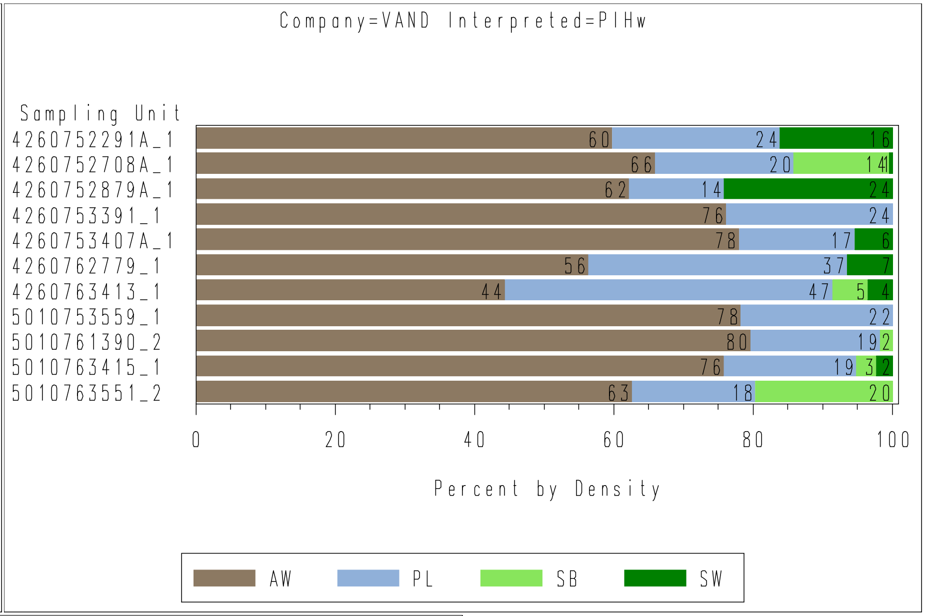
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Percent by Density
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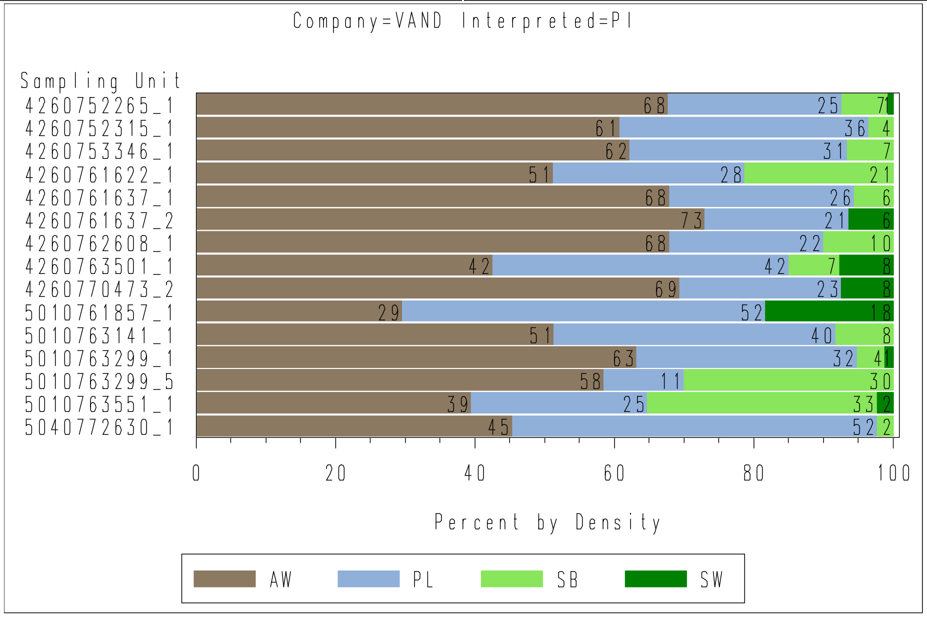
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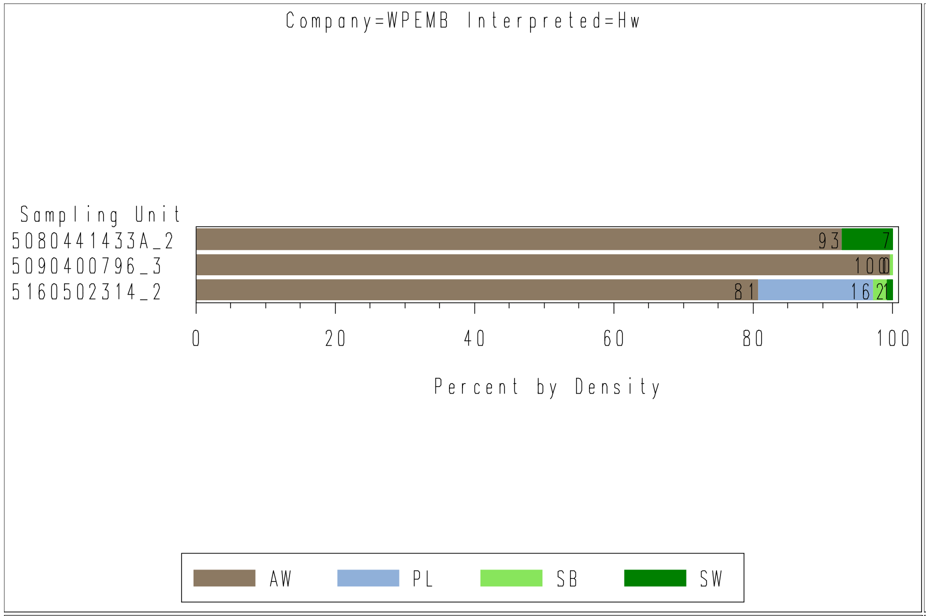
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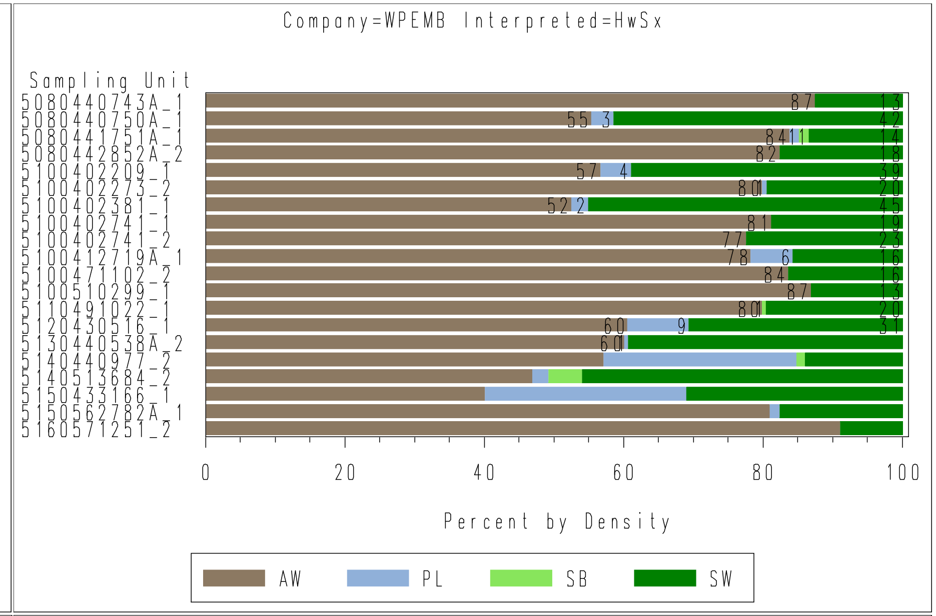
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Percent by Density
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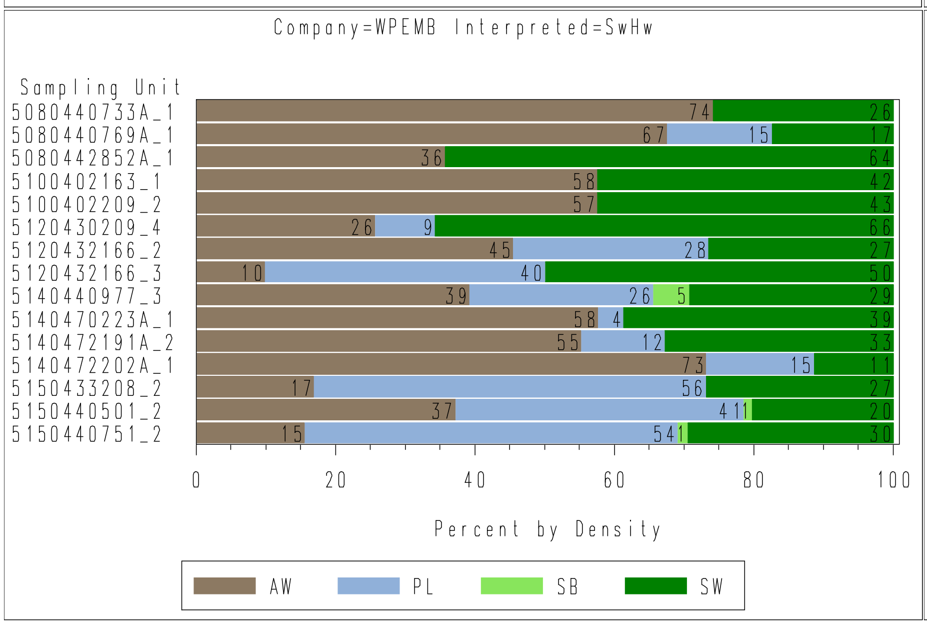
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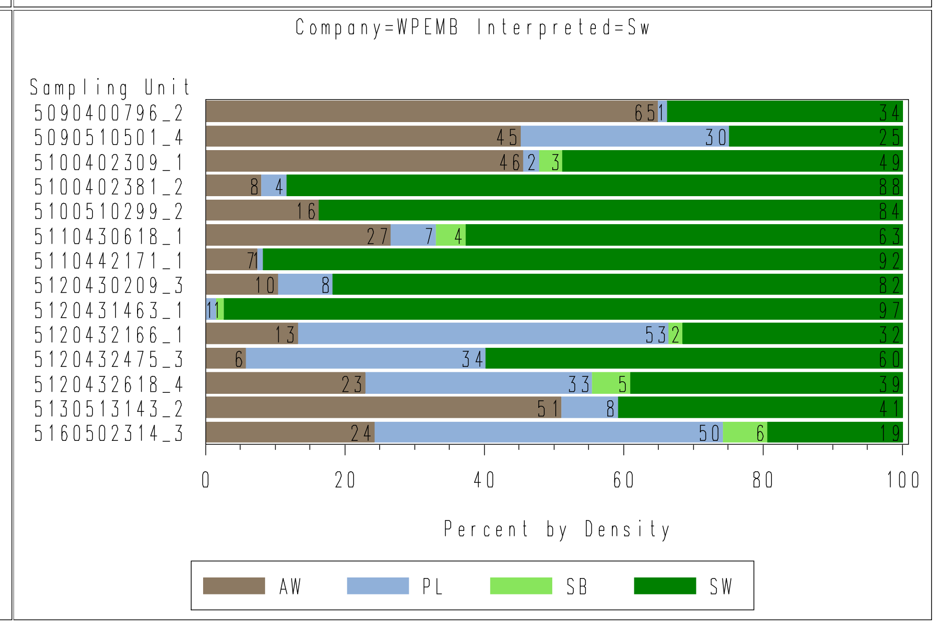
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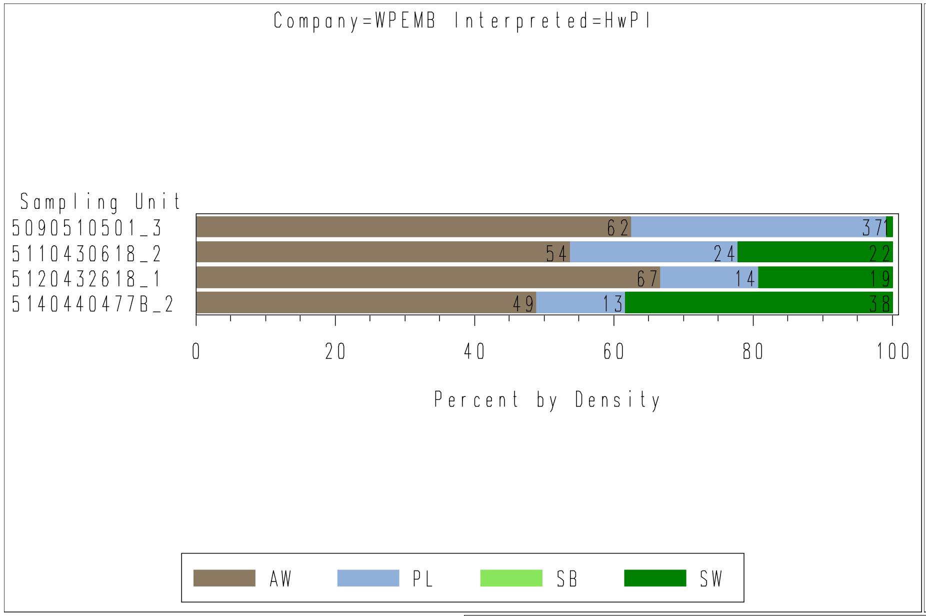
Percent by Density
AW PL SB SW



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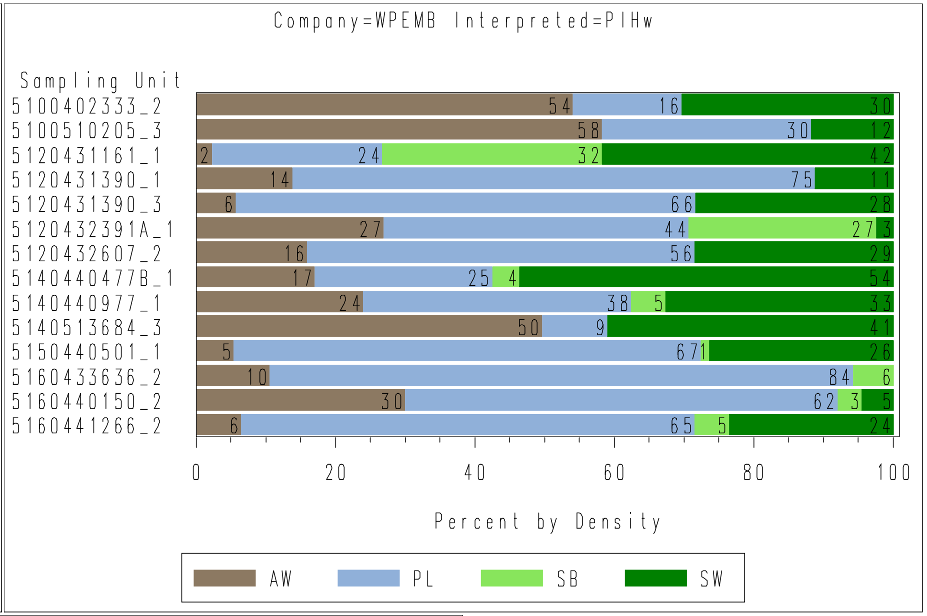

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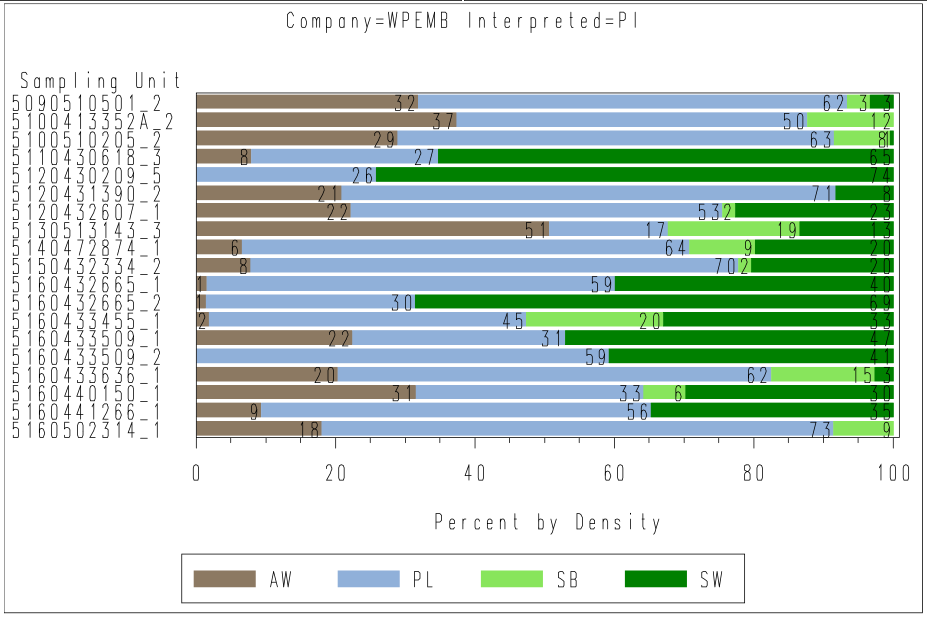
AW
PL
SB
SW



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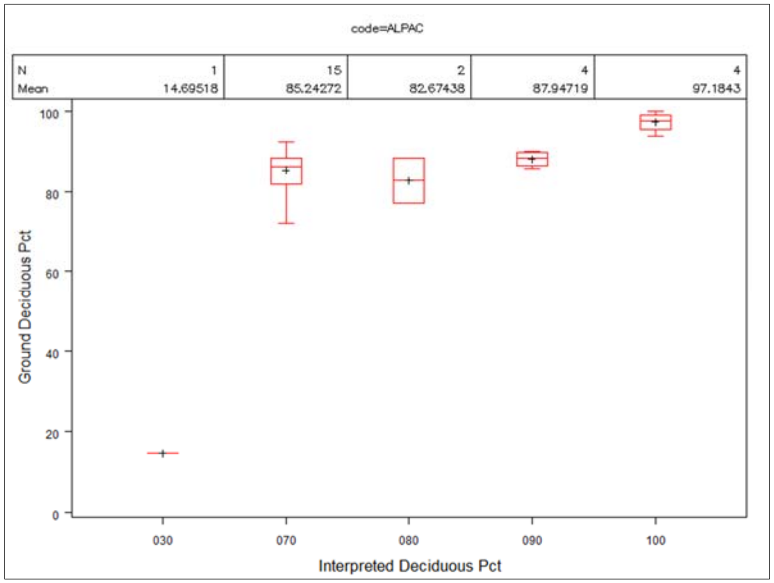
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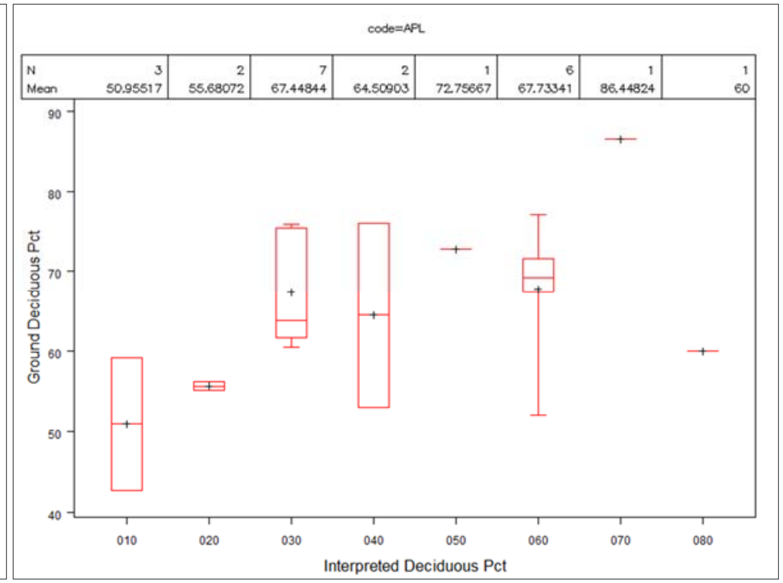
Interpreted Deciduous Pct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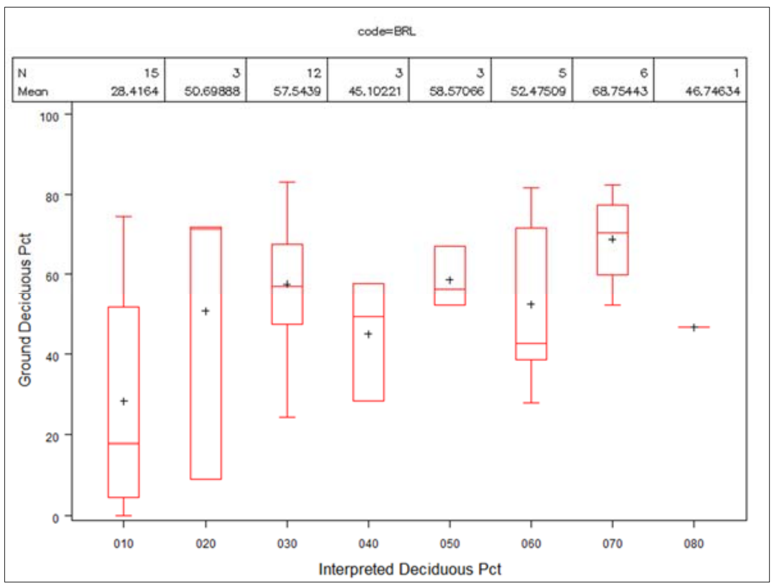
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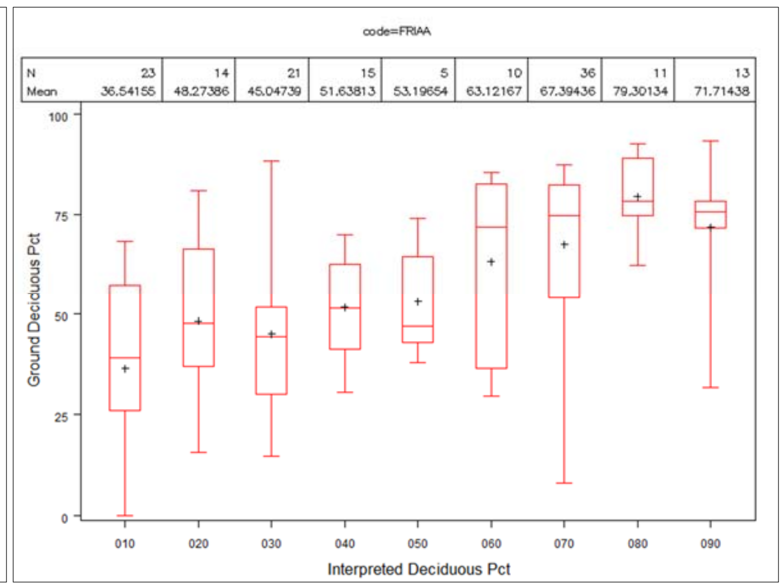
Interpreted Deciduous Pct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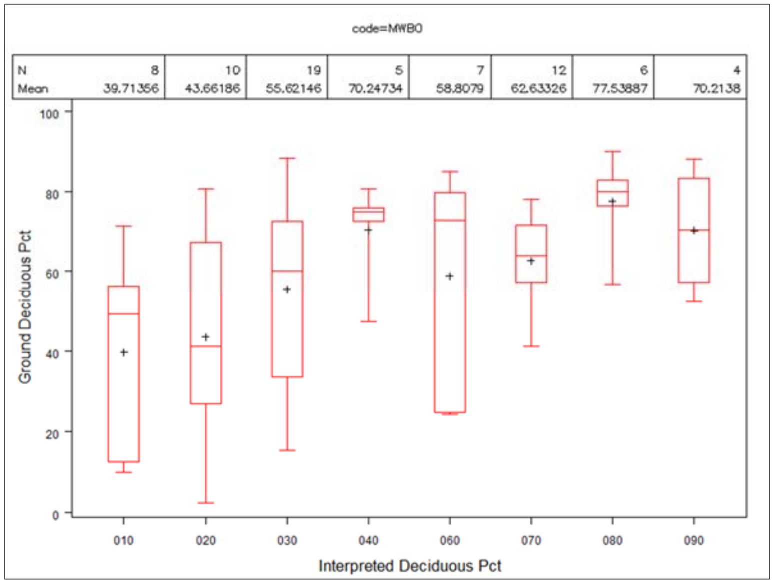
Interpreted Deciduous Pct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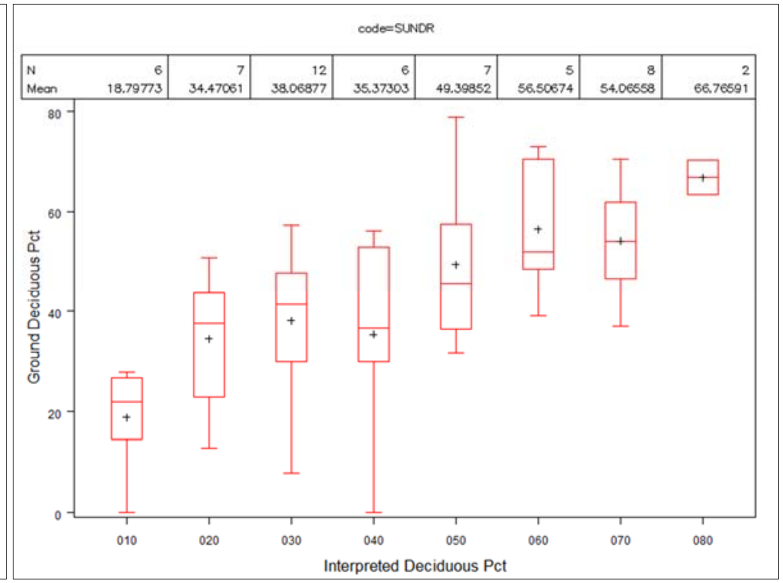
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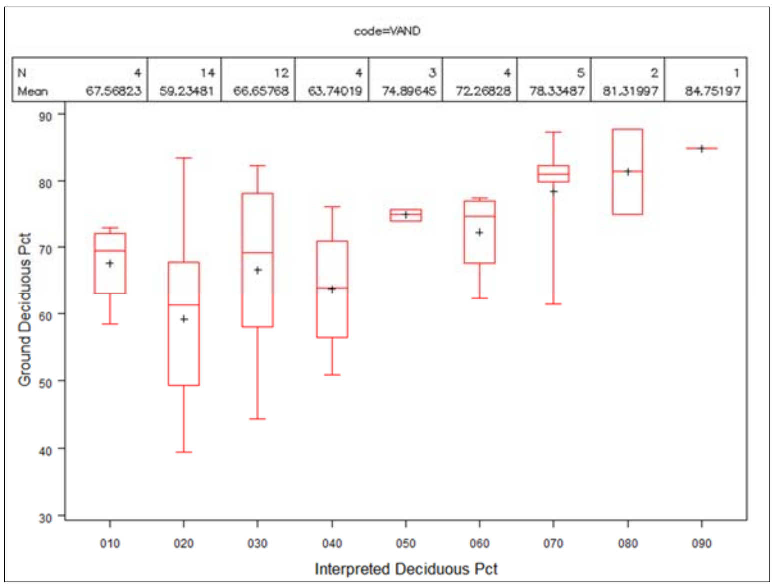
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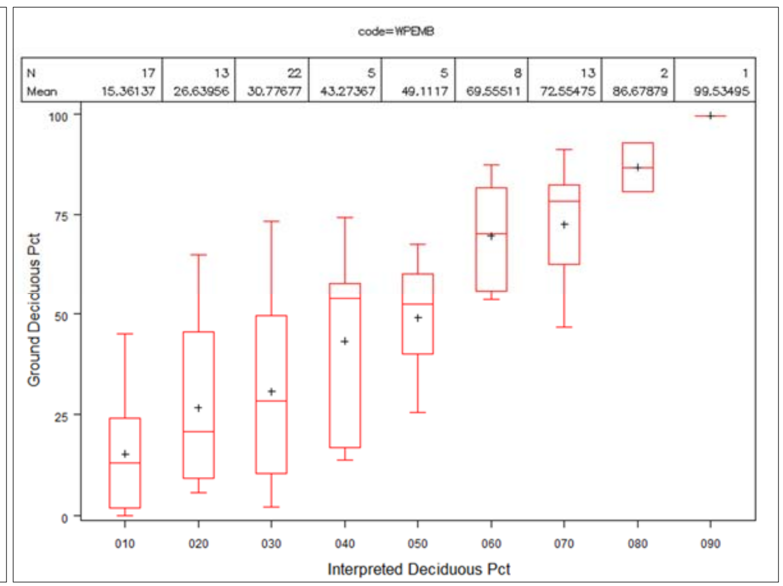
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Ground Deciduous Pct
Interpreted Deciduous Pct
010 020 030 040 050 060 070 080 090

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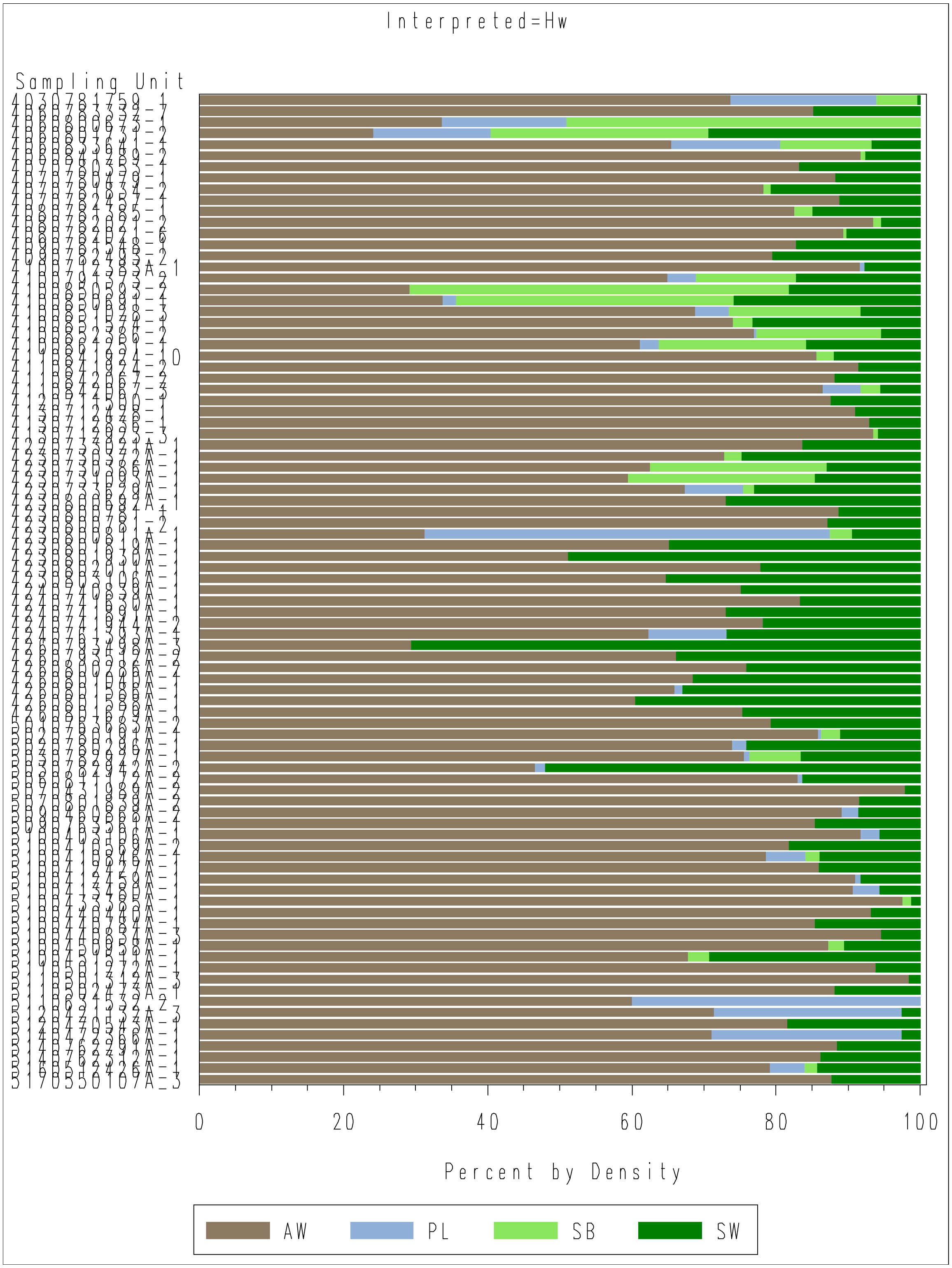
Proportion of Ground Density by Species Group and Interpreted Stratum

True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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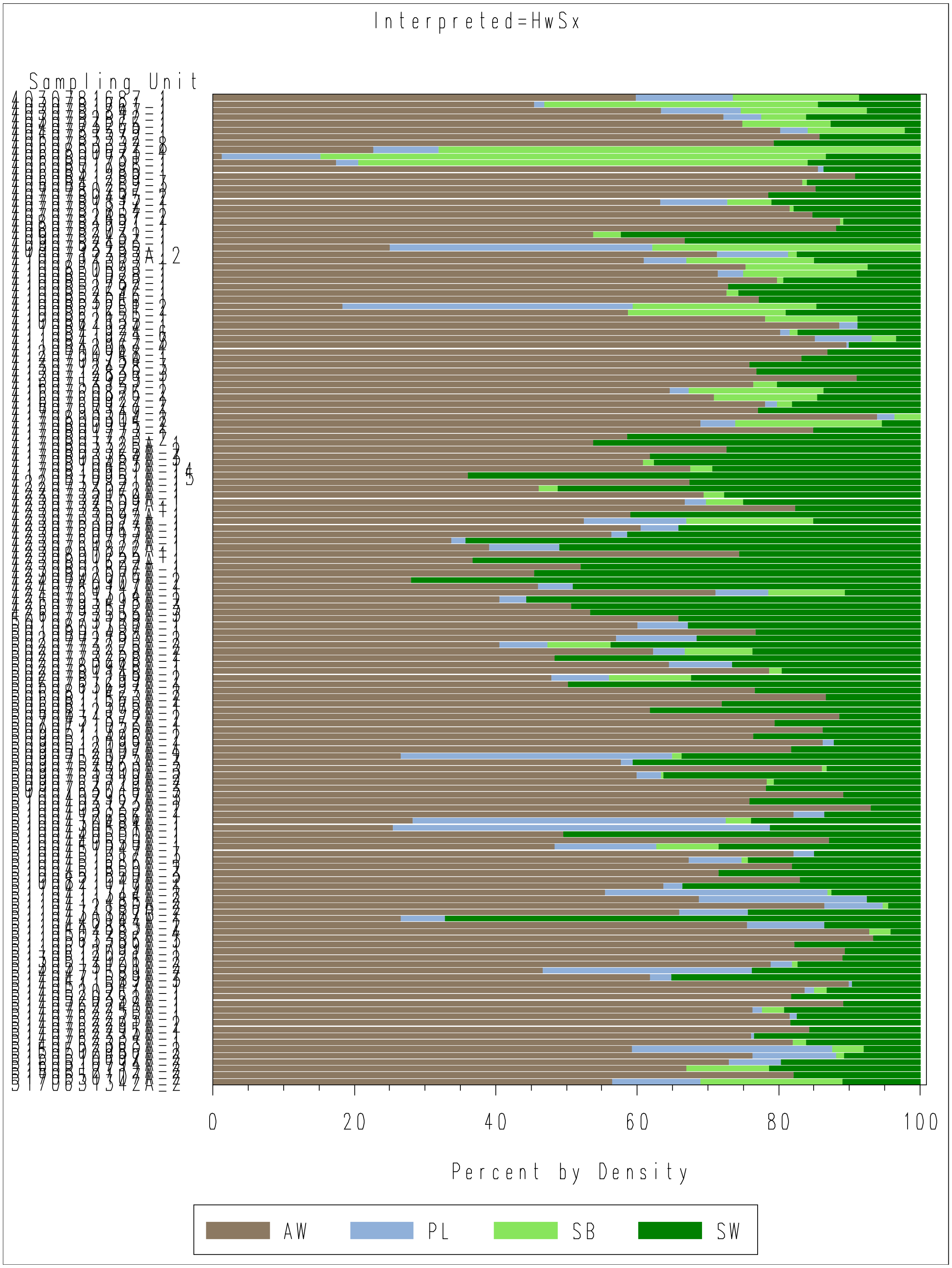
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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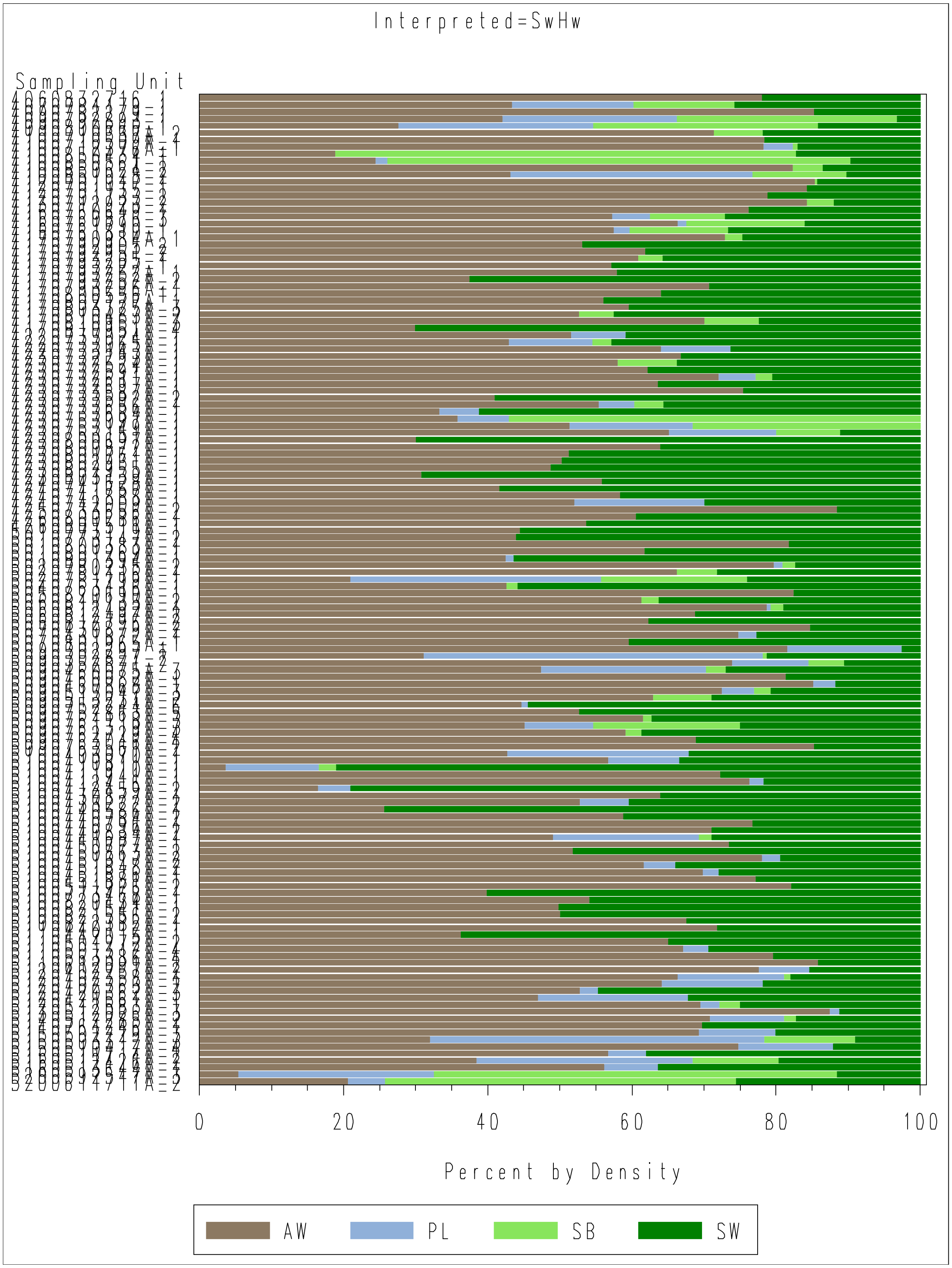
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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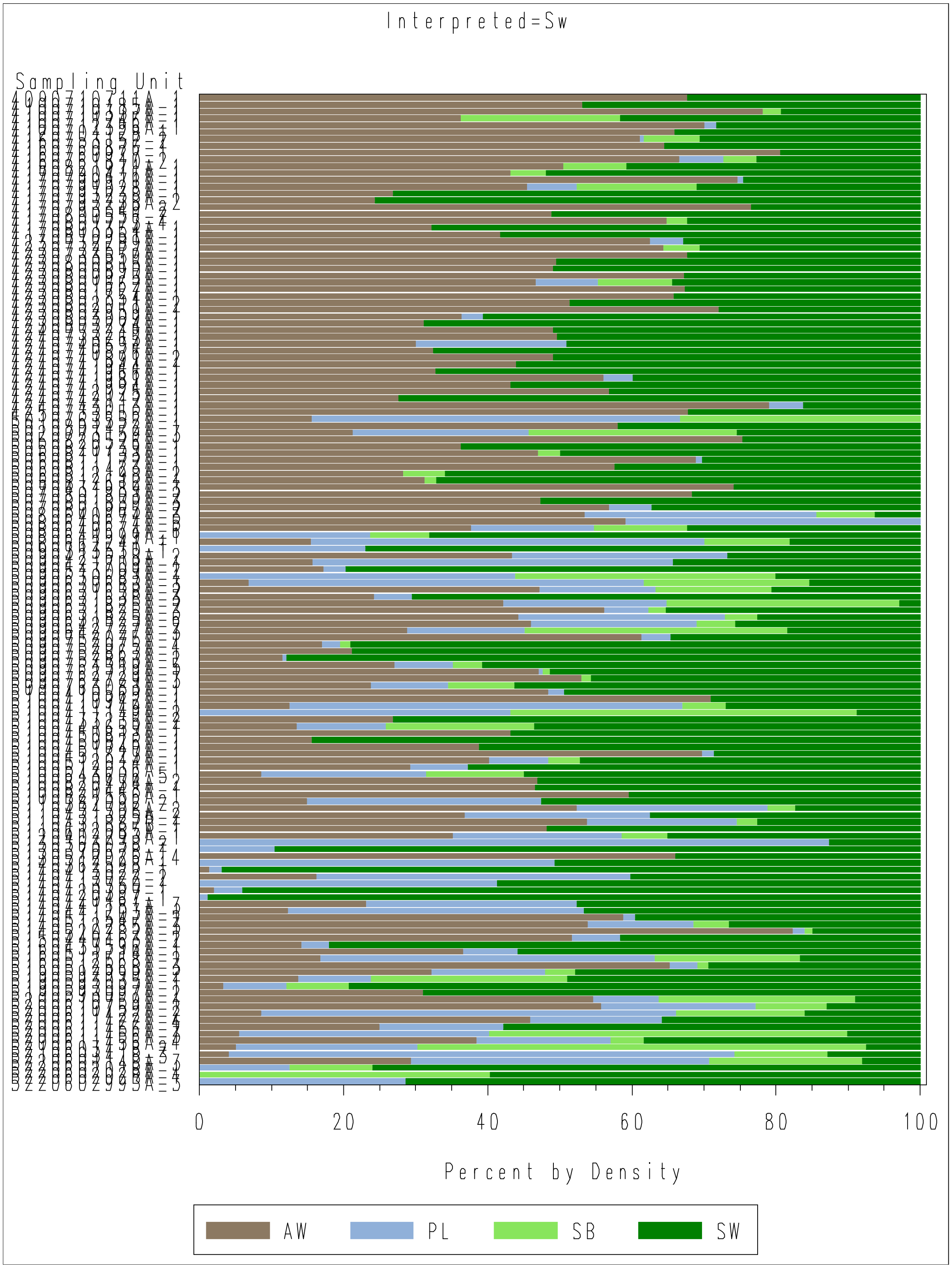
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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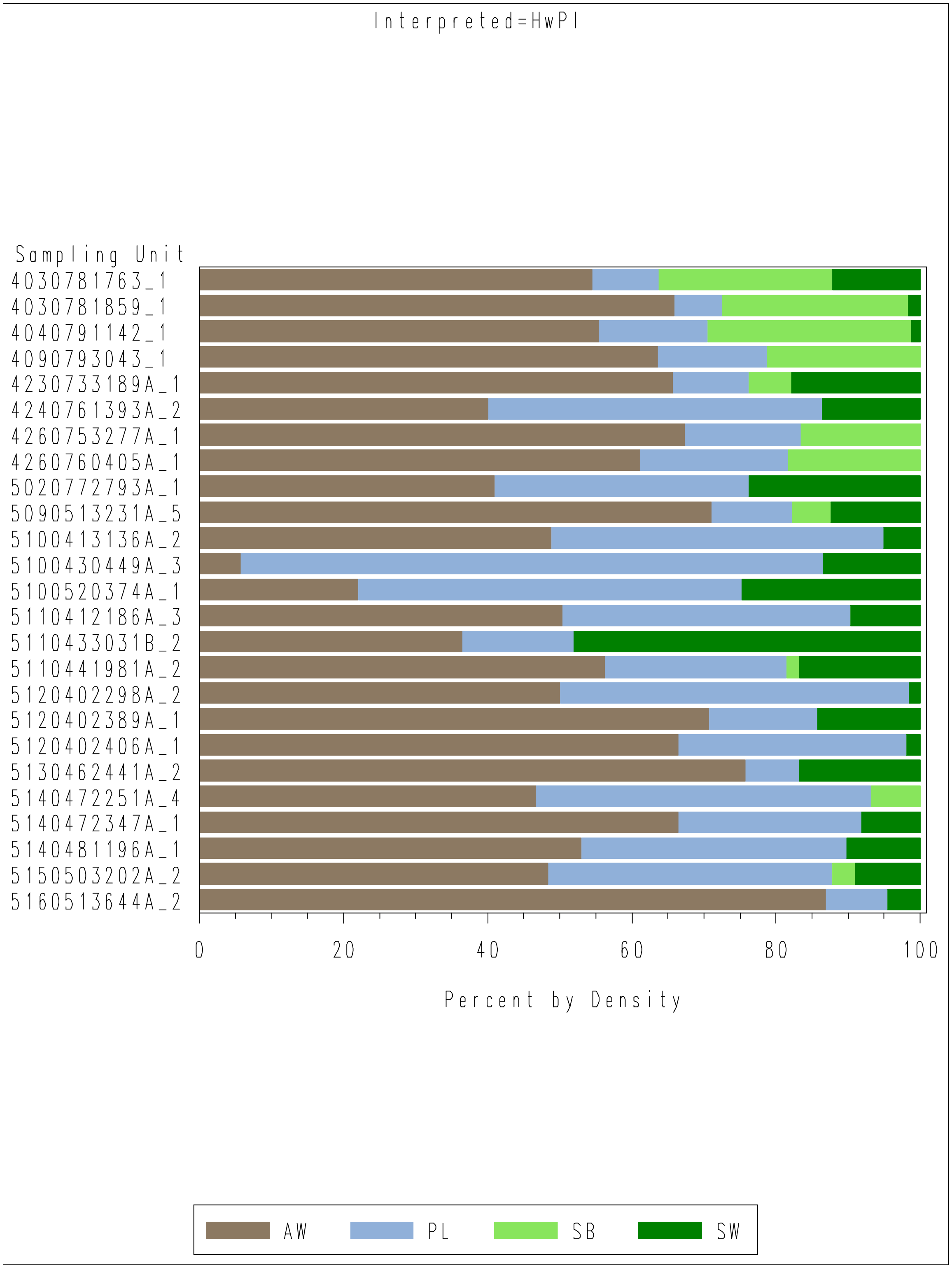
Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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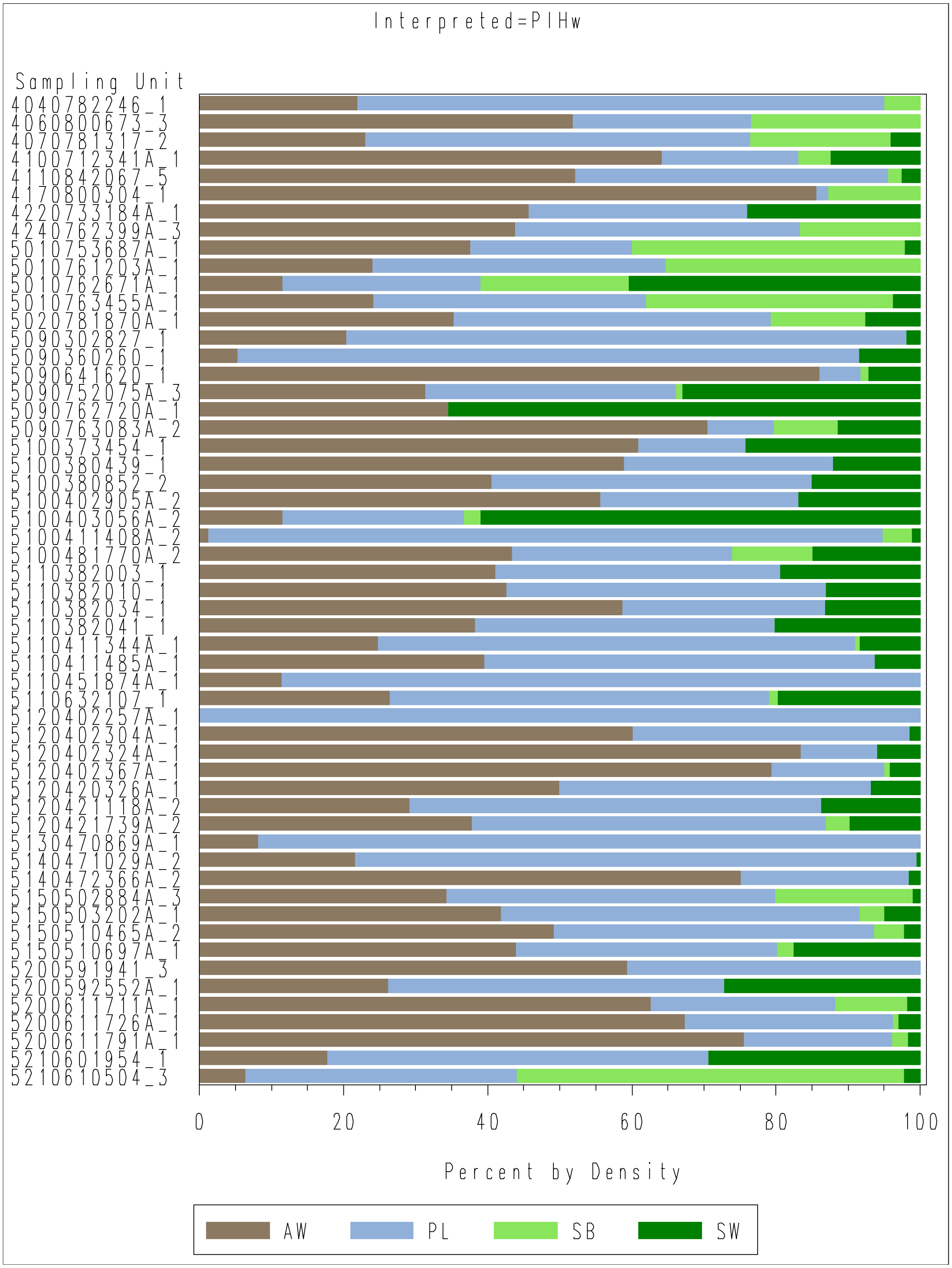
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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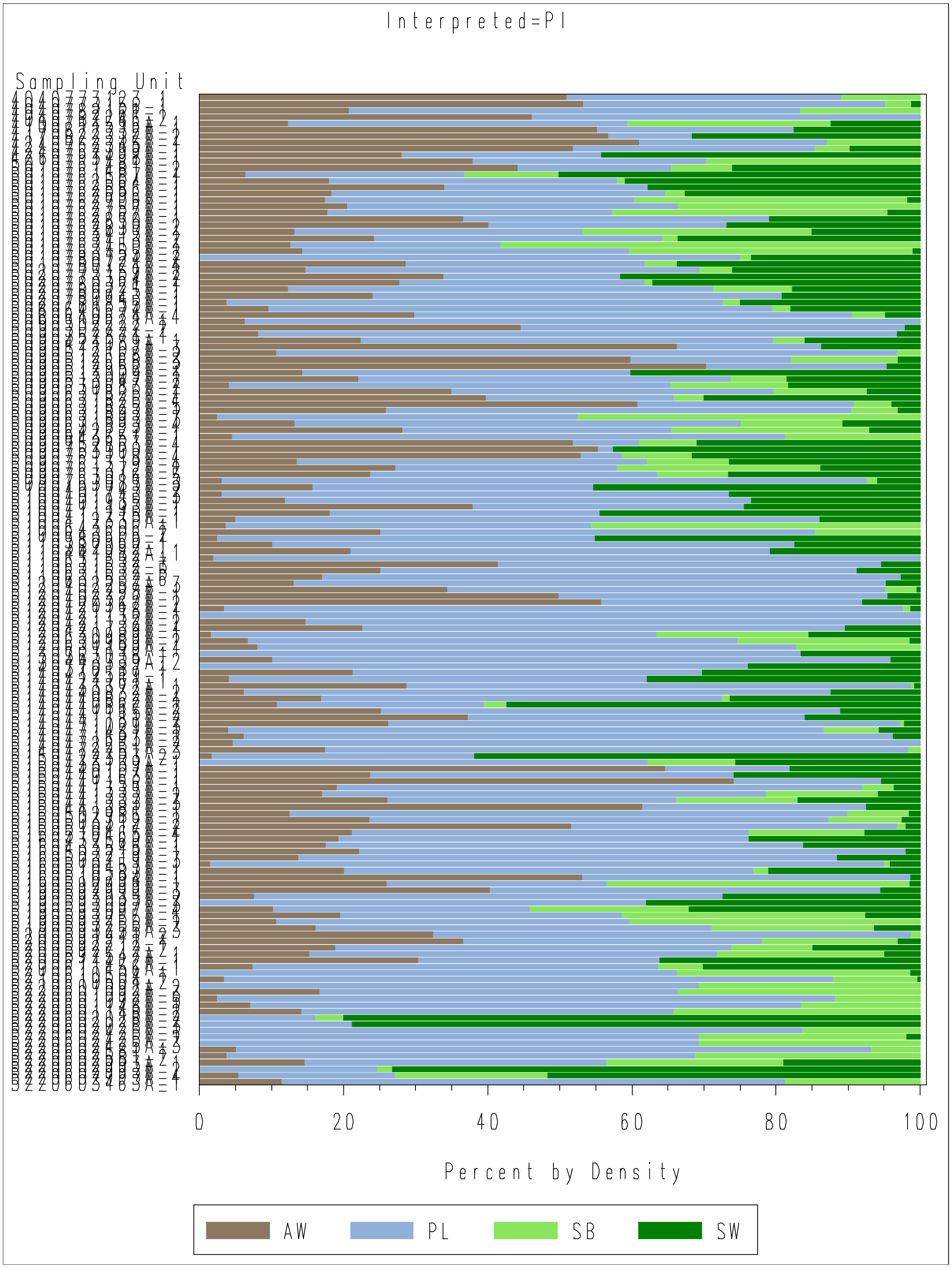
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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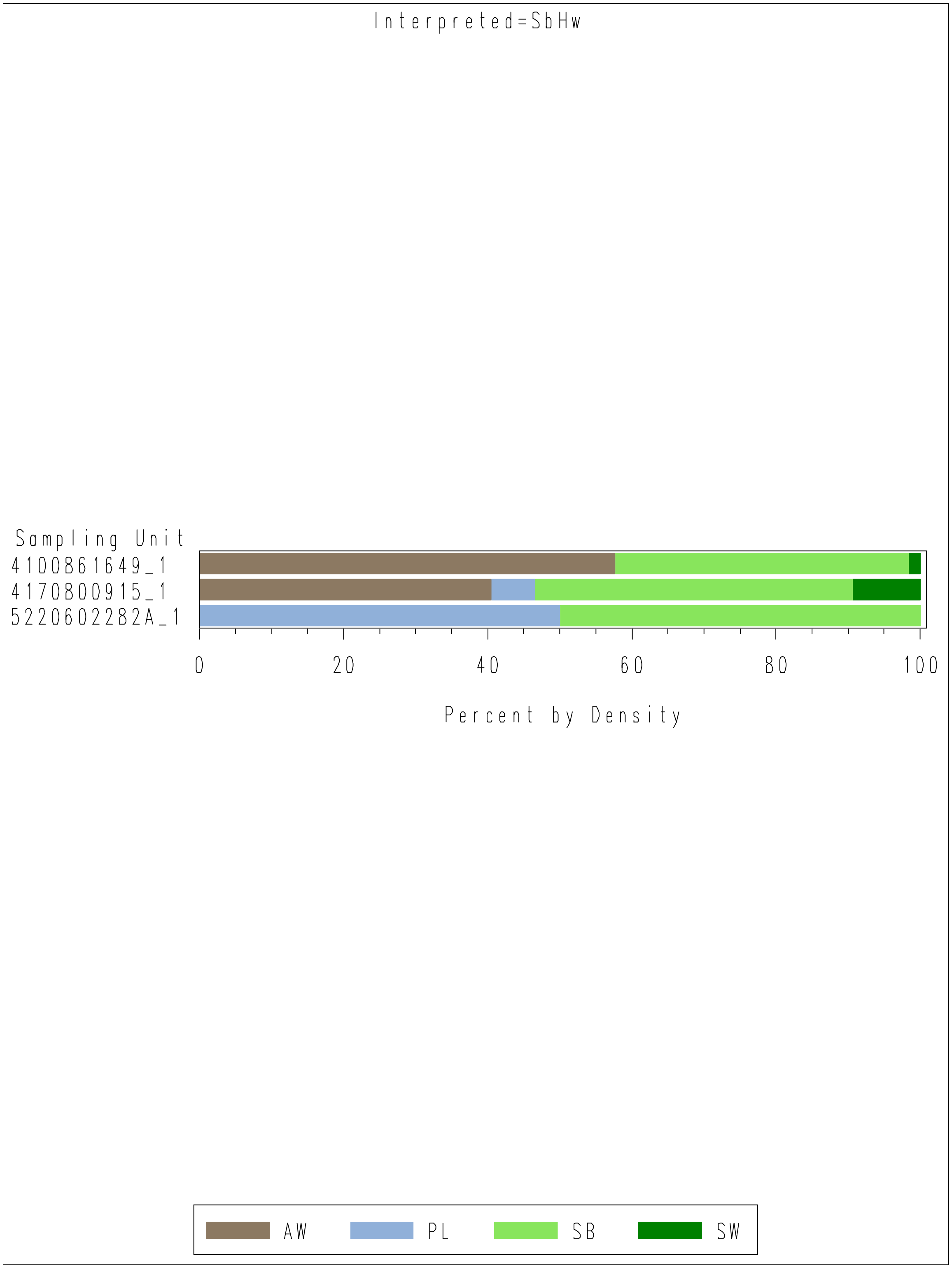
True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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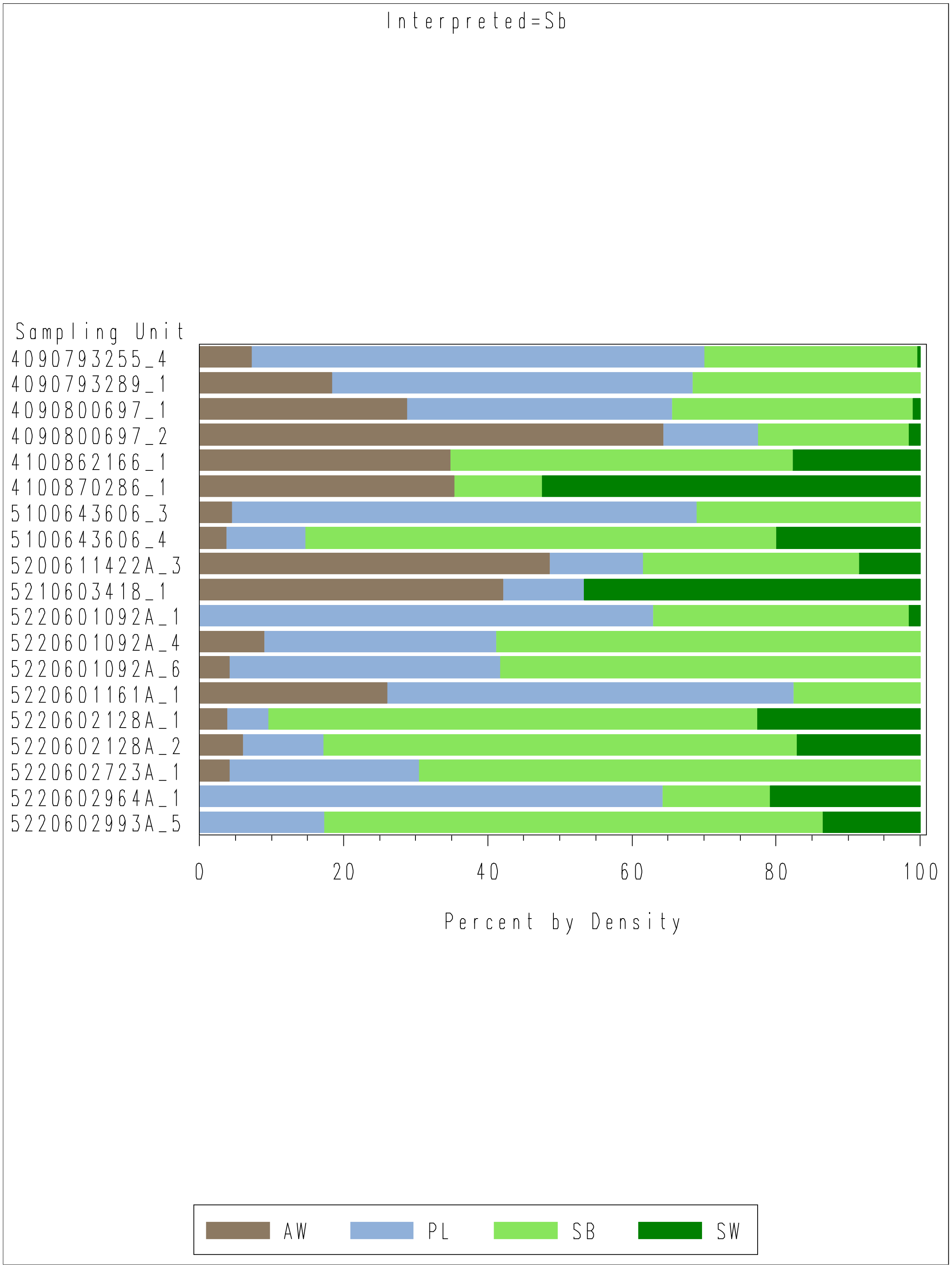
Proportion of Ground Density by Species Group and Interpreted Stratum

True Colour Photography (1:20,000)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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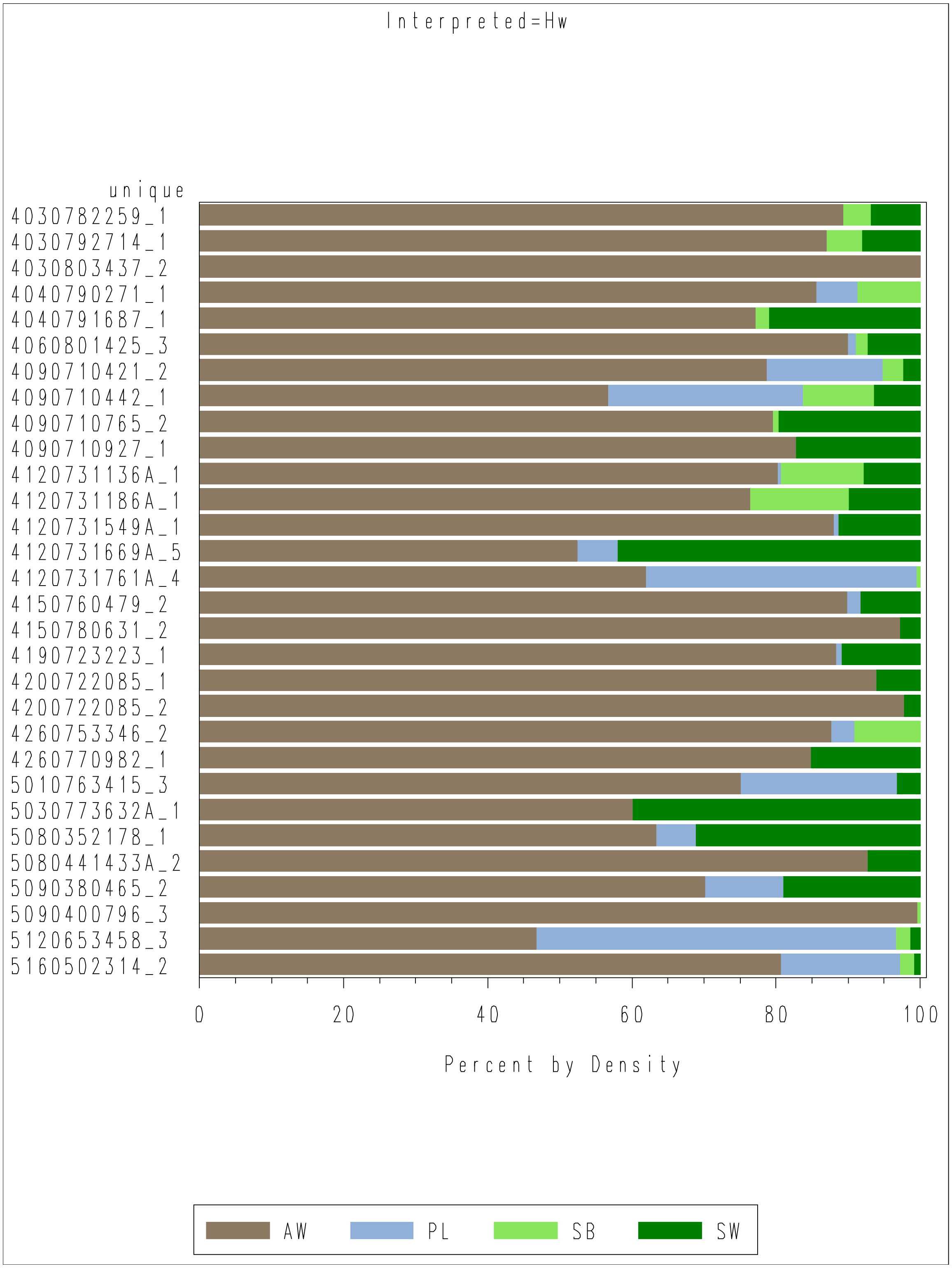
Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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Colour Infrared Photography (20 cm resolution)

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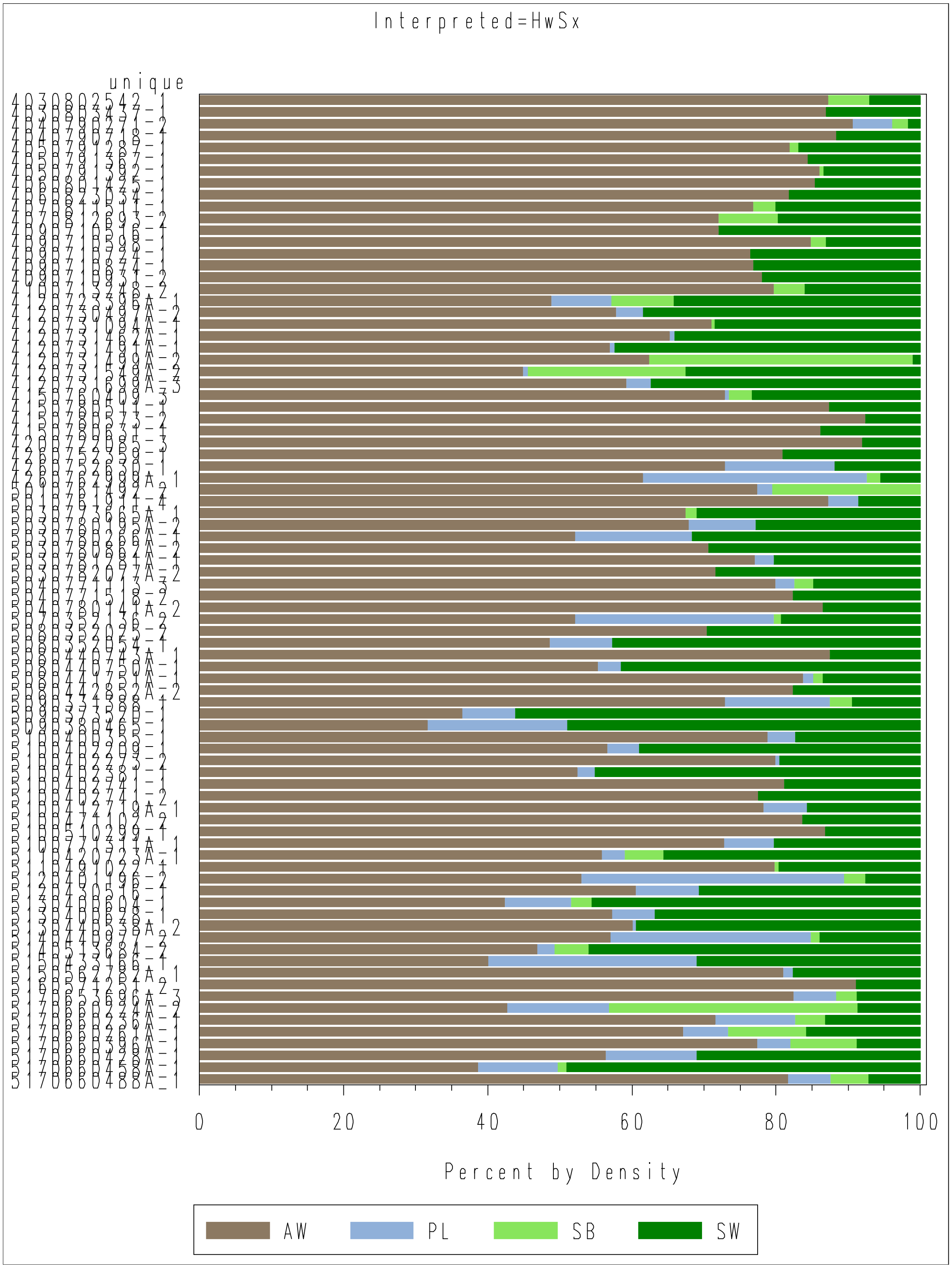

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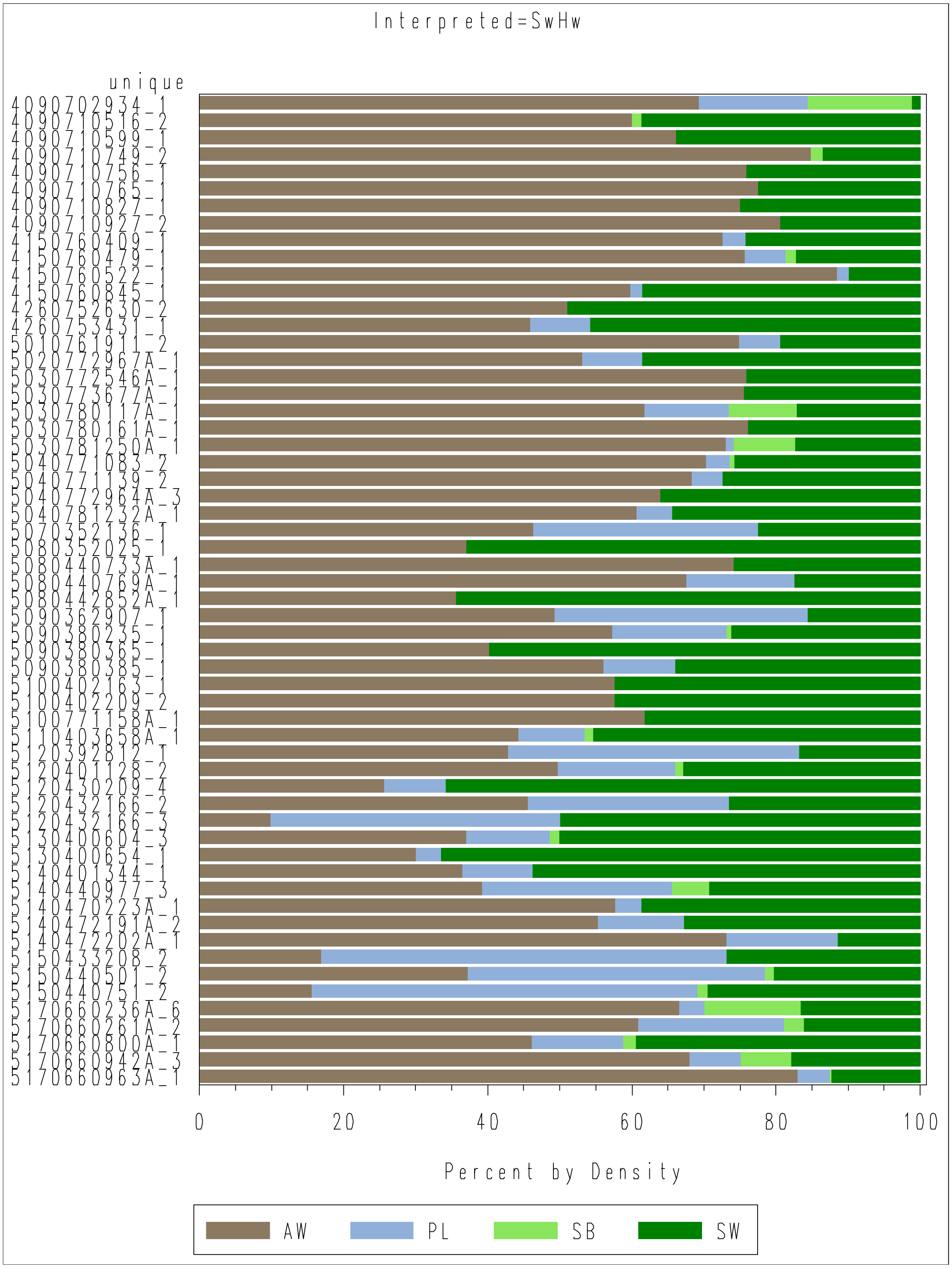
Colour Infrared Photography (20 cm resolution)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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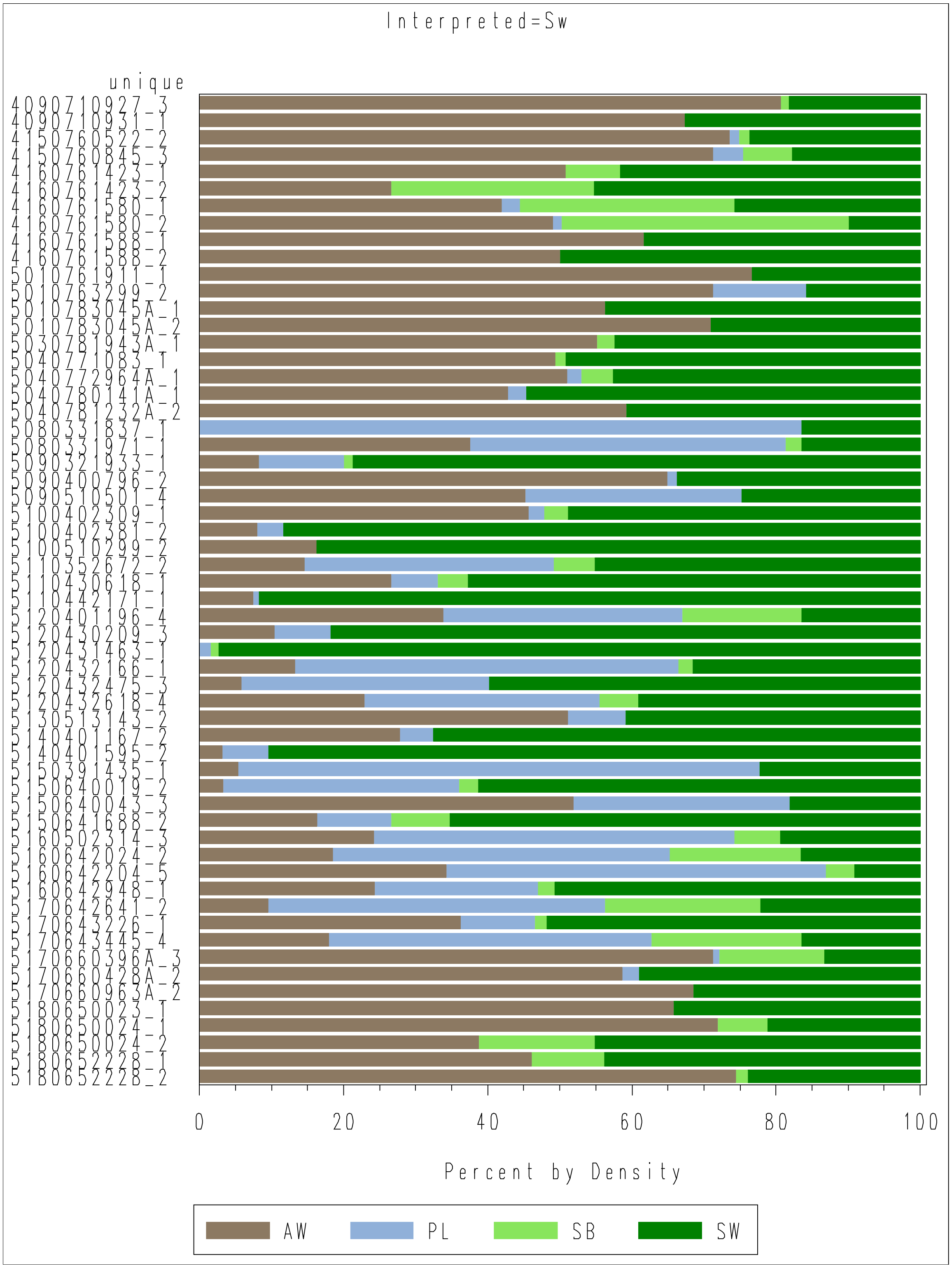
Colour Infrared Photography (20 cm resolution)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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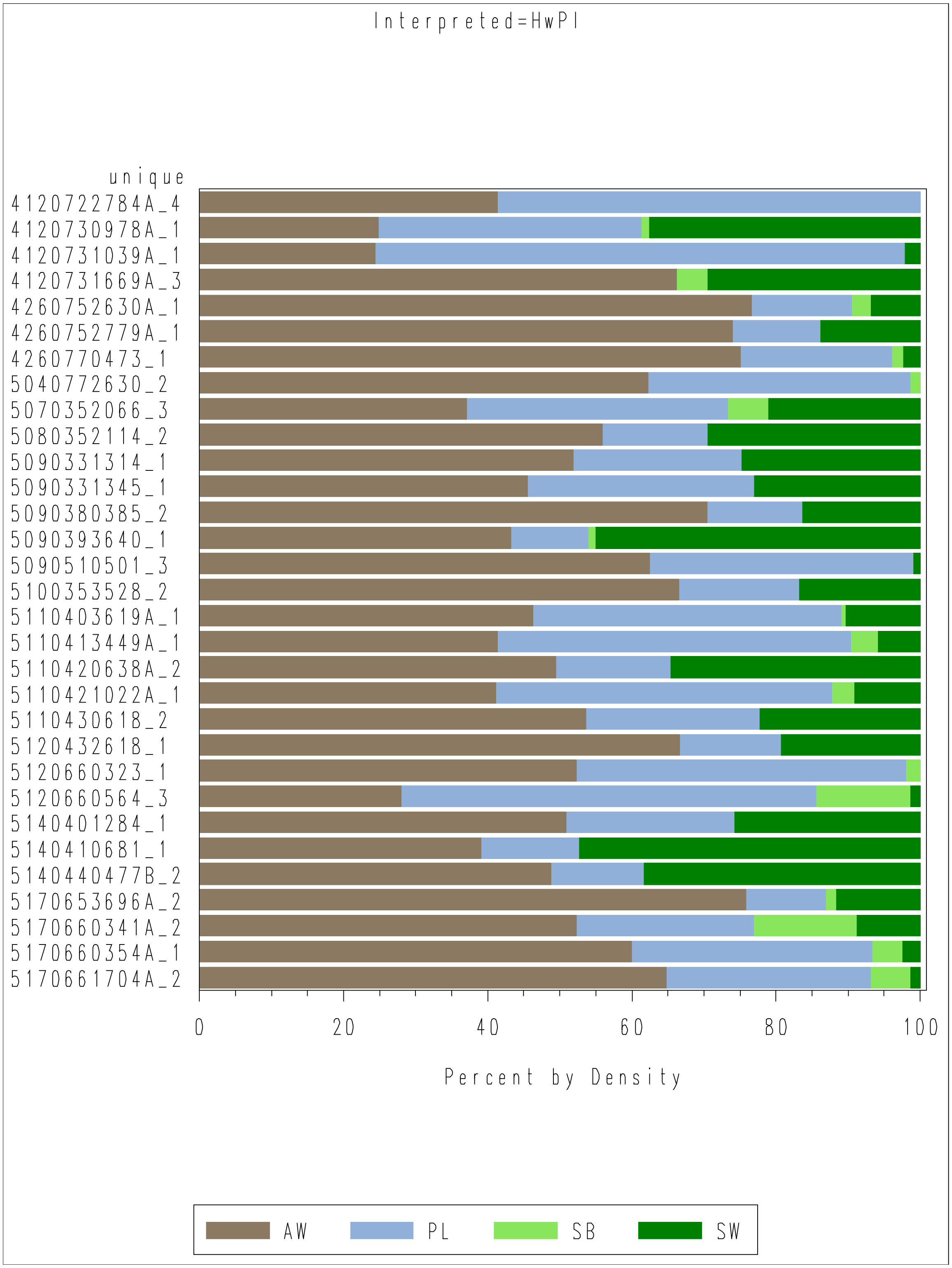
Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

Data: Al-Pac, Alberta Plywood, Blue Ridge, Millar Boyle, Sundre, Vanderwell, Weyerhaeuser Pembina



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Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

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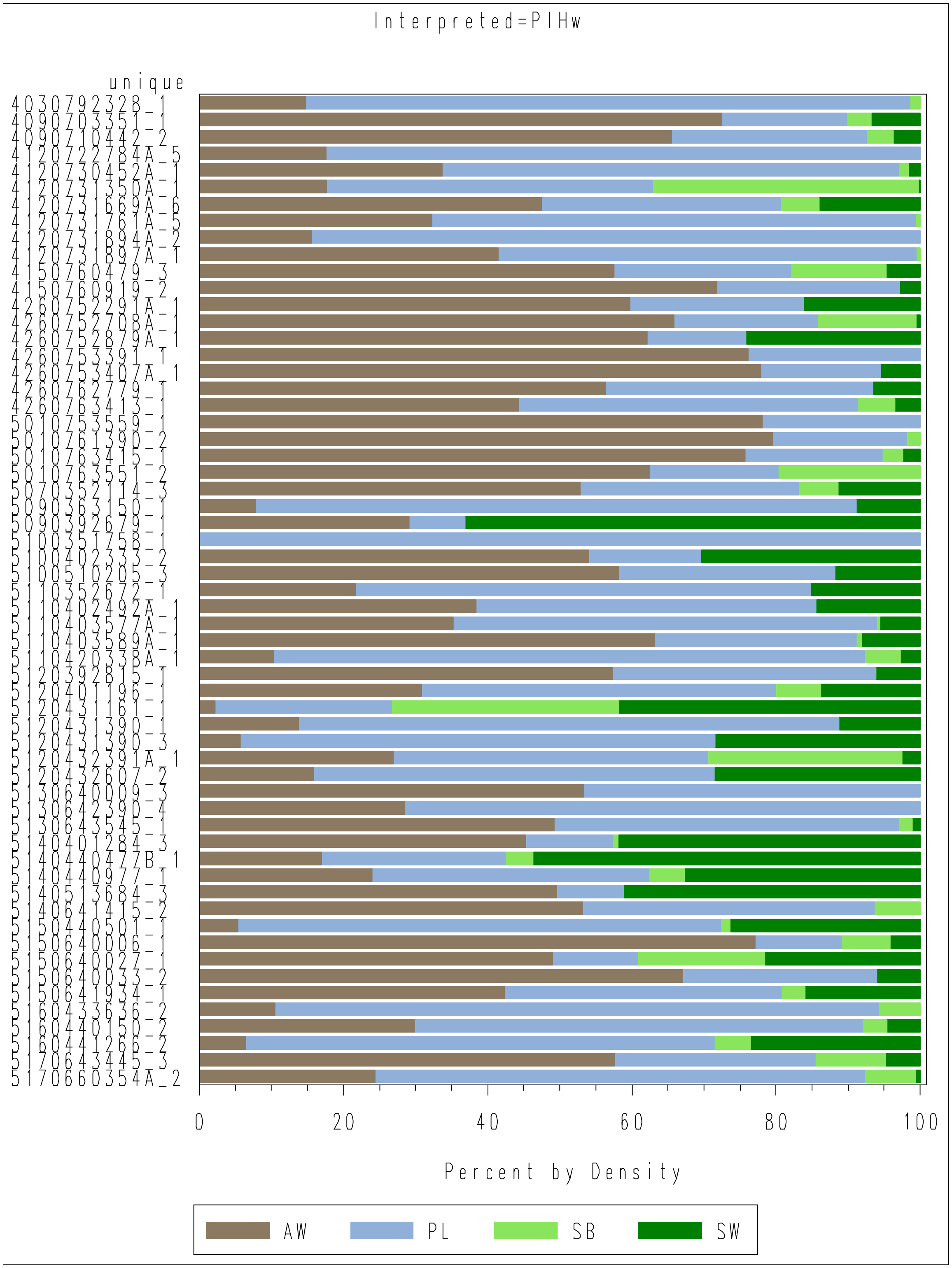

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Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

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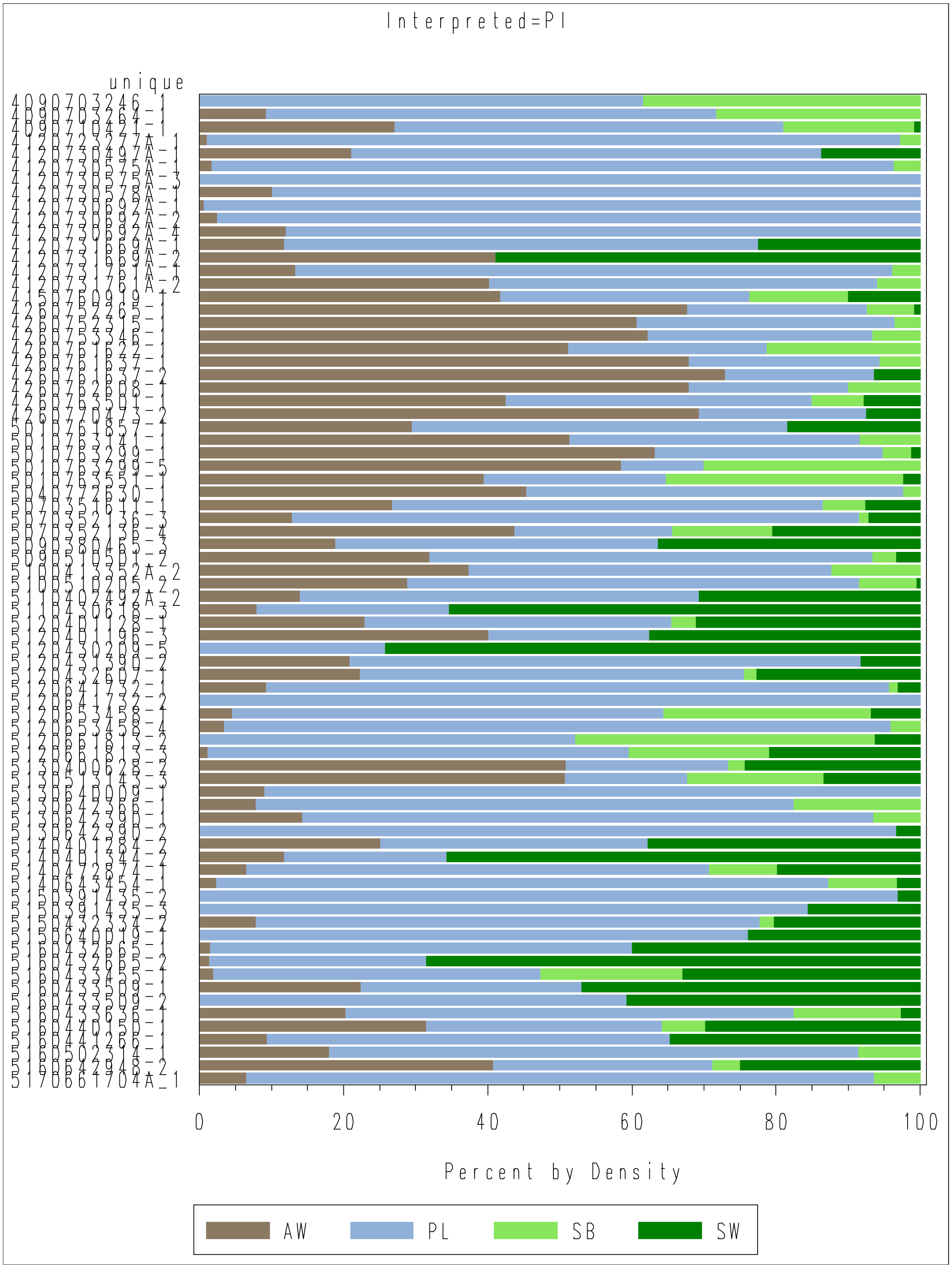

AFGO Strata Subcommittee Meeting August 27, 2014

Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

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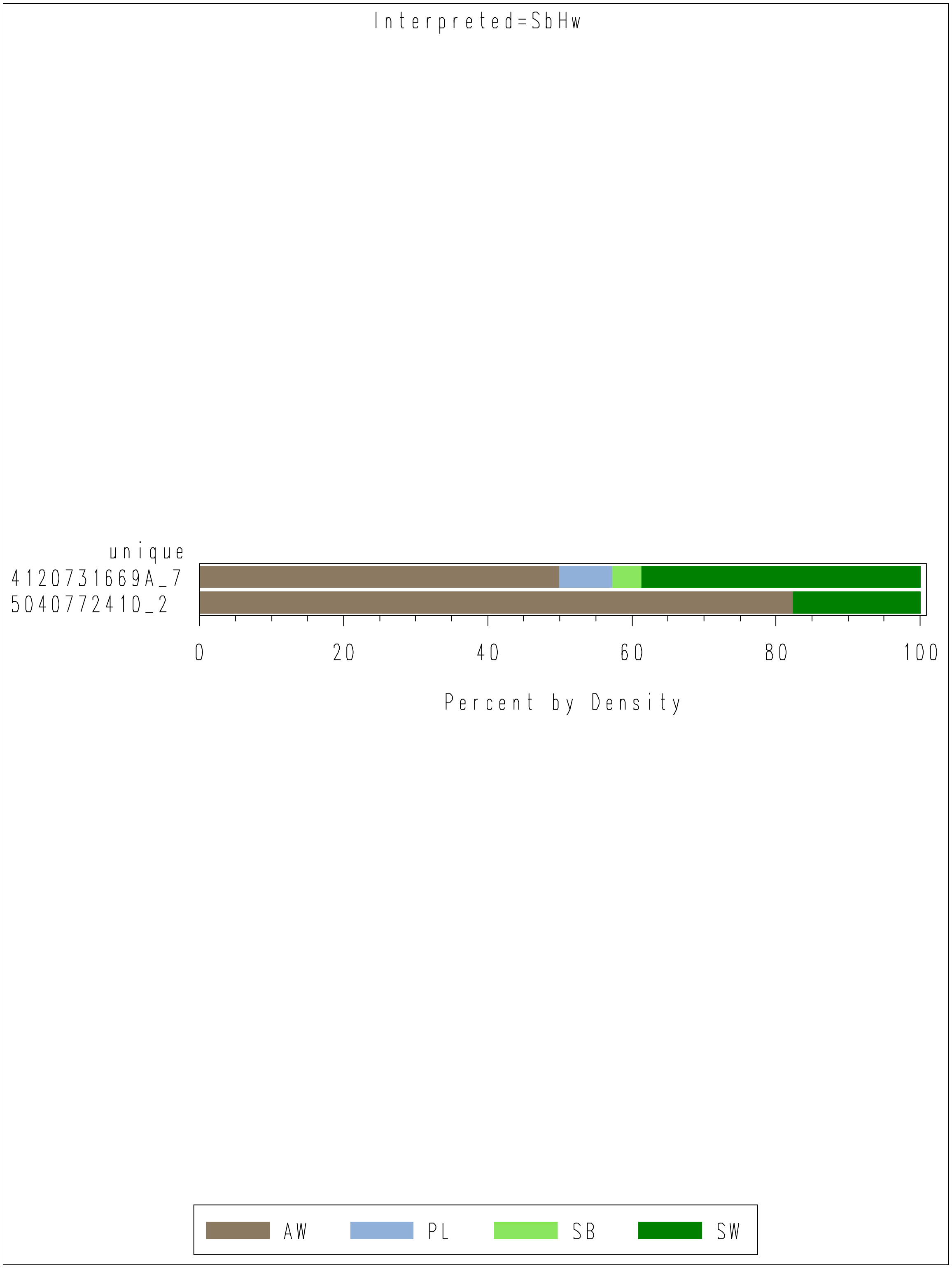

AFGO Strata Subcommittee Meeting August 27, 2014

Proportion of Ground Density by Species Group and Interpreted Stratum

Colour Infrared Photography (20 cm resolution)

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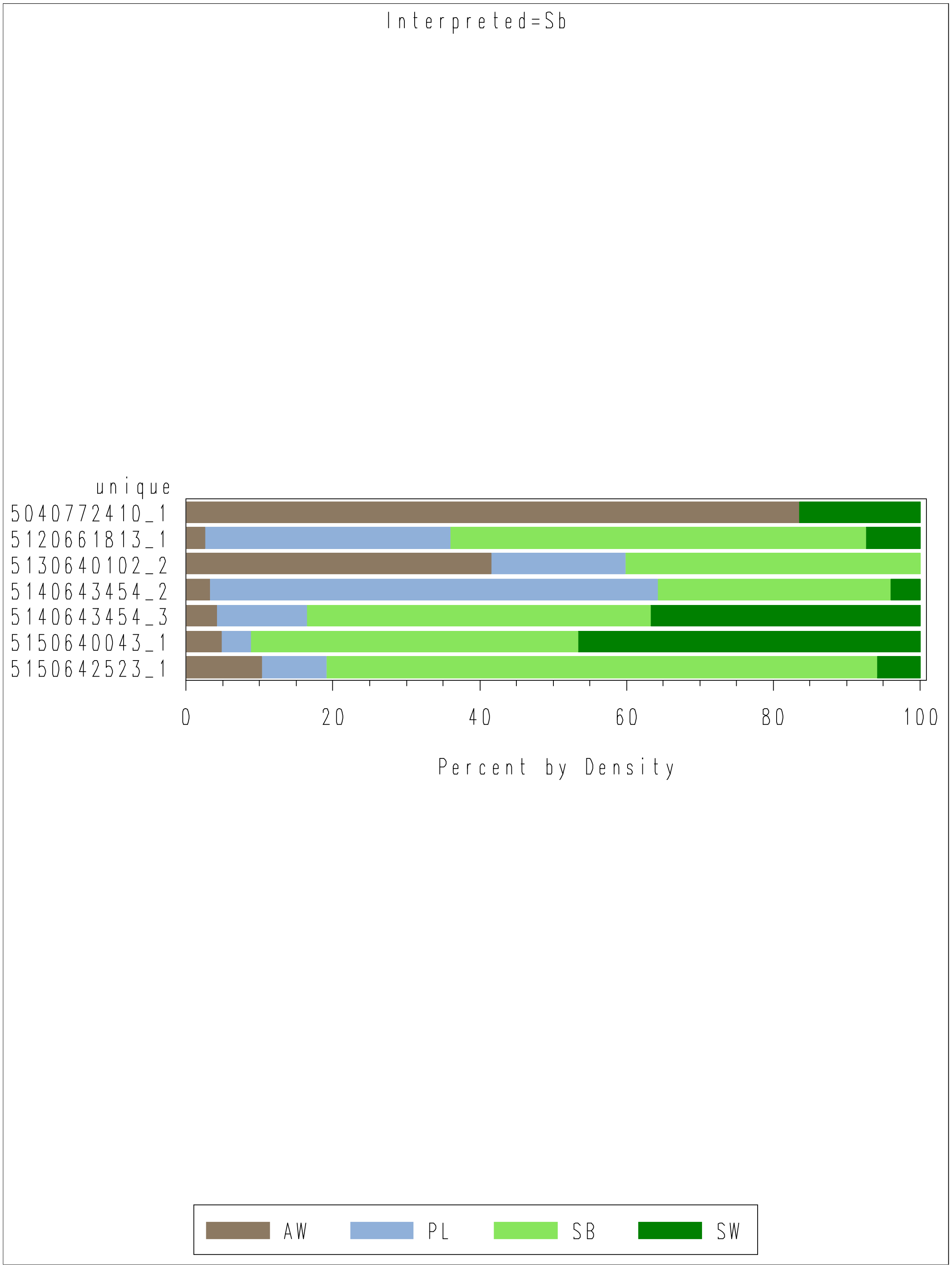

APPENDIX 4: ALTERNATE STRATIFICATION SCHEME TECHNICAL REPORT

TOR 2.2.6 Alternate Stratification Scheme Technical Report

Background:
Stratification of the forest landbase is a requirement under the Alberta Forest Management Planning Standard. As part of the 2001 reforestation standards, stratification was to four broad cover groups (BCG): Deciduous (D), Deciduous-leading mixedwoods (DC), Conifer-leading mixedwoods (CD) and Conifer (C) stands. In the current Reforestation Standard of Alberta (RSA) stratification is to the "Base-10" strata, which designate the leading conifer species within each BCG (Hw, HwSx, HwPl, PlHw, SwHw, SbHw, Sw, Pl, Sb, Fd). Currently under RSA aerial survey rules for performance surveys, interpreters are to use percentage cutoffs of 20/50/80 (percent deciduous density/total) based on photo-interpreted stem density to separate the broad cover groups and base-10 strata.

The Alberta Forest Growth Organization (AFGO) Stratification Subcommittee suggested that the current RSA stratification scheme for assigning strata to BCGs and base-10 strata at performance survey should consider alternate stratification schemes. There is debate that the current stratification scheme is not getting the mixedwoods right. That is, high deciduous densities overwhelm the percentage, creating too many deciduous stands which have sufficient densities of conifers (particularly white spruce) to succeed into DC, CD, or even C stands, given enough time. Thus, the current 20/50/80 stratification by performance age density percentage may result in stands which do not fit the strata call at maturity. We therefore evaluated if alternate stratification schemes might resolve more realistic strata as part of this 2013/14 review of the RSA standards.

Objective:
Evaluate if an alternate stratification scheme is better than the current stratification of 20/50/80 percent deciduous density/total density cut offs or splits. Since the key RSA performance metric is mean annual increment (MAI) at culmination, conifer and deciduous MAI (Con MAI, Dec MAI) and the composition of MAI, i.e. Con MAI/(Con MAI + Dec MAI) were the metrics chosen to evaluate alternate schemes. Further, better stratification should result in reduced variation in conifer and deciduous MAI and composition of MAI among the sampling units sampled within each stratum.

Data:
2010/2011 and 2011/2012 photo and non-photo RSA programs were used. Non-random weights generated by the RSA Sample Selection Tool were ignored. Each sampling unit was weighted equally as our purpose was to investigate alternate stratification schemes, rather than achieve an unbiased estimate of MAI.

Methods:

The alternate stratification schemes considered and analytical steps taken are as follows:

1. 30/60/90 percent deciduous density cutoffs versus current stratification of 20/50/80. Using available RSA performance survey interpreted data, the variation in conifer and deciduous MAI's for these two stratification schemes were compared.
2. A cap on deciduous density (i.e. if deciduous density is greater than the cap, then deciduous density is equal to the cap; the cap tested was 6000 sph) versus 20/50/80 and

30/60/90 density splits. Using available RSA performance survey ground data, the variation in conifer and deciduous MAI's for these stratification schemes were compared.

3. Stocking splits of 20/50/80 and 30/60/90 deciduous percent stocking versus 20/50/80 and 20/50/90 deciduous density splits. Using available RSA performance survey ground data, the variation in conifer and deciduous MAI's for these stratification schemes were compared.
4. Analysis to evaluate the link between performance age attributes and forecast MAI proportions.

    a. We used the GYPSY PASS Tool (Performance Assessment Siviculture Senarios) an Excel implementation of GYPSY 2009) to help choose caps, densities and stocking levels efficiently. This was an analysis based on GYPSY simulations to evaluate the link between crown closure proportions at maturity, MAI target proportions and density proportions at performance survey age.
    b. A stratification scheme with minimum conifer thresholds (e.g. 200 or 300 for D/DC boundary, meaning that if conifer density is less than 200 or 300 and the broad cover group was D, otherwise these would be mixed or conifer stands using 50/20 deciduous density percentage splits) versus 20/50/80 and 30/60/90 density splits. Using available RSA performance survey ground data, the variation in conifer and deciduous MAI's for these stratification schemes were compared.
    c. Using the GYPSY PASS Tool and associted simulations to further evaluate the impact of dispersion and productivity assumptions on the relationship between culmination MAI proportions, and stocking or density proportions at performance age.

A better stratification scheme would reduce the variation in the outcome. To evaluate whether a different scheme is better, we looked at measures of variation in conifer and deciduous MAI and composition MAI i.e. conifer MAI/Total MAI. We chose box plots (Figure 1) of conifer MAI, deciduous MAI and composition MAI for each stratum. Box plots summarize variation quite effectively, indicating variation in the interquartile range (IQR: where 50% of the data occur) as a wide box separately from the remaining, more extreme data, shown in the whiskers. The mean and median are indicated by a + symbol and horizontal line, respectively. In our review of variation in MAI, we weighted the IQR variation (i.e. height of the wide box) more heavily than the variation in the extremes (length of the whiskers).

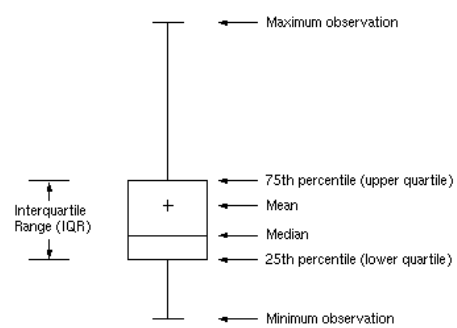

Figure 1: An illustration of the elements of a box plot

Our first set of analysis, i.e. 1 above (30/60/90 percent deciduous density cutoffs versus current stratification of 20/50/80), was based on interpreted densities, chiefly the percentage (by stem density) of each species, was used to re-stratify sampling units . The rest of the analysis was based on actual ground data (2 - 4).

GYPSY 2009 was used for all projections of performance age conditions forward to maturity (we simply used the RSA Compiler MAI outputs to save time). Rotation age for MAI calculation is assumed to be at conifer culmination (peak conifer MAI) in most cases. We acknowldege this analysis assumes that GYPSY is correct. However, GYPSY is currently the only fully approved growth model for RSA projections of MAI. These results also provide feedback on GYPSY's behaviour in this regard, and may point to areas where this model could be improved.

Results:

1. Current 20/50/80 vs. 30/60/90 Performance Age Density Stratification (based on interpreted densities)

Our first analysis was to investigate if an alternate stratification scheme of 30/60/90 percent deciduous density thresholds would reduce the variability in conifer and deciduous MAI. This would result in some of the D (Hw) stands with significant densities of conifer to be re-assigned DC mixedwoods (HwSx, HwPl). Similarly some DC stands would shift to CD, and CD stands to C.

Based on the ranking system used, our results indicated that our current stratification of 20/50/80 has less variation in deciduous MAI in most of the strata (e.g. HwPl, HwSx, Pl etc.) than the 30/60/90 percent deciduous density scheme. For conifer and composition MAI there is no clear difference between the current stratification and this alternate scheme (Tables 1 and 2, Figures 2, 3 and 4).

Our results also indicated that there is less variation in Hw, PlHw, SbHw and SwHw under the 30/60/90 percent deciduous density stratification scheme. HwPl, HwSx, Pl, Sb and Sw were also less variable under the current stratification scheme. In most cases the magnitude of the difference between the current and the alternate stratification schemes was very small.

It is important to note that the ranking system used here can over emphasis minor differences. The most important difference observed between these two stratification schemes that should be noted occurs in the Hw stratum, with a substantive improvement in observed variation when using the alternative stratification scheme (i.e. 30/60/90). This observation suggests a threshold of 90 deciduous density proportions between DC and D stand types would be an improvement over current stratification rules.

Table 1: The best stratification scheme i.e. our current stratification of 20/50/80% deciduous density thresholds vs. an alternate of 30/60/90% deciduous density thresholds for each stratum in terms of variability in deciduous, coniferous and composition of MAI. This was based on graphical inspection of Figures 2, 3 and 4.

Strata	**Dec MAI**	**Con MAI**	**Composition MAI**
Hw	30/60/90	30/60/90	30/60/90
HwPl	Current	Current	current
HwSx	Current	Current	current
Pl	current	Current	current
PlHw	30/60/90	No clear difference	30/60/90
Sb	current	30/60/90	No clear difference
SbHw	30/60/90	30/60/90	30/60/90
Sw	current	current	current
SwHw	30/60/90	30/60/90	30/60/90

Table 2: Ranking derived from Table 1 of the different stratification schemes for each stratum. The highlighted cells indicate the stratification type with least variation (In most cases the difference between the current and the alternate stratification schemes were not much).

Strata	**Dec MAI**		**Con MAI**		**Composition MAI**	
	current	**30/60/90**	**current**	**30/60/90**	**current**	**30/60/90**
Hw	2	1	2	1	2	1
HwPl	1	2	1	2	1	2
HwSx	1	2	1	2	1	2
Pl	1	2	1	2	1	2
PlHw	2	1			2	1
Sb	1	2	2	1		
SbHw	2	1	2	1	2	1
Sw	1	2	1	2	1	2
SwHw	2	1	2	1	2	1
TOTAL	**13**	**14**	**12**	**12**	**12**	**12**

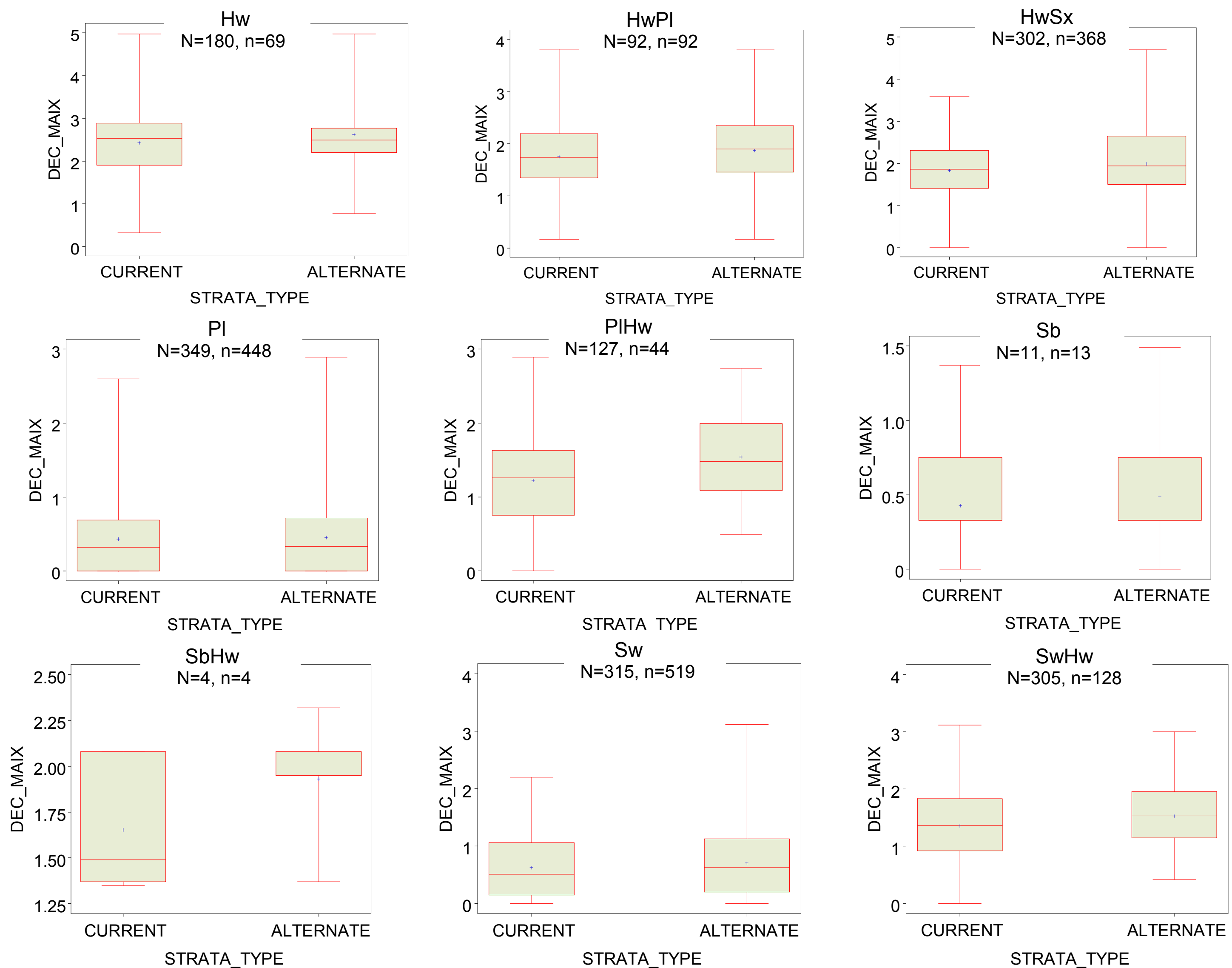

Figure 2: Variability in deciduous MAIs by considering the current stratification scheme of 20/50/80% deciduous density thresholds vs. an alternate stratification scheme (30/60/90)% deciduous density thresholds based on photo interpreted density. N=current stratification sample size, n= alternate stratification sample size.

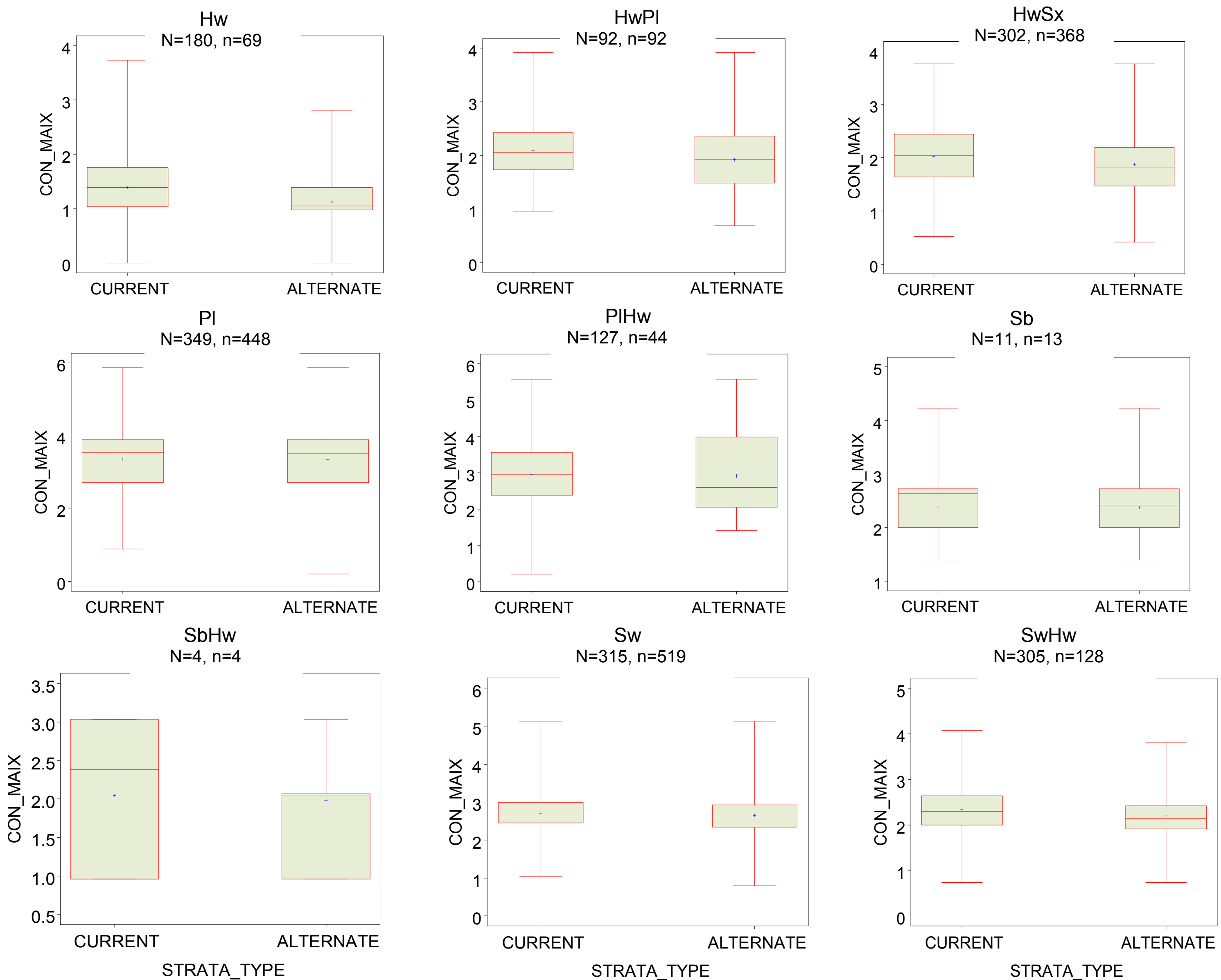

Figure 3: Variability in conifer MAIs by considering the current stratification scheme of 20/50/80% deciduous density thresholds deciduous density cut off vs. an alternate stratification scheme (30/60/90)% deciduous density thresholds based on photo interpreted density. N=current stratification sample size, n= alternate stratification sample size.

COMP_MAIX = CON_MAI/TOTAL_MAI

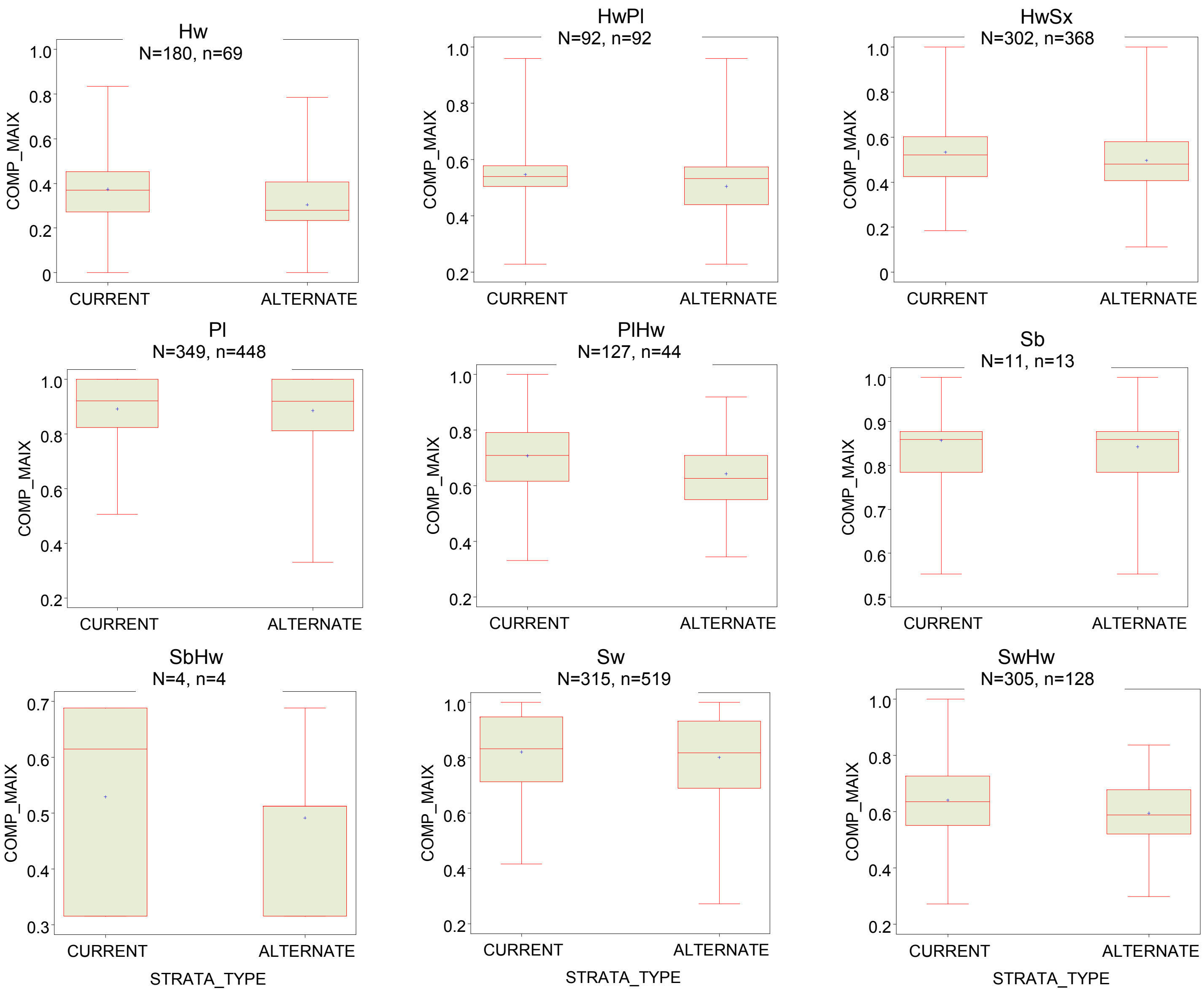

Figure 4: Variability in conifer MAI/Total MAI by considering the current stratification scheme of 20/50/80% deciduous density cut off vs. an alternate stratification scheme (30/60/90)% deciduous density thresholds based on photo interpreted density. N=current stratification sample size, n= alternate stratification sample size.

2. Current 20/50/80 vs 30/60/90 vs D-Capped 20/50/80 and D-Capped 30/60/90 Performance Age Density Stratification (based on ground measures of densities)

We tested a suggested cap of 6000 sph on deciduous density, i.e. deciduous densities above 6000 stems per hectare (sph) would only count as 6000 sph in determining percentages for strata thresholds. A sensitivity analysis of GYPSY has indicated that 6000 sph should provide nearly the maximum deciduous yield. We then stratified using 20/50/80% deciduous density thresholds and 30/60/90% deciduous density thresholds versus our current stratification and 30/60/90% deciduous density thresholds without a cap. We found that a cap on the deciduous density did not have any appreciable overall impact on stratification. Table 3 and 4 (with reference to Figures 5-7) indicates that there is less variation in deciduous MAI under the current stratification scheme in most of the stratum. For conifer MAI, 30/60/90% deciduous density thresholds without a cap is better followed by our current stratification scheme. Our results also indicate that there is less variation in composition MAI when using either the current stratifcation or 30/60/90 deciduous density thresholds without a cap. In most cases the difference between the current and the 30/60/90 deciduous density stratification were niether very large nor signicant. The reason why the deciduous cap did not have any impact on strata may be explained by the fact that there were very few decidous densities equal or greater than 6000 sph (Figure 14 a and b).

Table 3 (Refer to Figures 5, 6 and 7): The best stratification scheme (i.e. our current stratification of 20/50/80% deciduous density thresholds (C) vs. 30/60/90% deciduous density thresholds (A), 20/50/90% deciduous density thresholds with a deciduous cap (DC) and 30/60/90% deciduous density thresholds with a deciduous cap (DA)) for each stratum in terms of the less variability in MAI.

Strata	Dec MAI	Con MAI	Composition MAI
Hw	DA<A<C<DC	DA<A<DC<C	DA<A<DC<C
HwPl	C<A<DA<DC	C=A=DC<DA	A<C<DC<DA
HwSx	C<DC<A=DA	C=A<DA<DC	C<A<DA=DC
Pl	C<DC<A<DA	No clear difference	C=DC<A<DA
PlHw	A<C=DC=DA	A<C=DC=DA	A<DA<C<DC
Sb	C=DC<A=DA	C=DC<A=DA	C=DC<A=DA
SbHw	DA<A<C=DC	A<C=DC<DA	A<C=DC<DA
Sw	C=DC<A=DA	A=DA<C=DC	C=DC<A<DA
SwHw	C<A<DC<DA	No clear difference	No clear difference

Table 4 (Refer to Table 3): Table indicating the ranking of the different stratification schemes for each stratum, the highlighted cells indicate stratification type with least variation.

Strata	Dec MAI				Con MAI				Composition MAI			
	C	**A**	**DC**	**DA**	**C**	**A**	**DC**	**DA**	**C**	**A**	**DC**	**DA**
Hw	3	2	4	1	4	2	3	1	4	2	3	1
HwPl	1	2	4	3	1	1	2	3	2	1	3	4
HwSx	1	3	2	3	1	1	3	2	1	2	3	3
Pl	1	3	2	4	1	1	1	1	1	2	1	2
PlHw	1	1	1	1	2	1	2	3	3	1	4	2
Sb	1	2	1	2	1	2	1	2	1	2	1	2
SbHw	3	2	3	1	2	1	2	3	2	1	2	3
Sw	1	2	1	2	2	1	2	1	1	2	1	3
SwHw	1	2	3	4	1	1	1	1	1	1	1	1
TOTAL	**13**	**19**	**21**	**21**	**15**	**11**	**17**	**17**	**16**	**14**	**19**	**21**

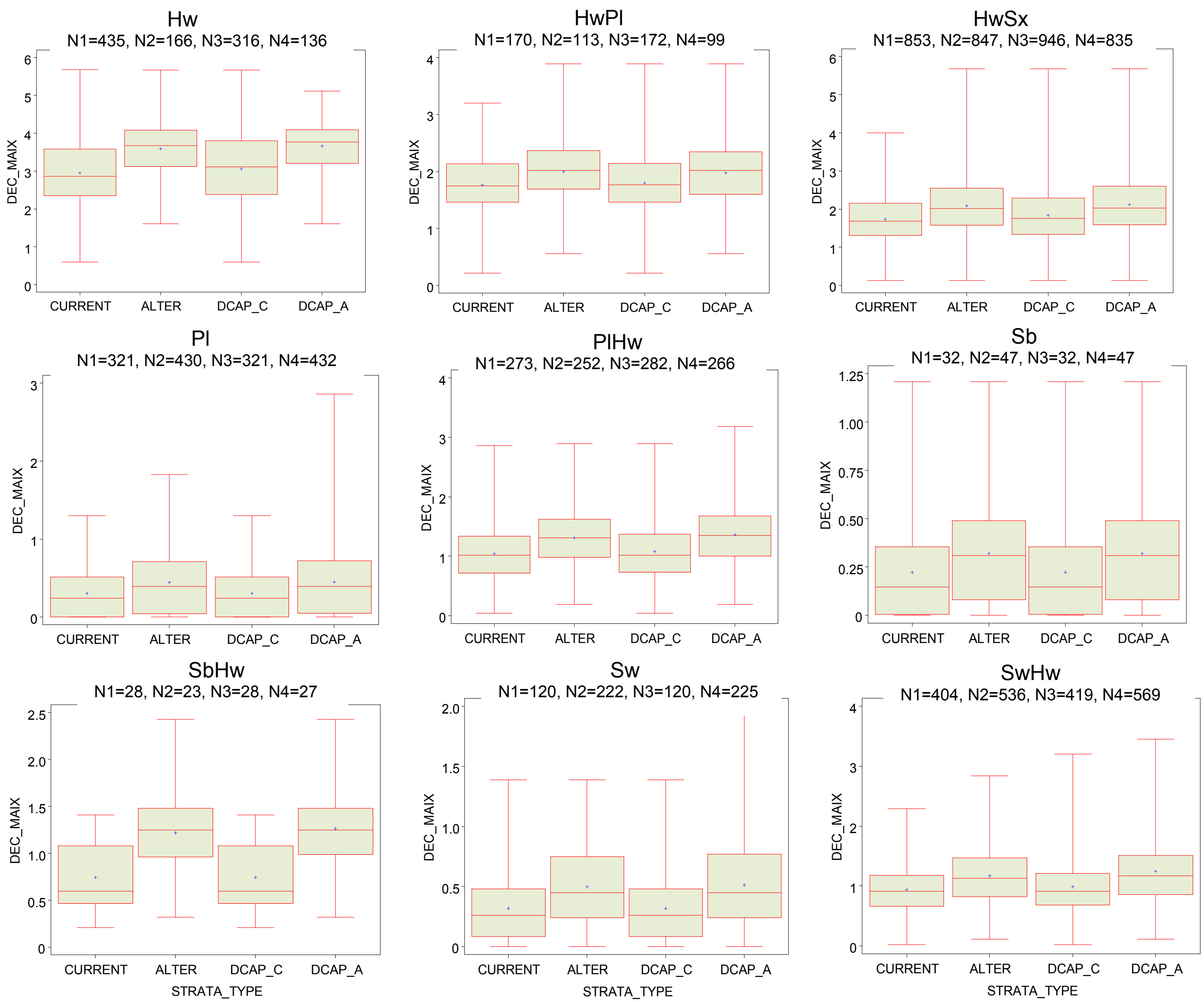

Figure 5: Variability in deciduous MAIs by considering the current stratification scheme vs. an alternate (30/60/90% deciduous cut off) and a deciduous cap of 6000sph on the current and the alternate stratification based on ground density. N1=current stratification sample size (CURRENT), N2=alternate stratification sample size (ALTER), N3=current stratification with deciduous cap sample size (DCAP_C), N4=alternate stratification with deciduous cap sample size (DCAP_A).

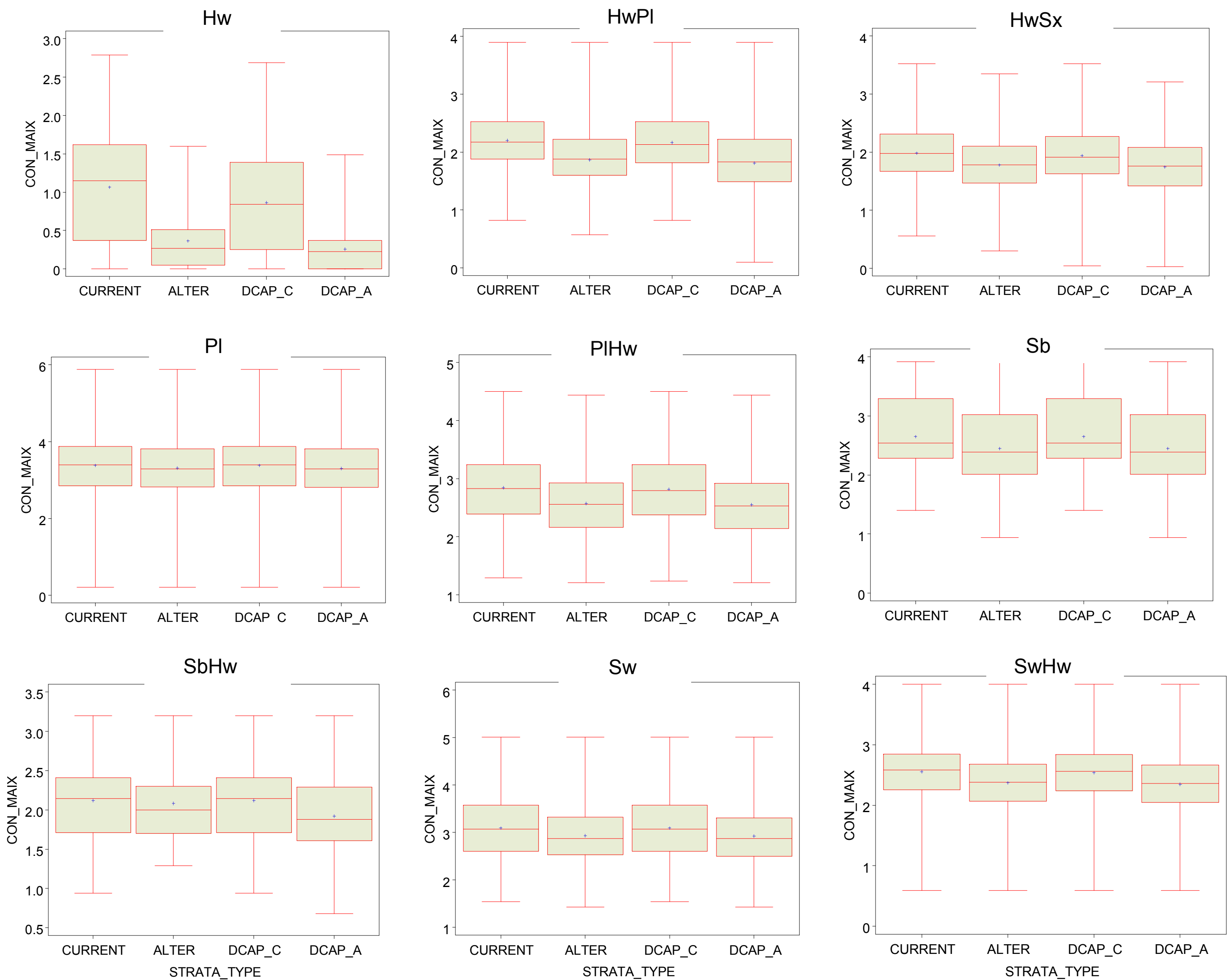

Figure 6: Variability in conifer MAIs by considering the current stratification scheme vs. an alternate (30/60/90%, deciduous thresholds) and a deciduous cap of 6000sph on the current and the alternate stratification based on ground density. The sample sizes for each of these strata types are as presented in figure5.

COMP_MAIX = CON_MAI/TOTAL_MAI

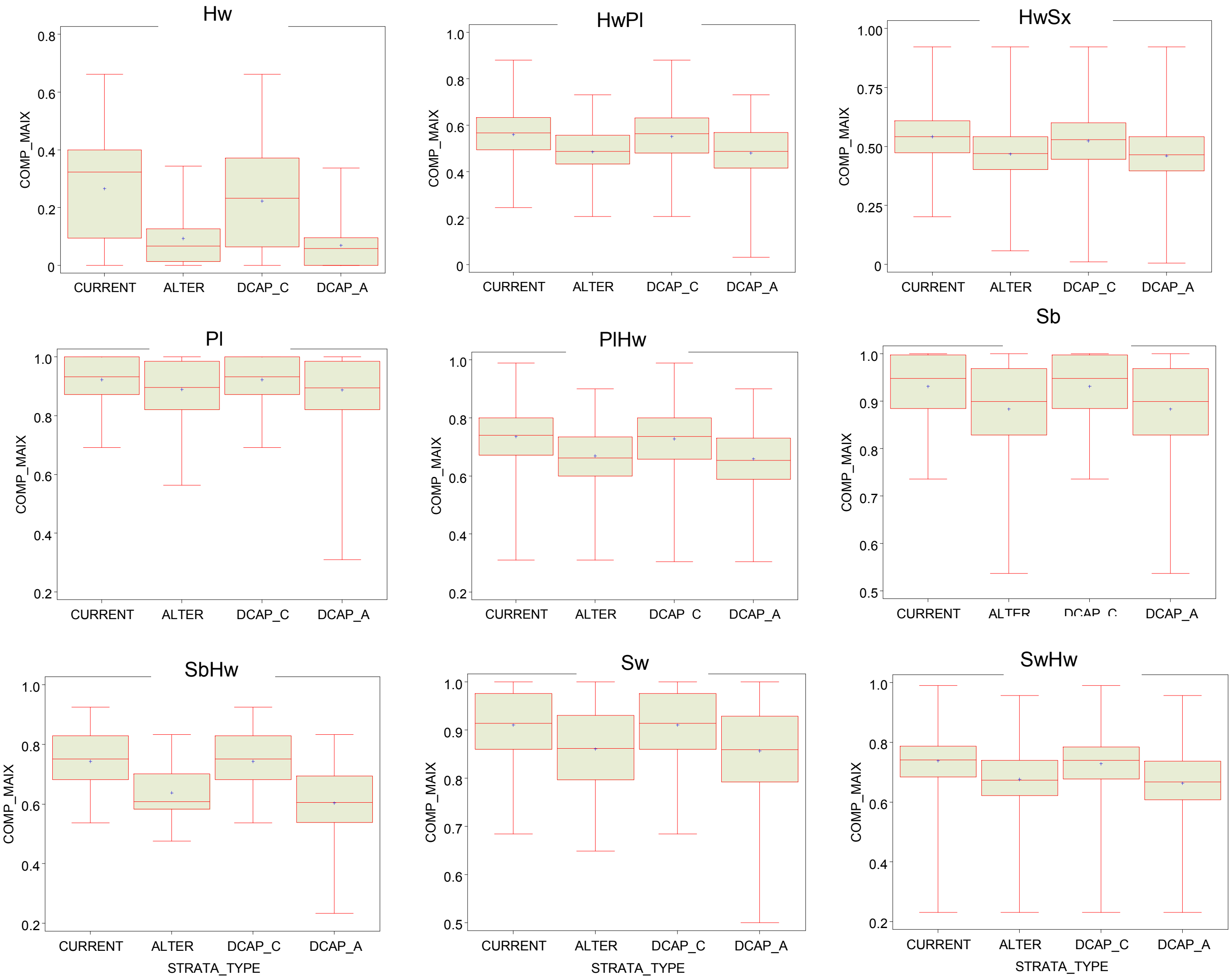

Figure 7: Variability in composition MAIs by considering the current stratification scheme vs. an alternate (30/60/90, deciduous cut off) and a deciduous cap of 6000sph on the current and the alternate stratification based on ground density. The sample sizes for each of these strata types are as presented in figure

3. Current 20/50/80 Stratification vs. 20/50/90 deciduous density cut-off vs. Stratification Based on Performance Age Stocking (based on ground measured densities)

We also considered stratifying based on percentage stocking. Here, we compared stocking thresholds of 20/50/80% deciduous percentage stocking thresholds (S_20) and 30/60/90% deciduous percentage stocking thresholds (S_30) versus the current stratifcation of 20/50/80% deciduous density thresholds (C) and an alternate scheme of 20/50/90 deciduous density cut-off.

Based on the ranking system used, our results do not show an improvement in deciduous MAI variation by stratifying with stocking. In confer MAI there is less variation in most of the strata under the S_30 stratification scheme (Tables 5 and 6 , Figures 9-11). There appears to be some value in using stocking thresholds if conifer MAI is the primary concern, but for deciduous MAI it is inferior to our current density based thresholds.

Stratification with stocking for the Hw stratum, is notably better than current stratification scheme. It is similar to the stratification scheme using a 90 percent deciduous density threshold between the D and DC strata as noted above. These analyses demonstrate that these alternative stratification schemes seem to have the most substantive impact on variation observed in the HW stratum.

Table 5 (Refer to Figures 9, 10 and 11): Table indicating the best stratification scheme, i.e. our current stratification of 20/50/80% deciduous density thresholds vs. 20/50/90% deciduous density cut-off vs. 20/50/80% and 30/60/90% deciduous percent stocking thresholds for each stratum in terms of the less variability in MAI.

Strata	**Dec MAI**	**Con MAI**	**Composition MAI**
Hw	S_30<S_20< D_20<C	S_30<S_20< D_20<C	S_30<S_20< D_20<C
HwPl	C< S_20=S_30< D_20	S_30<S_20< D_20<C	S_30< C < D_20<S_20
HwSx	C< D_20<S_20<S_30	S_30<C< D_20<S_20	S_20<C<D_20<S_30
Pl	C= D_20=S_20<S_30	No clear difference	C=D_20=S_20<S_30
PlHw	C= D_20<S_2<S_30	S_30< C= D_20<S_20	C=D_20<S_30<S_20
Sb	S_20< C= D_20<S_30	S_20<S_30< C= D_20	S_20< C=D_20<S_30
SbHw	C= D_20<S_30<S_20	S_30=S_20<C= D_20	C=D_20<S_30<S_20
Sw	C= D_20<S_20<S_30	S_30<S_20<C= D_20	C=D_20<S_20<S_30
SwHw	C= D_20<S_20<S_30	C= D_20<S_30<S_20	C=D_20<S_20<S_30

Table 6 (Refer to Table 5): Ranking of the different stratification schemes for each stratum. The highlighted cells indicate stratification schemes with least variation (In most cases the differences between the different stratification schemes were not much).

Strata	**Dec MAI**				**Con MAI**				**Composition MAI**			
	C	**D_20**	**S_20**	**S_30**	**C**	**D_20**	**S_20**	**S_30**	**C**	**D_20**	**S_20**	**S_30**
Hw	4	3	2	1	4	3	2	1	4	3	2	1
HwPl	1	4	2	2	4	3	2	1	2	3	4	1
HwSx	1	2	3	4	2	3	4	1	2	3	1	4
Pl	1	1	1	4					1	1	1	4
PlHw	1	1	3	4	2	2	4	1	1	1	4	3
Sb	1	2	2	4	3	3	1	2	2	2	1	4
SbHw	1	1	4	3	3	3	1	1	1	1	3	4
Sw	1	1	3	3	3	3	2	1	1	1	3	4

SwHw	1	1	3	3	1	1	4	3	1	1	3	4
TOTAL	**12**	**16**	**23**	**28**	**22**	**21**	**19**	**11**	**15**	**16**	**22**	**27**

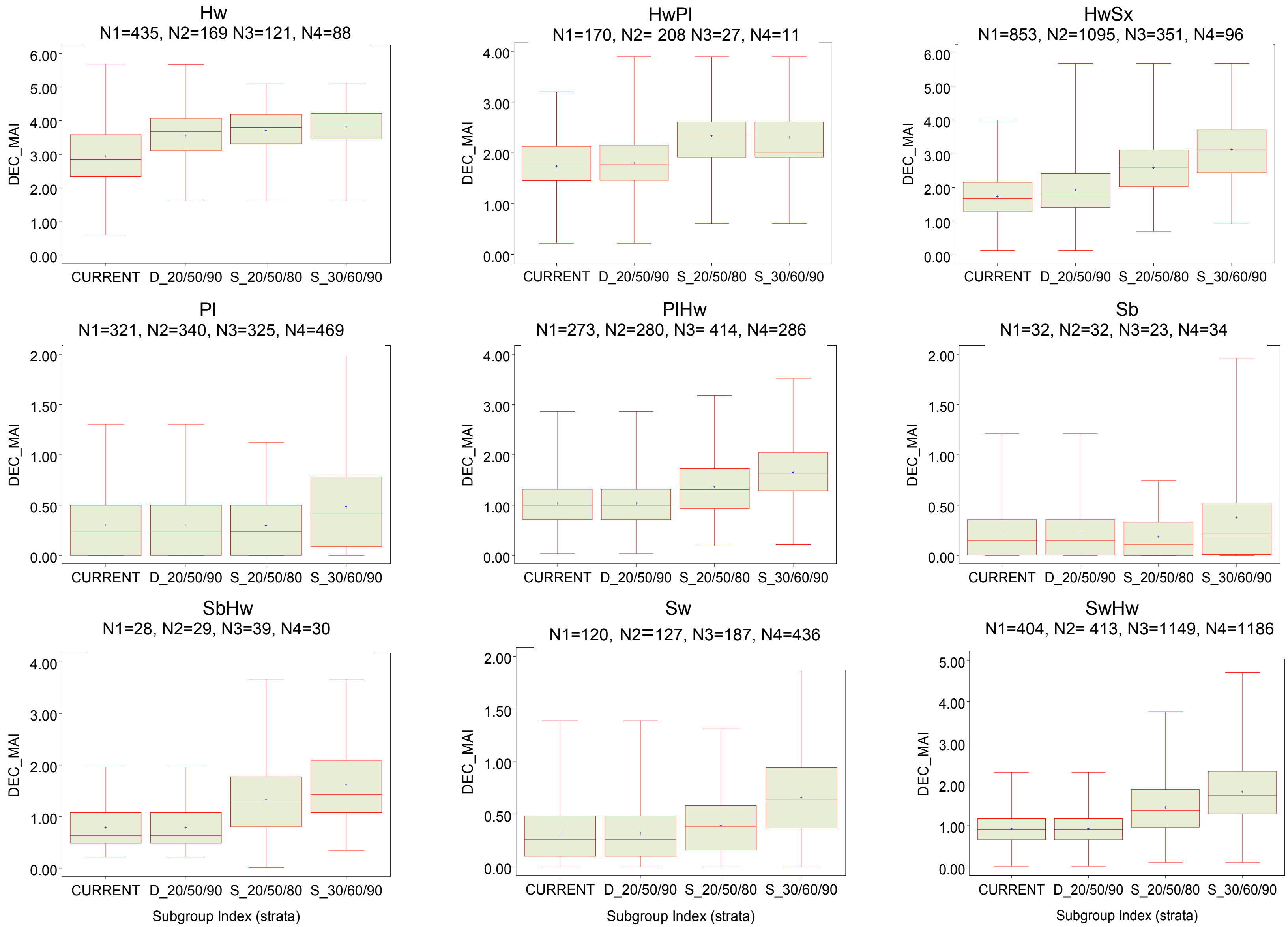

Figure 9: Variability in deciduous MAIs by considering the current stratification scheme of 20/50/80 deciduous density cut off vs 20/50/90 deciduous density cut off vs. 20/50/80 deciduous percent stocking cut off (S_20/50/80) and 30/60/90 deciduous percent stocking cut off (S_30/60/90) based on ground data. N1=current stratification sample size, N2=20/50/90 sample size, N3= S_20/50/80 sample size, N4= S_30/60/90 sample size.

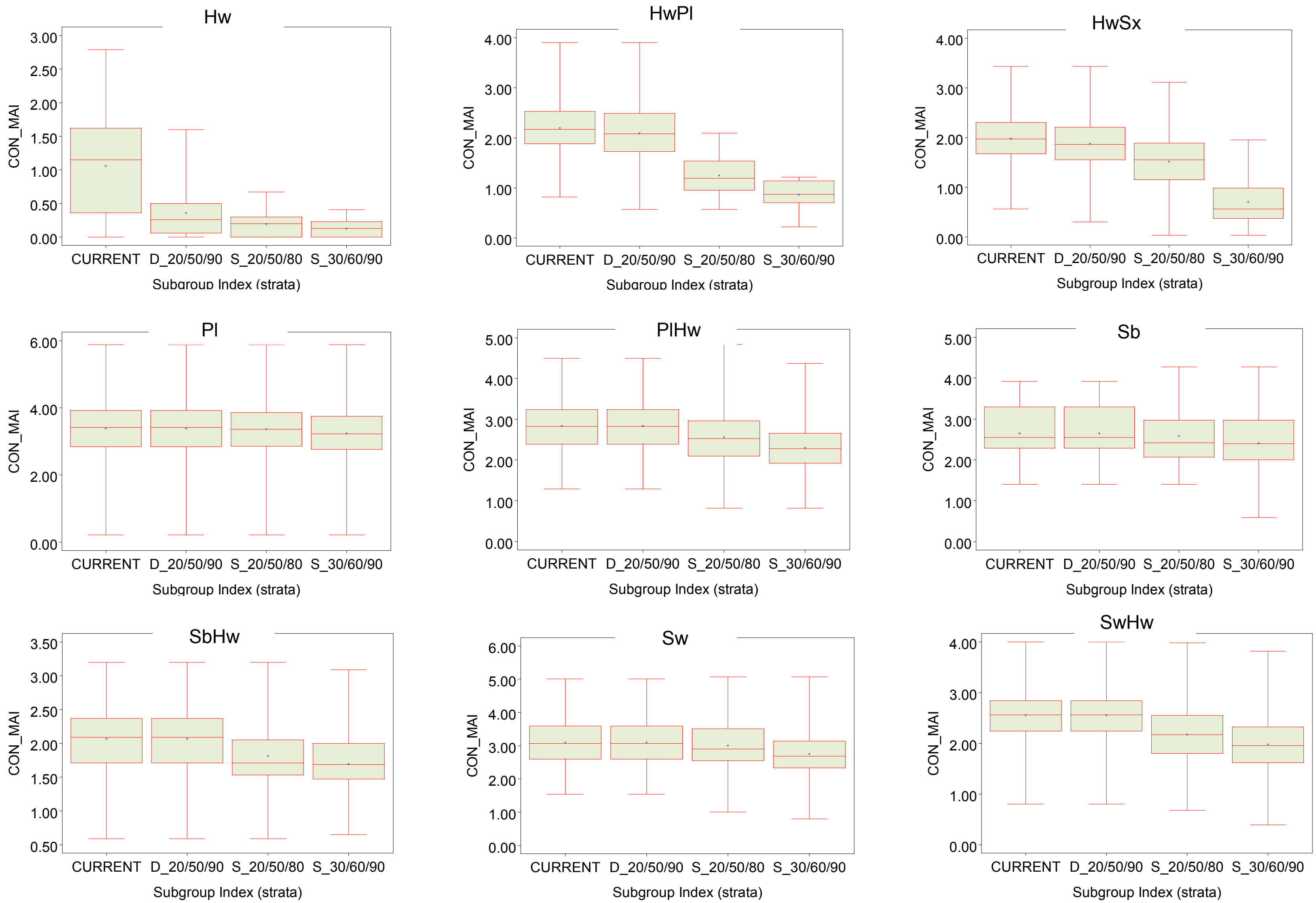

Figure 10: Variability in conifer MAIs by considering the current stratification scheme of 20/50/80 deciduous density cut off vs. 20/50/90 deciduous density cut off vs 20/50/80 deciduous percent stocking cut off (S_20/50/80) and 30/60/90 deciduous percent stocking cut off (S_30/60/90) based on ground data.

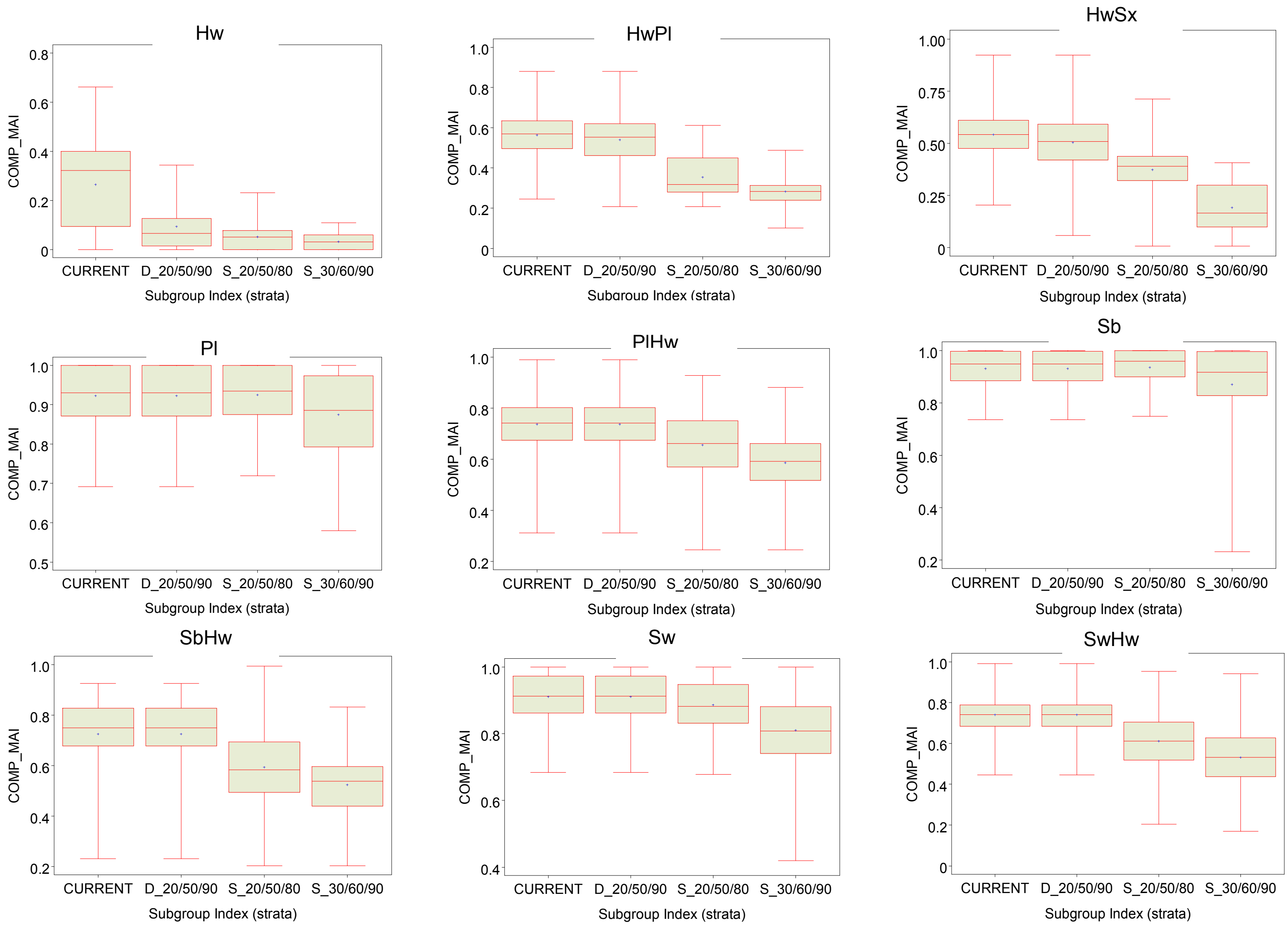

Figure 11: Variability in composition MAIs by considering the current stratification scheme of 20/50/80 deciduous density cut off vs 20/50/90 deciduous density cut off vs. 20/50/80 deciduous percent stocking cut off (S_20/50/80) and 30/60/90 deciduous percent stocking cut off (S_30/60/90) based on ground data.

4. Linking Performance Age Data to Future Yield Composition (MAI): GYPSY Simulations

4a. Performance Age Density Proportions to Forecast MAI Proportions (based on simulations)

To better understand the relationship between performance survey (~age 14) density and future volume at harvest, we used the GYPSY PASS Tool to estimate what the stratum would be based on the proportions of conifer and deciduous MAI out of the total MAI at conifer culmination. Targeted MAI thresholds were obtained from an analysis of the MAI Standards (Figure 12). The best fit generic thresholds between C, CD, DC and D were determined to be 20/50/70 percent deciduous MAI to total.

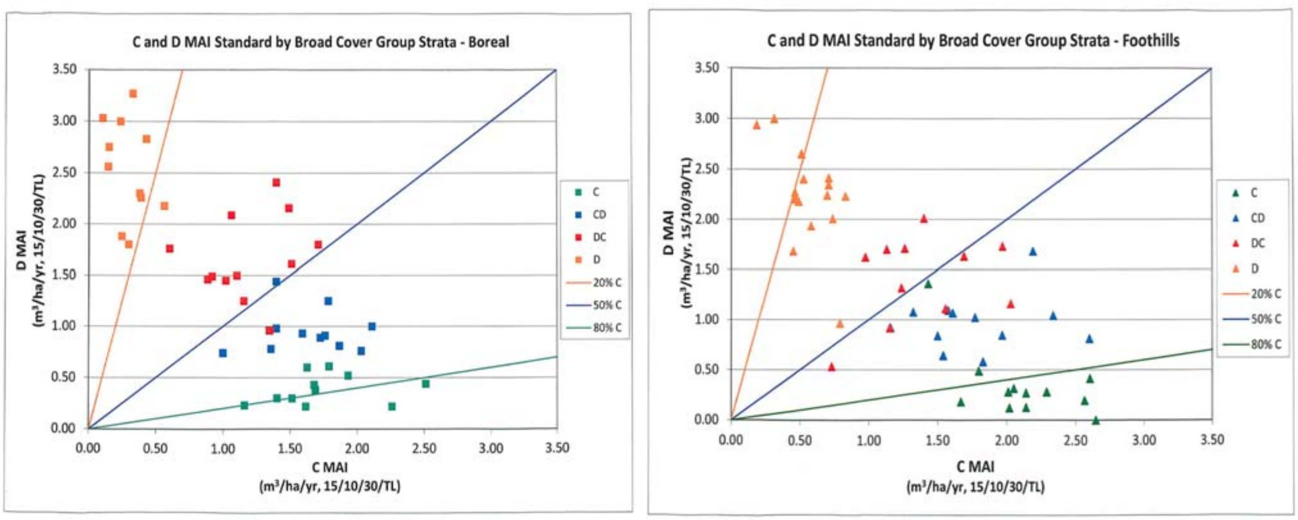

Figure 12: Conifer and deciduous MAI standard by broad cover group (D/DC/CD/C) strata

The intent of this exercise was to see what performance age conditions (primarily density and stocking proportions) provide the best relationships with these future strata. No RSA data was used in this exercise except to estimate a few parameters: these are simply projections of a range of starting conditions.

There were several GYPSY input assumptions we made for these projections. We turned the optional basal area inputs off. Our other work has shown that initial BA is not a strong driver from performance age to future conditions (see 2013/14 RSA Review Chapter on the GYPSY Sensitivity Analysis). Site index (at breast height age 50) was set to typical values of 20m for aspen, 17m for white spruce, and 19m for pine. Stocking scales non-linearly with density, but is strongly affected by the dispersion pattern: clumped trees will have low stocking at the same density, while dispersed trees will have higher stocking; random patterns will be intermediate. We computed the mean Morisita's dispersion index (MI, Feng et al. 2006) using the species counts in RSA ground plot data from the 2010/11 and 2011/12 aerial programs. MI is defined as a function of the number of plots (*n*) and the number of trees in a plot (*d*) with the summation across all the plots in each sampling unit within an opening.

(1) $$MI = n\,(\sum d^2 - \sum d\,/\,(\sum d)^2 - \sum d)$$

If the MI value is 1 then this indicates a random pattern, greater than 1 indicates clumping and less than 1 indicates a regular pattern. The mean MI's among the sample units in the 2010/11 and 2011/12 RSA data were 4.2, 2.5 and 4.8 for AW, SW and Pl respectively, indicating a generally clumped pattern at the scale of the regeneration plots ($10m^2$).

For density based stratification, stocking was calculated from the density and MI values using equation (2) (obtained from Feng et al. 2006). For stocking based stratification, density was calculated from stocking and MI using an iterative method (bisection), as it is difficult to invert Equation 2.

(2) $$S = 1 - e\left[-\left[\frac{\square 1 \square\square}{(1+\square\square)^{\square 2}}\right]^{\square 3 - a4MI}\right]$$

Here, S is stocking, D is density (sph), A is the area in ha (A=0.001 ha), MI is the dispersion factor, and a1 – a4 are parameter estimates. We used the values a1=1.7273, a2=0.7608, a3=1.0582 and a4=0.0353 generated by Feng et al. (2006). These density, stocking, and site index values were input into the PASS tool at a stand age of 14 years (performance age) and the stands projected to culmination.

Figure 13 shows the age 14 density of deciduous (aspen) on the vertical axis and density white spruce or pine on the horizontal axis. Other GYPSY inputs were SI=20, 17 and 19 m for aspen, white spruce and pine respectively and uniform stocking for spruce and pine, and random for aspen were chosen.

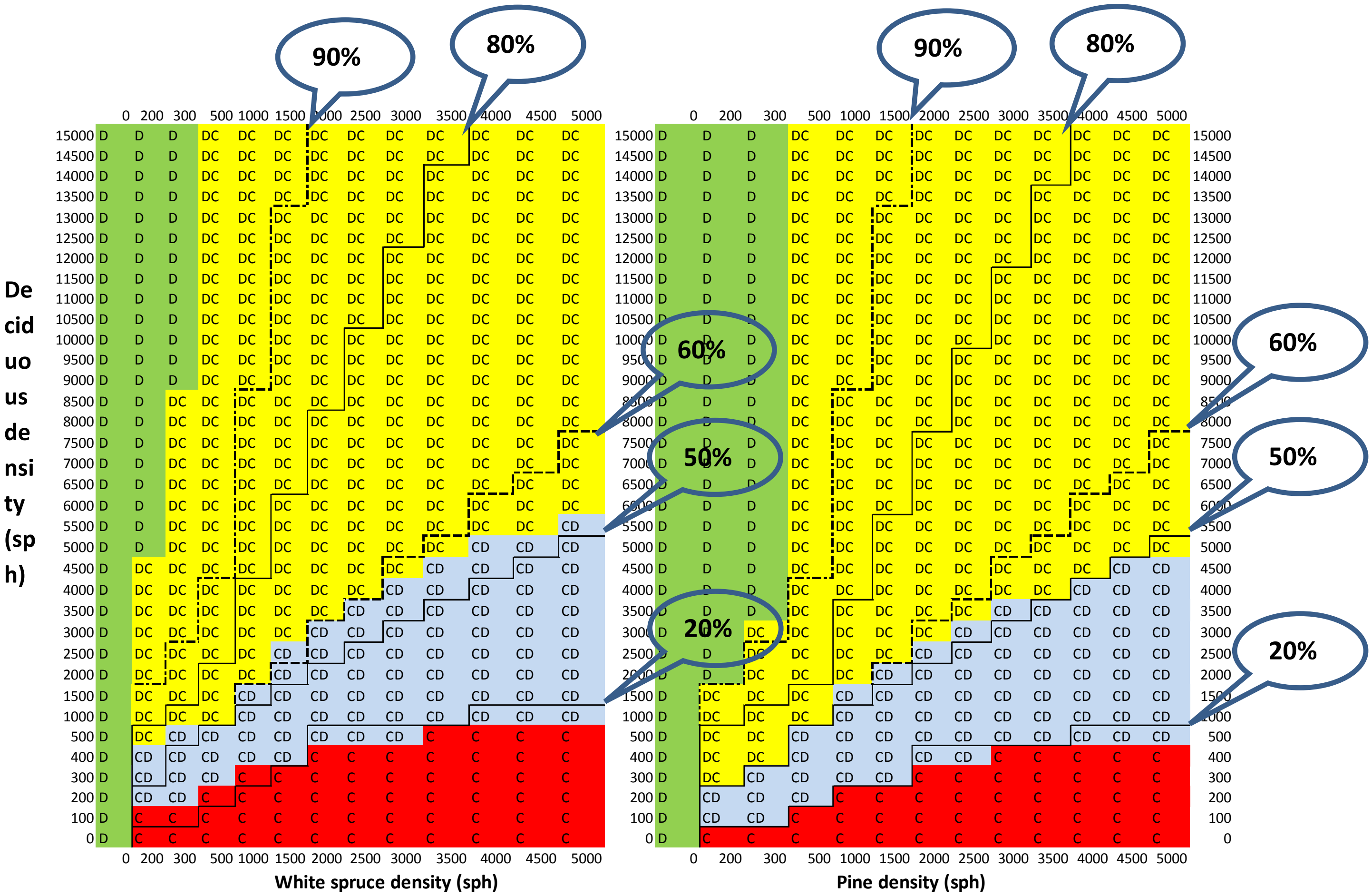

Figure 13: GYPSY output, showing predicted future stratum (D=green, DC=yellow, CD=blue, C=red) at <u>conifer</u> culmination (GYPSY criteria are 20/50/80% of total MAI at culmination). Axes are deciduous and conifer density (sph) at age 14 (performance age), solid lines represent age 14 density-based strata boundaries (20/50/80% conifer by density), dotted lines show 90 and 60% deciduous density strata boundaries, also by age 14 density.

It appears that 20% and 50% age 14 density in deciduous are reasonable thresholds between C and CD and between CD and DC strata. There is some indication that 60% deciduous density might be a better boundary between CD and DC for white spruce stands. These result in similar categories as GYPSY outputs at conifer culmination. However, 80% deciduous by density does not work well at all for the DC to D boundary. 90% is better, 95% is slightly better yet (not shown). Possibly a 200 to 300 sph conifer criterion would work best here.

4b. Performance Age Density Proportions, with conifer cap for D stratum, to Forecast MAI Proportions (based on ground measured densities)

To help understand which density ranges are important, we compiled a histogram of densities found in all the sampling units in the 2010/11 and 2011/12 programs (Figure 14). For ground data, most (~90%) of the densities were below 10000 sph for deciduous species, and below 3000 sph for white spruce and pine.

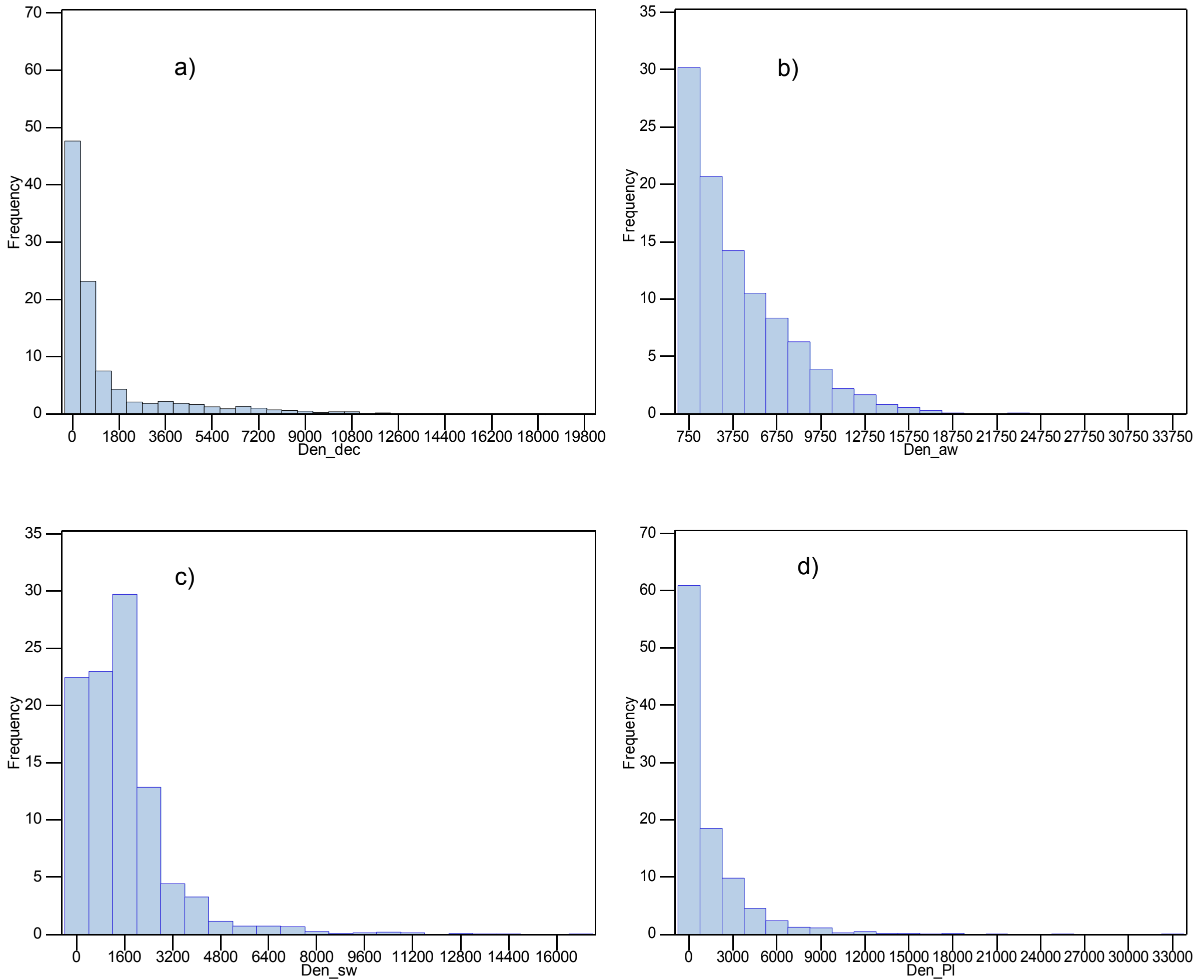

Figure 14: a) shows the distribution of deciduous density from *aerial* interpreted density in 2011 and 2012 RSA performance surveys, b) shows the distribution of deciduous density from *ground data* in 2011 and 2012 RSA performance surveys, c) shows the distribution of white spruce density from *ground data* in 2011 and 2012 RSA performance surveys, d) shows the distribution of pine density from *ground data* in 2011 and 2012 RSA performance surveys.

We therefore performed a different analysis to investigate if a minimum conifer density (another form of a "cap" rather than a percentage threshold) will impact our current stratification. We initially tested a cap of 200 sph, meaning that if conifer density was more than 200 sph and the broad cover group for that sampling unit was initially D, then the sample unit became a DC; at all conifer densities less than the conifer cap that were previously D, remained D. We thereafter stratified by 20/60/80% deciduous density thresholds, 20/50/80% deciduous density thresholds and 20/40/80% deciduous density thresholds and compared these with our current stratification scheme and the earlier "alternate" stratification of 30/60/90% deciduous density thresholds without the conifer cap.

It appears that 20/60/80% deciduous density thresholds with a conifer threshold of 200 sph reduced variability in deciduous and composition MAI (this scheme is shown as 200/60/80 in Tables 7-8 and

Figures 15-17 below), while the 30/60/90% deciduous density threshold (no C cap) scheme worked best for conifer MAI. Similar to results above, the largest impact observed by these analyses is in the defining threshold between the D and the DC strata. We also tried a threshold of 300 sph of conifer density between the D and DC boundary but the result wasn't any different than with 200 sph.

Table 7 (Refer to Figures 15, 16 and 17): Table indicating the best stratification scheme (i.e. our current stratification of 20/50/80% deciduous density thresholds (C) vs. alternates of 30/60/90% deciduous density thresholds (A), 20/60/80% deciduous density thresholds with a conifer threshold (200/60/80), 20/50/80% deciduous density thresholds with a conifer threshold (200/50/80) and 20/40/80% deciduous density thresholds (200/40/80) with a conifer threshold) for each stratum in terms of the less variability in MAI.

Strata	**Deciduous MAI**	**Conifer MAI**	**Composition MAI (Conifer MAI/Total MAI)**
Hw	C<A<200/40/80=200/50/80=200/60/80	C<A<200/60/80=200/50/80=200/40/80	C<A<200/40/80=200/50/80=200/60/80
HwPl	200/60/80=200/50/80<200/40/80=A<C	200/60/80<200/50/80=200/40/80<A<C	200/60/80=200/50/80<200/40/80<C<A
HwSx	200/60/80=200/40/80<200/50/80=A<C	200/60/80<200/50/80=200/40/80<A<C	200/60/80<200/50/80<200/40/80<A<C
Pl	A<200/60/80=200/50/80=200/40/80=C	No clear difference	A<200/60/80=200/50/80=200/40/80 =C
PlHw	200/40/80<A<200/50/80=C<200/60/80	200/50/80=200/40/80=C<A<200/60/80	200/50/80=200/40/80=C<A<200/60/80
Sb	A<200/60/80=200/50/80=200/40/80=C	A<200/60/80=200/50/80=200/40/80 =C	A<200/60/80=200/50/80=200/40/80 =C
SbHw	200/40/80<200/50/80=C<A<200/60/80	200/50/80=200/40/80=C<A<200/60/80 C	200/40/80<200/50/80=C<A<200/60/80
Sw	A<200/60/80=200/50/80=200/40/80=C	200/60/80=200/50/80=200/40/80=C<A	A<200/60/80=200/50/80=200/40/80 =C
SwHw	A=200/40/80<200/50/80=C<200/60/80	No clear difference	200/40/80<A<200/50/80=C<200/60/80

Table 8 (Refer to Table 7): Ranking of the different stratification schemes for each stratum. The highlighted cells indicate stratification type with least variation (In most cases the differences between the different stratification schemes were not much).

Strata	**Dec MAI**					**Con MAI**					**Composition MAI**				
	C	**A**	**200/40/80**	**200/50/80**	**200/60/80**	**C**	**A**	**200/40/80**	**200/50/80**	**200/60/80**	**C**	**A**	**200/40/80**	**200/50/80**	**200/60/80**
Hw	3	2	1	1	1	3	2	1	1	1	3	2	1	1	1
HwPl	1	2	2	3	3	1	2	3	3	4	2	1	3	4	4
HwSx	1	2	2	2	2	1	2	3	3	4	1	2	3	4	5
Pl	1	2	1	1	1						1	2	1	1	1
PlHw	2	3	3	2	1	3	2	3	3	1	3	2	3	3	1
Sb	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1
SbHw	3	2	4	3	1	3	2	3	3	1	3	2	4	3	1
Sw	1	2	1	1	1	2	1	2	2	2	1	2	1	1	1
SwHw	2	3	3	2	1						2	3	4	2	1
TOTAL	**15**	**20**	**18**	**16**	**12**	**14**	**13**	**16**	**16**	**14**	**17**	**18**	**21**	**20**	**16**

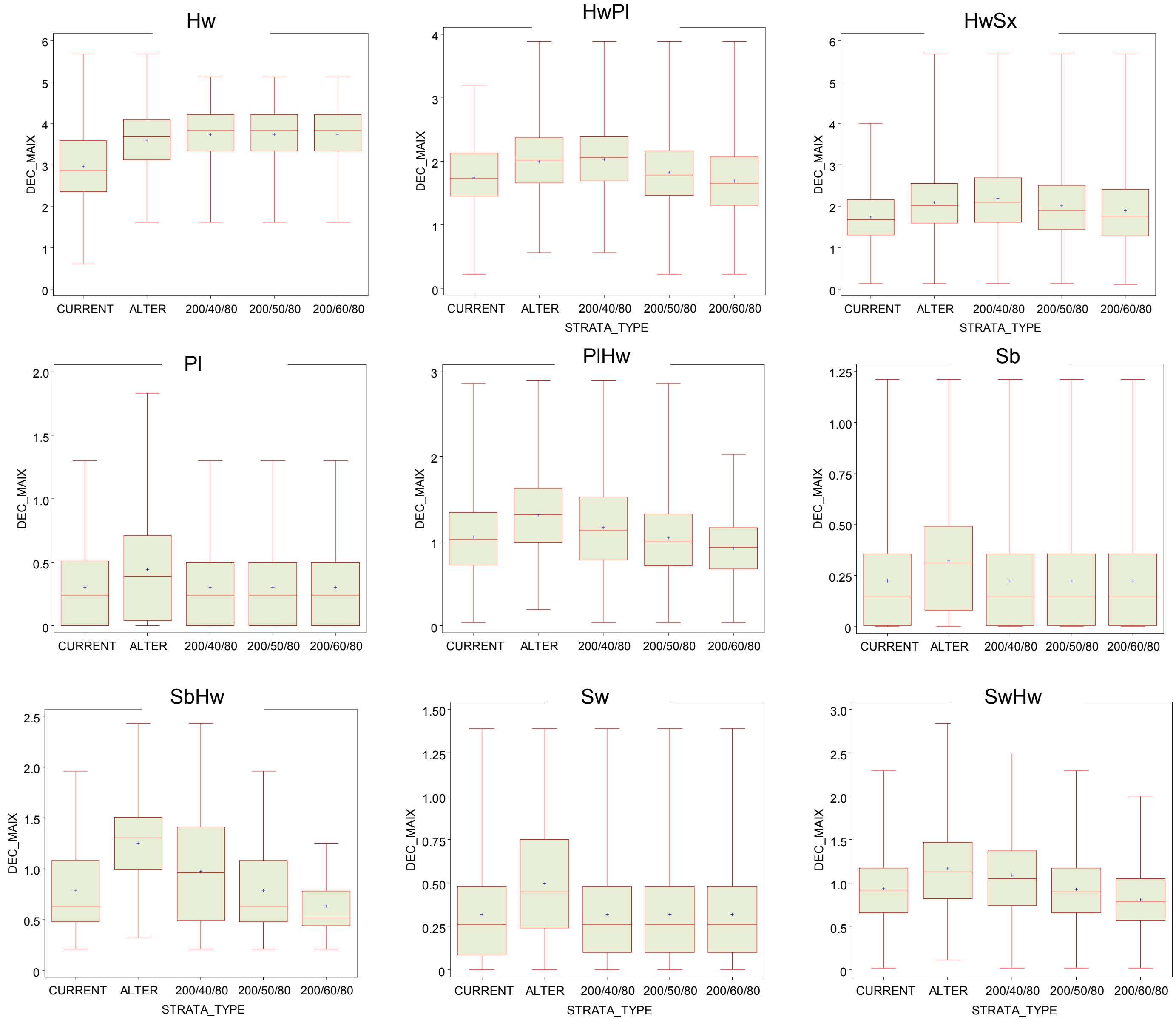

Figure 15: Variability in deciduous MAIs by considering the current stratification scheme (20/50/80) and other stratification scheme based on ground data.

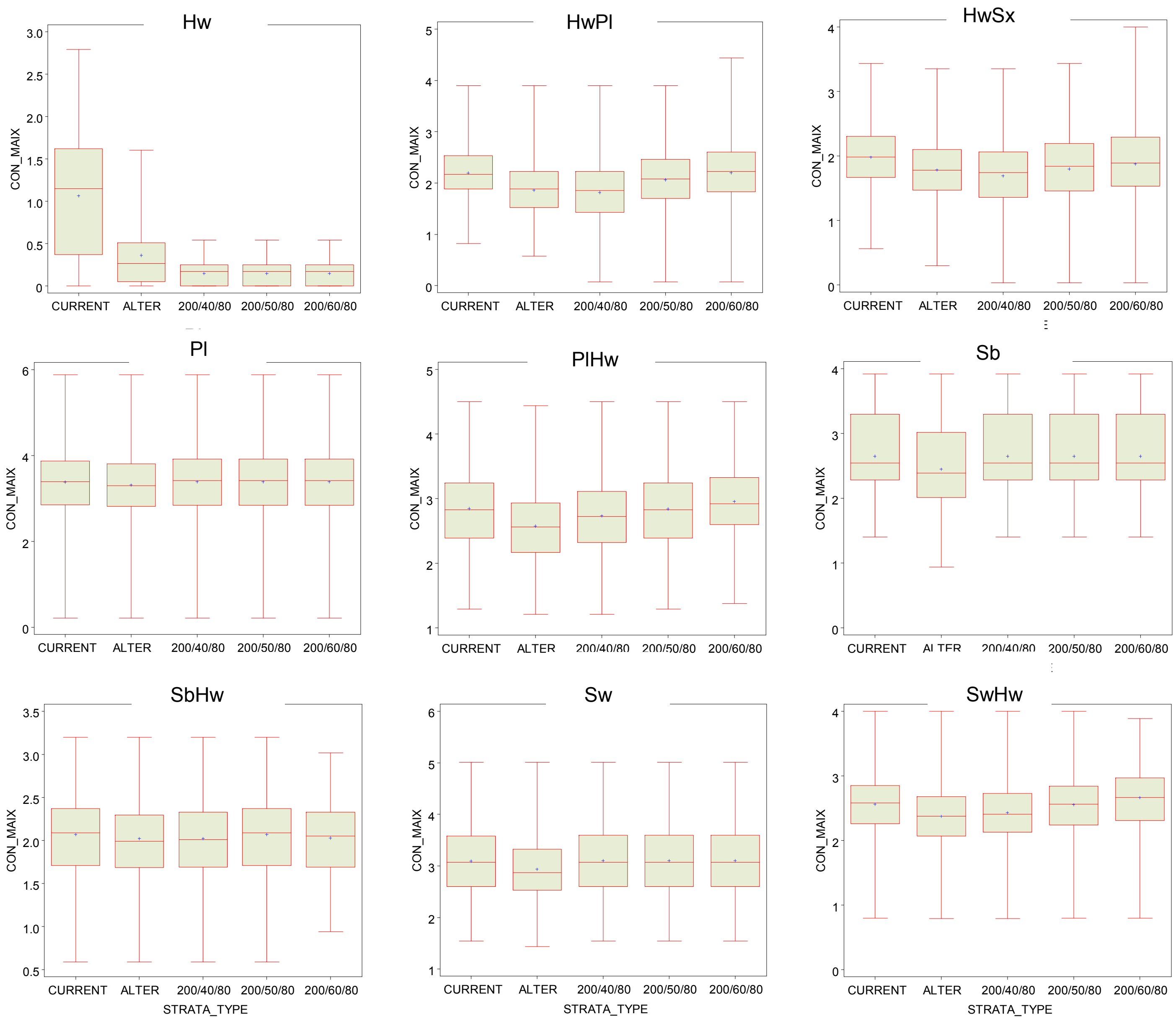

Figure 16: Variability in conifer MAIs by considering the current stratification scheme (20/50/80) and other stratification schemes based on ground data.

COMP_MAIX = CON_MAI/TOTAL_MAI

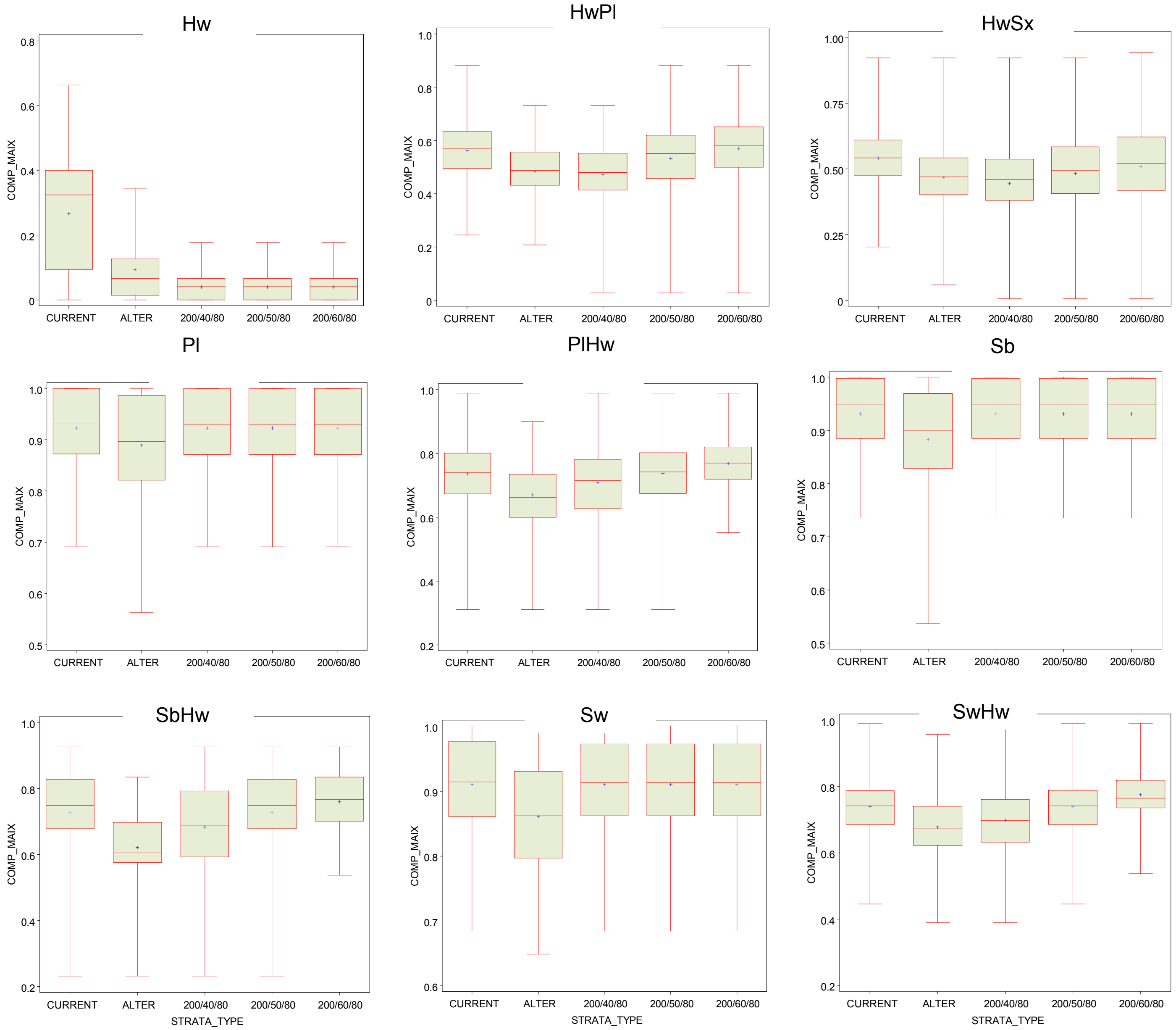

Figure 17: Variability in composition MAI (conifer MAI/Total MAI) by considering the current stratification and other stratification schemes based on ground data.

4c. Impact of Spatial dispersion and Site Index assumption on Performance Age Density Proportions relationship to Forecast MAI Proportions (based on simulations)

The above results represent average or median stands, but there is considerable variation in site quality and tree dispersion among stands. Consequently, we investigated the impact, first, of varying the dispersion represented by the Morisita index (MI), and, second, the site index on the future stratum (D, DC, CD, C), again using the criteria 20/50/70% of total MAI at culmination. We attempted to find suitable density or stocking-based performance age thresholds which would reliably yield the GYPSY strata at maturity despite these variations in input values.

Using starting average MI's of 4.2, 2.5 and 4.8 for aspen, white spruce and pine respectively, we varied these MI's: low MI was half of the average MI and high MI was twice the average MI for a given species. Equation 2 was used to convert density to stocking at various MI values; iterative methods were used to convert stocking to density. We used the typical site index values (aspen 20m, 17m for white spruce and 19m for pine) and restricted our analysis to factorial combinations (low, average, high MI) of aspen and white spruce MI, and aspen and pine MI.

There is one marked formatting difference in the graphs we generated from this analysis: the colored cells here are used to delineate the different strata predicted by the chosen performance age density or stocking thresholds. In previous graphs, the colors highlight the strata predicted by GYPSY. This difference was simply for efficiency: with so many graphs to generate, it was more effective to use Excel's conditional formatting to designate the predicted stratum with colors than to draw borderlines, as was done for the previous graphs. We could change the threshold performance density or stocking thresholds, then immediately evaluate the match to the GYPSY predictions of strata (the D, DC, CD, D characters).

The resulting graphs include low MI and typical SI, average MI and typical SI, and high MI and typical SI for AW, SW and PL for both density and stocking based stratification (Figures 17 and 18). Our results indicate that 20%, 50% and 80% age 14 stocking in deciduous are reasonable thresholds between C and CD, CD and DC and DC and D strata. However for density based stratification 20%, 50% and 90% deciduous are reasonable thresholds between C and CD, CD and DC and DC and D strata.

In the second analysis, we investigated the change in predicted future stratum for less or more productive sites while holding dispersion (MI) constant at the mean values. The combinations tested were low Aw SI vs. low Sw SI, low Aw SI vs. average Sw SI, average Aw SI vs. low Sw SI and average Aw SI vs. average Sw SI. The density and stocking values were calculated as defined above. The same set of combinations was tested for aspen and pine and both results shown in Figures 19-20. We observed that again 20%, 50% and 80% age 14 stocking in deciduous are reasonable thresholds between C and CD, CD and DC and DC and D strata. However for density based stratification 20%, 50% and 90% deciduous are reasonable thresholds between C and CD, CD and DC and DC and D strata. The 20/50/90% deciduous by density works best for low aspen site with average or typical spruce site index. This scheme also seems to work well for low aspen site vs. typical pine site index.

This analysis demonstrated that the variation of dispersion and productivity did have an impact on the best fit thresholds. The resulting thresholds discussed here were determined to be overall reasonable fit. When compared to anyone of the factorial combinations of starting conditions the fit may not be evident.

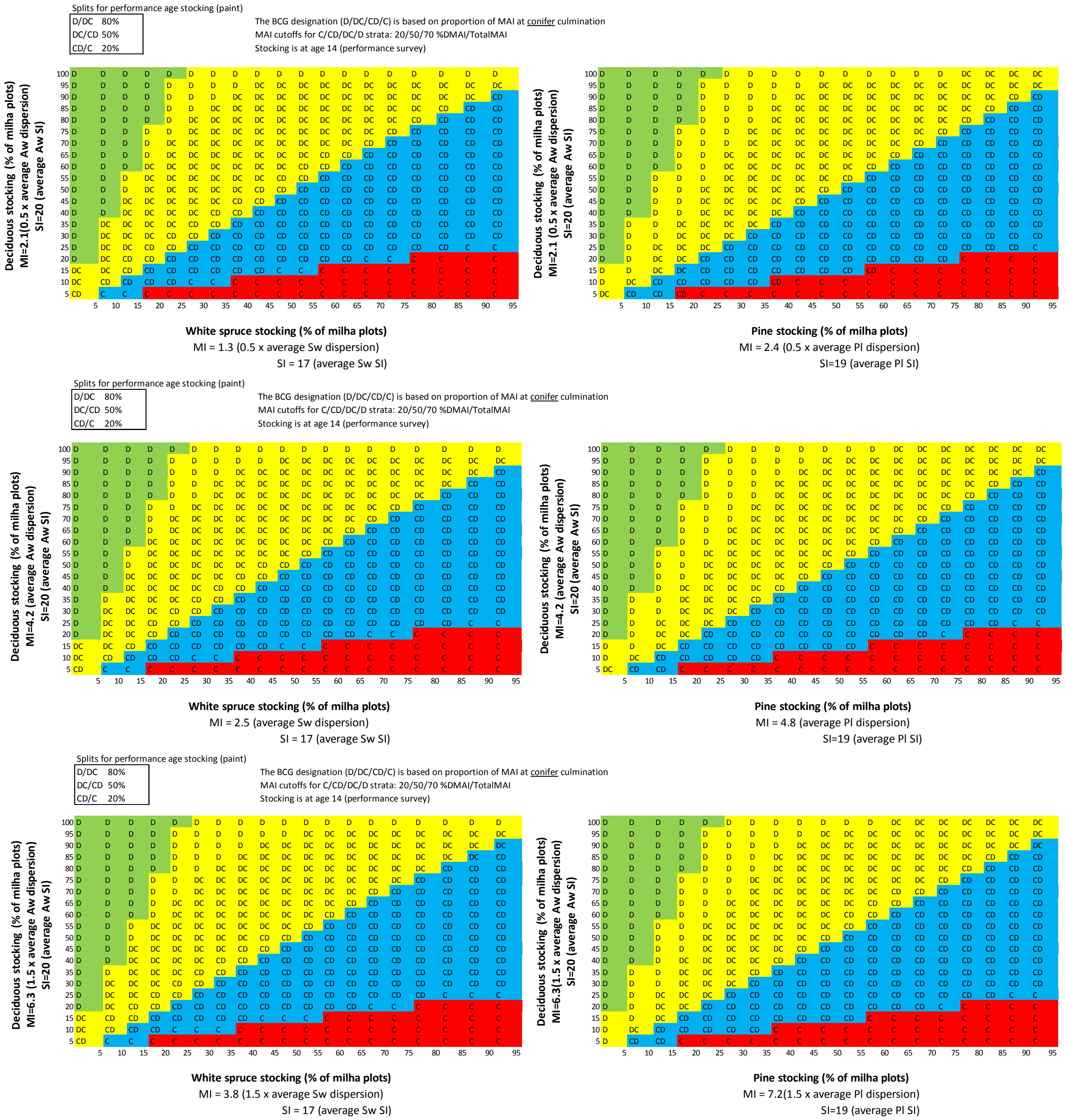

Figure 17: GYPSY Output, showing predicted future stratum (D, DC, CD, C) at conifer culmination (GYPSY criteria are 20/50/70% of total MAI at culmination). Axes are deciduous and conifer stocking (sph) at age 14 (performance age), red, blue and yellow cells indicates 20, 50 and 80% deciduous stocking boundaries, cells highlighted green shows strata above the 80% deciduous stocking thresholds.

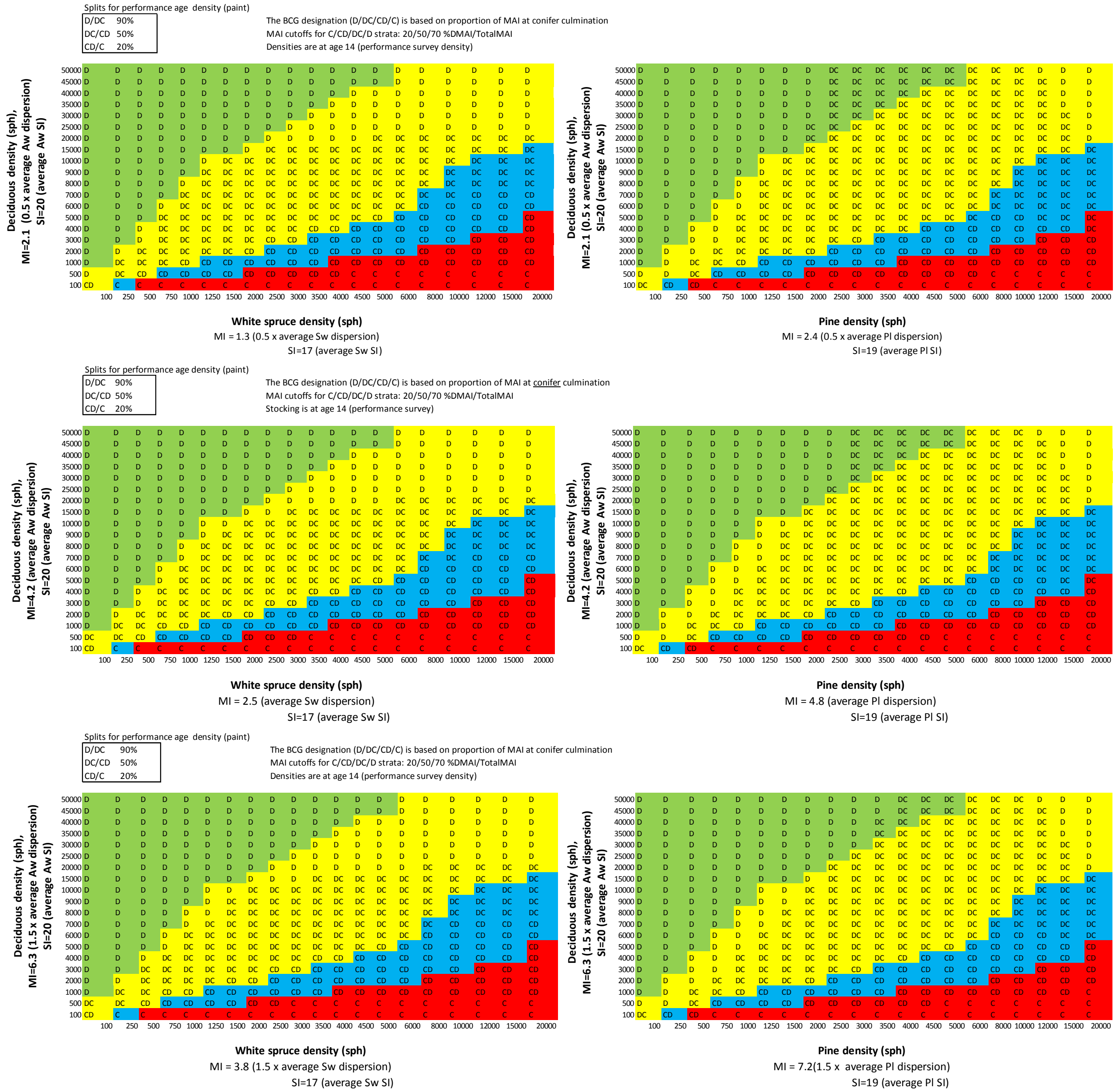

Figure 18: GYPSY Output, showing predicted future stratum (D, DC, CD, C) at conifer culmination (GYPSY criteria are 20/50/70% of total MAI at culmination). Axes are deciduous and conifer density (sph) at age 14 (performance age), red, blue and yellow cells indicates 20, 50 and 90% deciduous density boundaries, cells highlighted green shows strata above the 90% deciduous density thresholds.

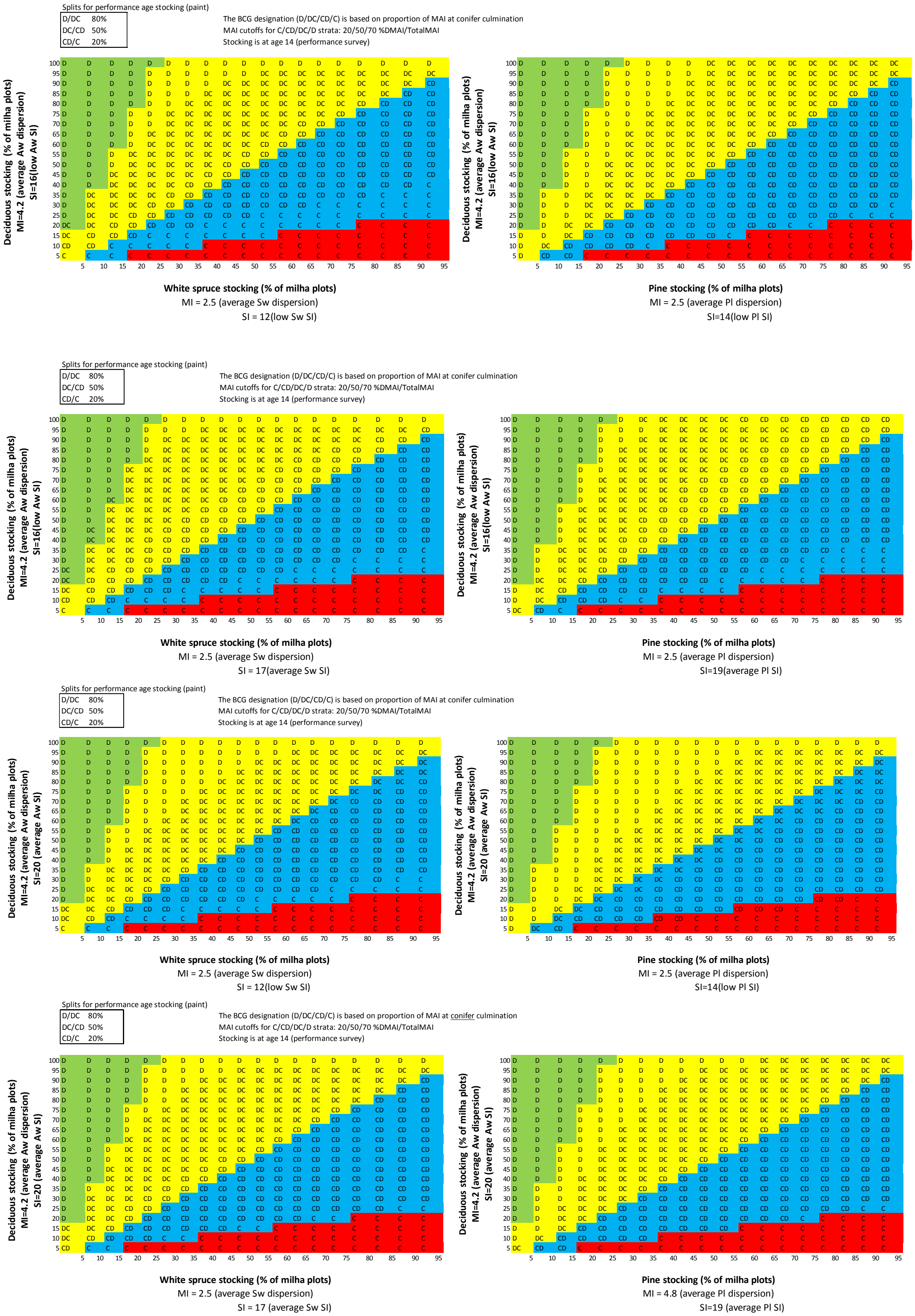

Figure 19: GYPSY Output, showing predicted future stratum (D, DC, CD, C) at conifer culmination (GYPSY criteria are 20/50/70% of total MAI at culmination). Axes are deciduous and conifer stocking (sph) at age 14 (performance age), red, blue and yellow cells indicates 20, 50 and 80% deciduous stocking boundaries, cells highlighted green shows strata above the 80% deciduous stocking thresholds.

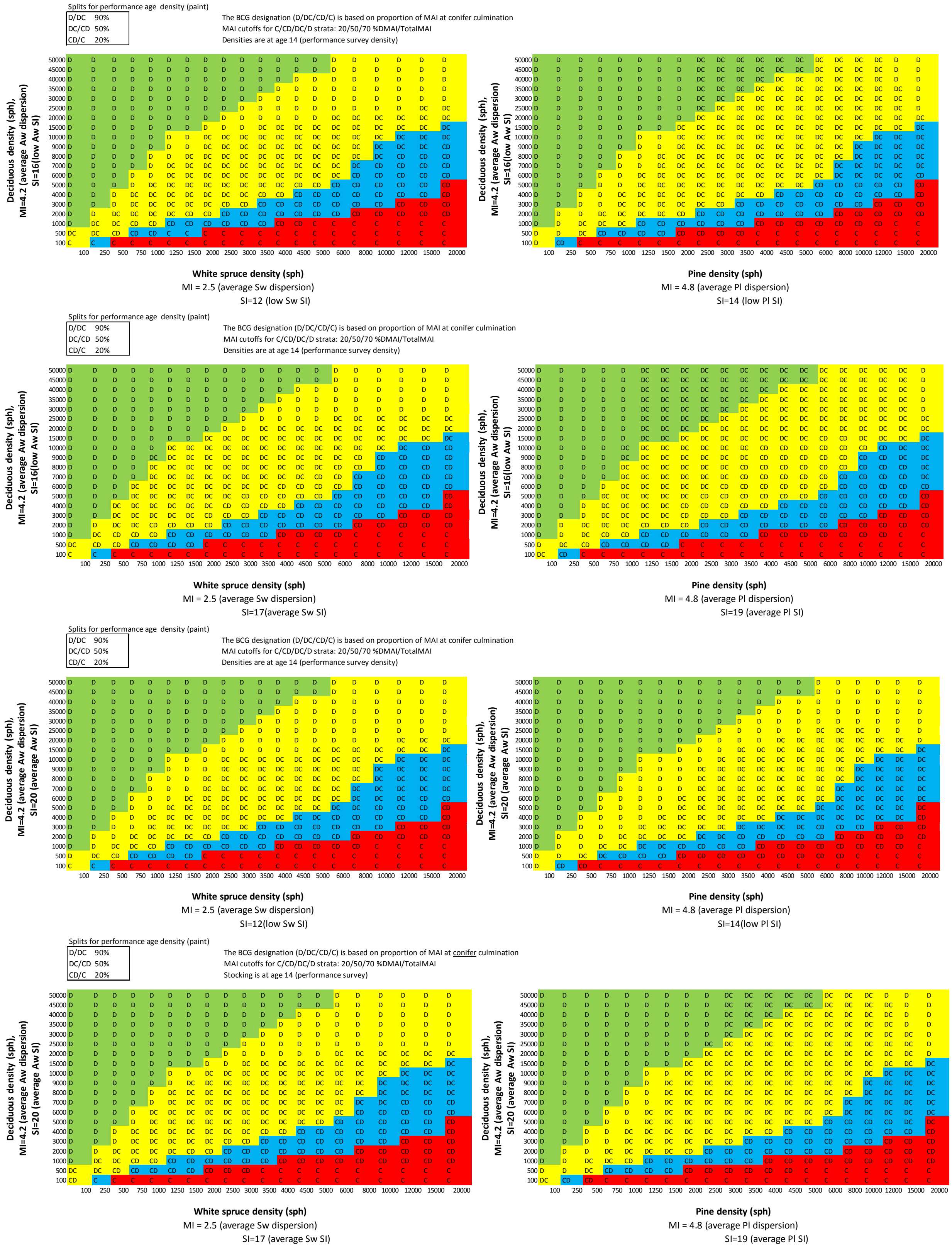

Figure 20: GYPSY Output, showing predicted future stratum (D, DC, CD, C) at conifer culmination (GYPSY criteria are 20/50/70% of total MAI at culmination). Axes are deciduous and conifer density (sph) at age 14 (performance age), red, blue and yellow cells indicates 20, 50 and 90% deciduous density boundaries, cells highlighted green shows strata above the 90% deciduous density thresholds.

Summary and conclusions

- There is no clear difference in terms of the variability in MAI between our current stratification of 20/50/80 and the alternate stratification scheme of 30/60/90% deciduous density thresholds in RSA 2010/11-2011/12 performance surveys. However, simple projections with GYPSY suggest 90% deciduous density of the total density at age 14 is a better boundary between DC and D.
- We found that a deciduous cap of 6000 sph did not reduce variation in MAI. This might be due to the fact that there were few deciduous densities equal or greater than 6000 sph in the 2011 to 2012 RSA performance surveys.
- Stratifying by stocking was not observed to be better than stratification by density when evaluating within stratum variation and ability to link performance age attributes to forecast MAI proportions.
- Different levels of dispersion does not greatly affect the future stratum, however different site productivity levels does have a little impact on the predicted future stratum. The 20/50/90% deciduous density/total scenario appears to be a reasonable threshold scheme for density based stratification. For stocking based stratification, 20/50/80% deciduous stocking/total worked best.

Literature Cited

1. Feng Z., Stadt K. J., Lieffers V. J., 2006. Linking juvenile white spruce density, dispersion, stocking, and mortality to future yield. Can. Jour. For. Res. 36: 3173-3182

Appendix 5: Evaluation of Photointerpreted Stocking

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update

froese forestry consulting inc.

Company: Alberta Forest Growth Organization, Strata Subcommittee
From: Katrina Froese
Date: July 23, 2014 Revised October 10, 2014
Re: Evaluation of Photo-Interpreted Stocking

Objective

The objective of the stocking re-interpretation is to examine whether using stocking for photo interpretation is more accurate (repeatable) than density.

Analysis

A total of 74 sampling units from 4 companies were re-interpreted as follows:

- No changes to linework (SU boundaries remain the same);
- Re-interpret density by species group; and
- Interpret percent stocking by species group, and for all conifers combined.

Ground data were taken from RSA compilers provided by each company. Compiled data were taken from the GYPSY_input table; percent coniferous stocking (ground) was manually compiled from the dat_PlotBasic tables.

	Photo-Interpreted Stratum									
Company	Hw	HwPl	HwSx	Pl	PlHw	Sb	SbHw	Sw	SwHw	Total
ALPAC	6		11		1					18
APLY	1		7	1			1	3	5	18
BRL	1			6	2	1		1		11
SUNDRE		9		11	7					27
Total	8	9	18	18	10	1	1	4	5	74

For simplicity's sake, analysis was restricted to comparison between overall coniferous, overall deciduous, and pine.

- Black and white spruce were obviously confused in several of the re-interpreted SUs, likely because interpreters were not provided with silviculture records (as is generally the norm); this would affect results for these species in a non-meaningful way.
- Proportion of overall conifer vs. deciduous species is important in describing species composition in order to assign stands to a broad cover group class.

Species composition (the relative proportion of coniferous vs. deciduous presence) was calculated as deciduous density/stocking divided by total density/stocking, expressed as a percent. For example:

- An SU with 2,000 sph of deciduous and 2,000 sph of coniferous (4,000 sph total) would be considered 50% deciduous.
- An SU with 100% stocking to deciduous and 100% stocked to coniferous (200% total) would also be considered 50% deciduous (and implicitly 50% coniferous, i.e. a 50-50 mix). This isn't how we normally think about stocking proportions and this may deserve additional consideration.

Percent difference between ground data and interpreted attributes were calculated for each SU. The following summary statistics were calculated:

- Average – the average percent difference between ground and aerial results;
- Standard deviation – distribution of the differences around the mean, or how variable the differences are from one observation to the next: e.g. 68% of differences are within +/- X% of the mean.
- Mean absolute deviation – the average of the absolute differences; sometimes outages in two directions average out and the mean difference is zero – what this metric tells us is the mean departure from the ground (actual) data regardless of whether it's an over or under estimate.

Results

Results by SU were presented in separate handouts; a summary of the results by interpreted stratum is provided in the following table. It appears that interpreted stocking is better aligned with ground sampled stocking than interpreted density is with ground sampled density. The absolute difference is lower for stocking in all cases except for one, indicating that the magnitude of % outages (regardless of whether positive or negative) is on average, greater for density than for stocking. Also, the standard deviation of the differences is lower for stocking, indicating less variability in outages. For both stocking and density, the mean difference tends to be negative, indicating a bias towards undercalling both density and stocking during photo interpretation. The exception may be overall conifer stocking, which is unbiased when examined across all strata, and shows low bias by stratum. The negative bias is greater for deciduous species, which results in a similar bias when predicting species composition (species composition is biased towards undercalling deciduous content).

Stocking-Based Stratum	No. of SUs	Deciduous						Coniferous						Proportion					
		Stocking			Density			Stocking			Density			Stocking			Density		
		Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD
Hw	8	-5	25	17	-44	48	56	8	27	21	-21	66	60	-4	8	7	-12	19	13
HwPl	9	-11	29	22	2	73	49	-3	9	8	-43	27	45	-3	8	6	10	15	14
HwSx	18	-30	38	41	-47	72	74	2	11	8	-28	30	35	-12	10	13	-23	25	29
PlHw	10	-5	42	37	-43	39	47	-5	18	12	-36	38	47	-2	9	7	-2	12	8
SwHw+SbHw	6	-46	18	46	-54	21	54	9	19	13	24	39	34	-17	8	17	-21	6	21
Pl	18	-63	26	63	-78	19	78	-5	17	12	-24	60	50	-13	10	13	-13	14	14
Sw+Sb	5	-46	35	46	-62	33	62	-10	38	28	-16	34	29	-10	15	16	-16	19	21
Total	74																		

Avg = average % difference between aerial and ground data; Std = standard deviation of the difference; MAD = mean absolute deviation.

Addition October 10, 2014

The Strata Subcommittee requested additional analysis of this dataset. Additional analysis involved re-assigning strata based on interpreted percent stocking, then creating the same outputs from the first round of analysis. The purpose of this analysis was to examine whether using a revised stratification would result in lower variability in outages on a stratum-by-stratum basis. Stocking was selected as the preferred method for assigning strata based on work completed in August 2014 (see the August 27, 2014 update for rationale).

Changes to stratum assignment are summarized in the table below. In both cases, strata were assigned using photo-interpreted attributes. Changing from a density-based metric (20/50/80 density proportions) to a stocking-based metric (also 20/50/80 stocking proportions) resulted in re-assignment of many SUs from deciduous-leading to conifer-leading strata.

Density-Based Stratum	No. of SUs	Deciduous						Coniferous						Proportion					
		Stocking			Density			Stocking			Density			Stocking			Density		
		Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD
Hw	8	-5	25	17	-44	48	56	8	27	21	-21	66	60	-4	8	7	-12	19	13
HwPl	9	-11	29	22	2	73	49	-3	9	8	-43	27	45	-3	8	6	10	15	14
HwSx	18	-30	38	41	-47	72	74	2	11	8	-28	30	35	-12	10	13	-23	25	29
PlHw	10	-5	42	37	-43	39	47	-5	18	12	-36	38	47	-2	9	7	-2	12	8
SwHw+SbHw	6	-46	18	46	-54	21	54	9	19	13	24	39	34	-17	8	17	-21	6	21
Pl	18	-63	26	63	-78	19	78	-5	17	12	-24	60	50	-13	10	13	-13	14	14
Sw+Sb	5	-46	35	46	-62	33	62	-10	38	28	-16	34	29	-10	15	16	-16	19	21
Total	74																		

Avg = average % difference between aerial and ground data; Std = standard deviation of the difference; MAD = mean absolute deviation.

Revised results are provided in the following table. Excluding the Hw and HwPl strata, which have a sample size on 1 SU, the following observations can be made:

- Some reductions in standard deviation and mean absolute deviation are evident in some cases, but the magnitude of difference is generally not large;

- In some cases the standard deviation/mean absolute deviation increases;
- The proportion of stocking is still better aligned between aerial and ground data than the proportion of density;
- Undercalling of deciduous stocking and density, and associated underestimation of the proportion of deciduous to coniferous species is still evident.

In essence, the conclusions drawn regarding the value of using photo-interpreted stocking rather than photo-interpreted densities remains unchanged. Given the reasonably small sample size in many cases, drawing conclusions regarding the impacts of changes to stratum assignment is difficult. See the August 27, 2014 memo for additional analysis on the impacts of differing stratification schemes on variability within strata.

Stocking-Based Stratum	No. of SUs	Deciduous						Coniferous						Proportion					
		Stocking			Density			Stocking			Density			Stocking			Density		
		Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD	Avg	Std	MAD
Hw	1	10	.	10	-52	.	52	.	.	.	.	.	.	0	.	0	0	.	0
HwPl	1	23	.	23	48	.	48	2	.	2	102	.	102	5	.	5	-6	.	6
HwSx	4	2	6	5	-39	25	39	16	35	33	-27	44	44	-2	7	6	-2	4	3
PlHw	12	-29	23	33	-50	26	50	-6	13	10	-40	59	64	-7	10	10	0	16	11
SwHw+SbHw	37	-29	32	37	-41	67	67	1	17	10	-23	38	38	-10	10	12	-17	24	25
Pl	14	-49	60	71	-68	42	71	-4	21	15	-20	52	46	-9	12	11	-10	12	10
Sw+Sb	5	-64	27	64	-81	13	81	-11	17	12	-28	29	31	-15	9	15	-16	10	16
Total	74																		

Avg = average % difference between aerial and ground data; Std = standard deviation of the difference; MAD = mean absolute deviation.

CONIFEROUS SPECIES

Header			Stocking - Coniferous								Density - Coniferous							
SP_CL	Company	UNIQUE_ID	Ground	Interp	Diff	%Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg	Ground	Interp	Diff	%Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg
Hw	ALPAC	4030782259_1	46.8	68.0	21.2	45			45		830	600	-230	-28			28	
Hw	ALPAC	4030792714_1	62.5	62.0	-0.5	-1			1		1,501	600	-901	-60			60	
Hw	ALPAC	4030803437_2	0.0	0.0	0.0	.			.		0	0	0	.			.	
Hw	ALPAC	4040790271_1	51.6	65.0	13.4	26			26		1,562	800	-762	-49			49	
Hw	ALPAC	4040791687_1	98.4	85.0	-13.4	-14			14		5,094	1,000	-4,094	-80			80	
Hw	ALPAC	4060801425_3	53.1	35.0	-18.1	-34			34		1,157	400	-757	-65			65	
Hw	APL	5070803462A_2	64.1	82.0	17.9	28			28		1,281	1,720	439	34			34	
Hw	BRL	5120630035_1	41.0	42.0	1.0	2	8	27	2	21	692	1,400	708	102	-21	66	102	60
HwPl	SUNDRE	5070352066_3	89.6	90.0	0.4	0			0		3,042	2,100	-942	-31			31	
HwPl	SUNDRE	5080352114_2	100.0	90.0	-10.0	-10			10		7,125	2,760	-4,365	-61			61	
HwPl	SUNDRE	5090331314_1	96.9	90.0	-6.9	-7			7		5,813	3,000	-2,813	-48			48	
HwPl	SUNDRE	5090331345_1	96.9	95.0	-1.9	-2			2		6,844	2,520	-4,324	-63			63	
HwPl	SUNDRE	5090380385_2	87.5	95.0	7.5	9			9		2,250	1,850	-400	-18			18	
HwPl	SUNDRE	5090393640_1	84.4	80.0	-4.4	-5			5		3,813	2,250	-1,563	-41			41	
HwPl	SUNDRE	5100353528_2	75.0	85.0	10.0	13			13		1,610	1,800	190	12			12	
HwPl	SUNDRE	5140401284_1	90.6	85.0	-5.6	-6			6		5,657	2,200	-3,457	-61			61	
HwPl	SUNDRE	5140410681_1	94.4	80.0	-14.4	-15	-3	9	15	8	7,111	2,000	-5,111	-72	-43	27	72	45
HwSx	ALPAC	4030802542_1	71.9	89.0	17.1	24			24		1,672	800	-872	-52			52	
HwSx	ALPAC	4030803437_1	70.3	81.0	10.7	15			15		1,125	800	-325	-29			29	
HwSx	ALPAC	4040790271_2	55.9	70.0	14.1	25			25		1,118	1,200	82	7			7	
HwSx	ALPAC	4040790718_1	92.5	90.0	-2.5	-3			3		1,400	1,100	-300	-21			21	
HwSx	ALPAC	4050791287_1	90.6	90.0	-0.6	-1			1		2,703	1,100	-1,603	-59			59	
HwSx	ALPAC	4050791367_1	93.8	85.0	-8.8	-9			9		2,219	1,000	-1,219	-55			55	
HwSx	ALPAC	4050791392_1	84.6	85.0	0.4	0			0		1,750	900	-850	-49			49	
HwSx	ALPAC	4060801425_1	82.8	90.0	7.2	9			9		1,750	1,000	-750	-43			43	
HwSx	ALPAC	4060823034_1	68.8	70.0	1.2	2			2		1,156	800	-356	-31			31	
HwSx	ALPAC	4070811511_1	71.9	70.0	-1.9	-3			3		1,750	800	-950	-54			54	
HwSx	ALPAC	4070812693_2	84.4	80.0	-4.4	-5			5		2,032	900	-1,132	-56			56	
HwSx	APL	5060802532A_3	87.5	85.0	-2.5	-3			3		1,844	1,150	-694	-38			38	
HwSx	APL	5060802557A_2	79.7	85.0	5.3	7			7		1,593	1,500	-93	-6			6	
HwSx	APL	5060803666A_1	93.8	90.0	-3.8	-4			4		1,891	2,400	509	27			27	
HwSx	APL	5060803666A_3	96.9	75.0	-21.9	-23			23		2,439	700	-1,739	-71			71	
HwSx	APL	5060810162A_3	95.7	95.0	-0.7	-1			1		1,702	2,070	368	22			22	
HwSx	APL	5070802648A_2	100.0	97.0	-3.0	-3			3		2,313	2,541	228	10			10	
HwSx	APL	5070803596A_1	95.3	95.0	-0.3	0	2	11	0	8	2,141	2,100	-41	-2	-28	30	2	35
Pl	APL	4220783394A_1	98.0	85.0	-13.0	-13			13		15,082	14,750	-332	-2			2	
Pl	SUNDRE	5070351611_1	82.8	85.0	2.2	3			3		2,110	1,755	-355	-17			17	
Pl	SUNDRE	5070352136_3	96.9	95.0	-1.9	-2			2		10,562	3,840	-6,722	-64			64	
Pl	SUNDRE	5070352136_4	96.9	95.0	-1.9	-2			2		4,032	2,400	-1,632	-40			40	

CONIFEROUS SPECIES

Pl	SUNDRE	5090380465_3	100.0	95.0	-5.0	-5			5		13,219	6,000	-7,219	-55			55	
Pl	BRL	5110632276_1	96.9	94.0	-2.9	-3			3		4,345	4,900	555	13			13	
Pl	SUNDRE	5120401128_1	100.0	90.0	-10.0	-10			10		15,056	4,080	-10,976	-73			73	
Pl	SUNDRE	5120401196_3	95.2	90.0	-5.2	-5			5		3,000	2,250	-750	-25			25	
Pl	BRL	5120630035_2	73.7	90.0	16.3	22			22		2,213	5,300	3,087	139			139	
Pl	BRL	5120630035_5	88.4	66.0	-22.4	-25			25		2,163	2,700	537	25			25	
Pl	SUNDRE	5130400628_2	96.9	95.0	-1.9	-2			2		3,281	3,050	-231	-7			7	
Pl	BRL	5130632435A_1	87.5	100.0	12.5	14			14		3,828	7,200	3,372	88			88	
Pl	SUNDRE	5140401284_2	93.8	95.0	1.3	1			1		7,125	2,200	-4,925	-69			69	
Pl	SUNDRE	5140401344_2	92.2	75.0	-17.2	-19			19		3,188	1,300	-1,888	-59			59	
Pl	BRL	5140650469_1	70.3	88.0	17.7	25			25		22,125	7,000	-15,125	-68			68	
Pl	BRL	5140650469_2	68.8	36.0	-32.8	-48			48		4,814	1,800	-3,014	-63			63	
Pl	SUNDRE	5150391435_2	100.0	95.0	-5.0	-5			5		20,625	3,800	-16,825	-82			.	
Pl	SUNDRE	5150391435_3	100.0	82.0	-18.0	-18	-5	17	18	12	5,985	1,400	-4,585	-77	-24	60	.	50
PlHw	ALPAC	4030792328_1	100.0	65.0	-35.0	-35			35		5,625	800	-4,825	-86			86	
PlHw	SUNDRE	5070352114_3	96.9	95.0	-1.9	-2			2		4,907	2,600	-2,307	-47			47	
PlHw	SUNDRE	5090363150_1	93.8	90.0	-3.8	-4			4		2,594	2,250	-344	-13			13	
PlHw	SUNDRE	5090392679_1	88.7	90.0	1.3	1			1		6,919	2,520	-4,399	-64			64	
PlHw	SUNDRE	5100351758_1	59.4	50.0	-9.4	-16			16		2,000	1,050	-950	-48			.	
PlHw	SUNDRE	5110352672_1	92.6	90.0	-2.6	-3			3		3,630	2,160	-1,470	-40			40	
PlHw	SUNDRE	5120392815_1	94.1	90.0	-4.1	-4			4		7,000	3,600	-3,400	-49			49	
PlHw	SUNDRE	5120401196_1	96.9	95.0	-1.9	-2			2		6,031	4,400	-1,631	-27			27	
PlHw	BRL	5120630035_6	93.7	75.0	-18.7	-20			20		4,438	2,500	-1,938	-44			44	
PlHw	BRL	5130630148_4	62.5	85.0	22.5	36	-5	18	36	12	1,188	1,850	662	56	-36	38	56	47
Sb	BRL	5130632435A_2	96.9	60.0	-36.9	-38			38		4,500	2,500	-2,000	-44			44	
Sw	APL	5050802193A_1	65.6	95.0	29.4	45			45		1,313	1,620	307	23			23	
Sw	APL	5050810772A_2	93.8	95.0	1.3	1			1		1,750	1,900	150	9			9	
Sw	APL	5060810162A_2	96.9	95.0	-1.9	-2			2		1,844	1,600	-244	-13			13	
Sw	BRL	5120630035_4	87.0	40.0	-47.0	-54	-10	38	54	28	2,871	1,250	-1,621	-56	-16	34	56	29
SbHw	APL	4220783394A_4	84.4	85.0	0.6	1			1		7,563	8,500	937	12			12	
SwHw	APL	4220783394A_3	84.4	85.0	0.6	1			1		7,751	7,500	-251	-3			3	
SwHw	APL	5050802193A_2	65.6	95.0	29.4	45			45		1,594	1,940	346	22			22	
SwHw	APL	5060803666A_2	96.9	85.0	-11.9	-12			12		2,125	1,580	-545	-26			26	
SwHw	APL	5070802416A_1	87.5	96.0	8.5	10			10		1,906	3,000	1,094	57			57	
SwHw	APL	5070803462A_3	87.5	95.0	7.5	9	9	19	9	13	1,453	2,640	1,187	82	24	39	82	34
Overall Average / Standard Deviation Across All Strata							-1	19		13					-24	46		43

DECIDUOUS SPECIES

Header			Stocking - Deciduous								Density - Deciduous							
SP_CL	Company	UNIQUE_ID	Ground	Interp	Diff	%Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg	Ground	Interp	Diff	%Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg
Hw	ALPAC	4030782259_1	89.4	97.0	7.6	9			9		6,894	3,000	-3,894	-56			56	
Hw	ALPAC	4030792714_1	68.8	49.0	-19.8	-29			29		10,063	400	-9,663	-96			96	
Hw	ALPAC	4030803437_2	90.6	100.0	9.4	10			10		7,891	3,800	-4,091	-52			52	
Hw	ALPAC	4040790271_1	89.1	95.0	5.9	7			7		9,266	5,000	-4,266	-46			46	
Hw	ALPAC	4040791687_1	98.4	45.0	-53.4	-54			54		17,141	700	-16,441	-96			96	
Hw	ALPAC	4060801425_3	93.8	90.0	-3.8	-4			4		10,344	5,000	-5,344	-52			52	
Hw	APL	5070803462A_2	89.1	87.0	-2.1	-2			2		8,625	8,500	-125	-1			1	
Hw	BRL	5120630035_1	48.7	60.0	11.3	23	-5	25	23	17	2,641	3,900	1,259	48	-44	48	48	56
HwPl	SUNDRE	5070352066_3	52.1	75.0	22.9	44			44		1,792	4,900	3,108	173			173	
HwPl	SUNDRE	5080352114_2	93.8	80.0	-13.8	-15			15		9,031	6,440	-2,591	-29			29	
HwPl	SUNDRE	5090331314_1	90.6	50.0	-40.6	-45			45		6,250	3,000	-3,250	-52			52	
HwPl	SUNDRE	5090331345_1	90.6	40.0	-50.6	-56			56		5,719	1,080	-4,639	-81			81	
HwPl	SUNDRE	5090380385_2	71.9	75.0	3.1	4			4		5,375	6,750	1,375	26			26	
HwPl	SUNDRE	5090393640_1	59.4	60.0	0.6	1			1		2,906	2,250	-656	-23			23	
HwPl	SUNDRE	5100353528_2	68.8	70.0	1.2	2			2		3,203	4,200	997	31			31	
HwPl	SUNDRE	5140401284_1	81.3	70.0	-11.3	-14			14		5,844	5,000	-844	-14			14	
HwPl	SUNDRE	5140410681_1	75.0	60.0	-15.0	-20	-11	29	20	22	4,556	4,000	-556	-12	2	73	12	49
HwSx	ALPAC	4030802542_1	95.3	46.0	-49.3	-52			52		11,375	700	-10,675	-94			94	
HwSx	ALPAC	4030803437_1	84.4	55.0	-29.4	-35			35		7,453	800	-6,653	-89			89	
HwSx	ALPAC	4040790271_2	100.0	60.0	-40.0	-40			40		10,706	2,400	-8,306	-78			78	
HwSx	ALPAC	4040790718_1	95.0	40.0	-55.0	-58			58		10,550	600	-9,950	-94			94	
HwSx	ALPAC	4050791287_1	93.8	40.0	-53.8	-57			57		12,219	600	-11,619	-95			95	
HwSx	ALPAC	4050791367_1	96.9	45.0	-51.9	-54			54		12,000	700	-11,300	-94			94	
HwSx	ALPAC	4050791392_1	92.3	40.0	-52.3	-57			57		10,788	600	-10,188	-94			94	
HwSx	ALPAC	4060801425_1	93.8	40.0	-53.8	-57			57		10,172	600	-9,572	-94			94	
HwSx	ALPAC	4060823034_1	78.1	40.0	-38.1	-49			49		5,156	600	-4,556	-88			88	
HwSx	ALPAC	4070811511_1	76.6	40.0	-36.6	-48			48		5,797	500	-5,297	-91			91	
HwSx	ALPAC	4070812693_2	96.9	40.0	-56.9	-59			59		5,219	600	-4,619	-89			89	
HwSx	APL	5060802532A_3	28.1	55.0	26.9	96			96		1,375	3,800	2,425	176			176	
HwSx	APL	5060802557A_2	69.5	70.0	0.5	1			1		5,254	7,000	1,746	33			33	
HwSx	APL	5060803666A_1	87.5	75.0	-12.5	-14			14		8,094	8,000	-94	-1			1	
HwSx	APL	5060803666A_3	68.8	40.0	-28.8	-42			42		4,438	2,000	-2,438	-55			55	
HwSx	APL	5060810162A_3	72.3	60.0	-12.3	-17			17		7,043	5,000	-2,043	-29			29	
HwSx	APL	5070802648A_2	84.4	85.0	0.6	1			1		7,563	8,000	437	6			6	
HwSx	APL	5070803596A_1	81.3	75.0	-6.3	-8	-30	38	8	41	6,188	8,000	1,812	29	-47	72	29	74
Pl	APL	4220783394A_1	59.2	5.0	-54.2	-92			92		2,490	250	-2,240	-90			90	
Pl	SUNDRE	5070351611_1	17.2	15.0	-2.2	-13			13		766	195	-571	-75			75	
Pl	SUNDRE	5070352136_3	50.0	40.0	-10.0	-20			20		1,547	960	-587	-38			38	
Pl	SUNDRE	5070352136_4	65.6	40.0	-25.6	-39			39		3,125	600	-2,525	-81			81	

DECIDUOUS SPECIES

Pl	SUNDRE	5090380465_3	81.3	40.0	-41.3	-51			51		3,063	1,000	-2,063	-67			67	
Pl	BRL	5110632276_1	4.7	0.0	-4.7	-100			100		78	0	-78	-100			100	
Pl	SUNDRE	5120401128_1	71.7	30.0	-41.7	-58			58		4,453	1,020	-3,433	-77			77	
Pl	SUNDRE	5120401196_3	42.9	15.0	-27.9	-65			65		2,000	250	-1,750	-88			88	
Pl	BRL	5120630035_2	59.0	25.0	-34.0	-58			58		2,279	1,000	-1,279	-56			56	
Pl	BRL	5120630035_5	46.5	5.0	-41.5	-89			89		1,744	200	-1,544	-89			89	
Pl	SUNDRE	5130400628_2	81.3	40.0	-41.3	-51			51		3,375	450	-2,925	-87			87	
Pl	BRL	5130632435A_1	18.8	10.0	-8.8	-47			47		328	200	-128	-39			39	
Pl	SUNDRE	5140401284_2	62.5	15.0	-47.5	-76			76		2,375	200	-2,175	-92			92	
Pl	SUNDRE	5140401344_2	18.8	5.0	-13.8	-73			73		422	100	-322	-76			76	
Pl	BRL	5140650469_1	6.3	0.0	-6.3	-100			100		266	0	-266	-100			100	
Pl	BRL	5140650469_2	25.0	5.0	-20.0	-80			80		688	50	-638	-93			93	
Pl	SUNDRE	5150391435_2	0.0	0.0	0.0	.			.		0	0	0	.			.	
Pl	SUNDRE	5150391435_3	0.0	0.0	0.0	.	-63	26	.	63	0	0	0	.	-78	19	.	78
PlHw	ALPAC	4030792328_1	40.6	50.0	9.4	23			23		969	300	-669	-69			69	
PlHw	SUNDRE	5070352114_3	81.3	50.0	-31.3	-38			38		5,500	2,600	-2,900	-53			53	
PlHw	SUNDRE	5090363150_1	12.5	20.0	7.5	60			60		219	250	31	14			14	
PlHw	SUNDRE	5090392679_1	64.5	45.0	-19.5	-30			30		2,839	1,080	-1,759	-62			62	
PlHw	SUNDRE	5100351758_1	0.0	0.0	0.0	.			.		0	0	0	.			.	
PlHw	SUNDRE	5110352672_1	22.2	15.0	-7.2	-32			32		1,000	240	-760	-76			76	
PlHw	SUNDRE	5120392815_1	94.1	65.0	-29.1	-31			31		9,412	5,400	-4,012	-43			43	
PlHw	SUNDRE	5120401196_1	54.7	30.0	-24.7	-45			45		2,688	110	-2,578	-96			96	
PlHw	BRL	5120630035_6	43.8	38.0	-5.8	-13			13		1,719	1,600	-119	-7			7	
PlHw	BRL	5130630148_4	12.5	20.0	7.5	60	-5	42	60	37	563	600	37	7	-43	39	7	47
Sb	BRL	5130632435A_2	25.0	0.0	-25.0	-100			100		594	0	-594	-100			100	
Sw	APL	5050802193A_1	68.8	40.0	-28.8	-42			42		2,156	1,200	-956	-44			44	
Sw	APL	5050810772A_2	34.4	20.0	-14.4	-42			42		1,500	500	-1,000	-67			67	
Sw	APL	5060810162A_2	68.8	40.0	-28.8	-42			42		4,219	750	-3,469	-82			82	
Sw	BRL	5120630035_4	22.6	22.0	-0.6	-3	-46	35	3	46	710	600	-110	-15	-62	33	15	62
SbHw	APL	4220783394A_4	87.5	30.0	-57.5	-66			66		5,000	1,500	-3,500	-70			70	
SwHw	APL	4220783394A_3	71.9	20.0	-51.9	-72			72		3,969	500	-3,469	-87			87	
SwHw	APL	5050802193A_2	71.9	50.0	-21.9	-30			30		3,219	2,000	-1,219	-38			38	
SwHw	APL	5060803666A_2	53.1	35.0	-18.1	-34			34		2,219	1,000	-1,219	-55			55	
SwHw	APL	5070802416A_1	59.4	40.0	-19.4	-33			33		4,656	2,500	-2,156	-46			46	
SwHw	APL	5070803462A_3	76.6	45.0	-31.6	-41	-46	18	41	46	3,547	2,500	-1,047	-30	-54	21	30	54
Overall Average / Standard Deviation Across All Strata							-32	38		41					-48	55		64

PROPORTION (SPECIES COMPOSITION)

Header			Stocking Proportion - %D/(%D+%C)							Density Proportion - sph D/(sph D+sph C)						
SP_CL	Company	UNIQUE_ID	Ground	Interp	Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg	Ground	Interp	Diff	Avg Diff	Std Diff	Abs Diff	Abs Avg
Hw	ALPAC	4030782259_1	65.6	58.8	-7			7		89.3	83.3	-6			6	
Hw	ALPAC	4030792714_1	52.4	44.1	-8			8		87.0	40.0	-47			47	
Hw	ALPAC	4030803437_2	100.0	100.0	0			0		100.0	100.0	0			0	
Hw	ALPAC	4040790271_1	63.3	59.4	-4			4		85.6	86.2	1			1	
Hw	ALPAC	4040791687_1	50.0	34.6	-15			15		77.1	41.2	-36			36	
Hw	ALPAC	4060801425_3	63.8	72.0	8			8		89.9	92.6	3			3	
Hw	APL	5070803462A_2	58.2	51.5	-7			7		87.1	83.2	-4			4	
Hw	BRL	5120630035_1	54.3	58.8	5	-4	8	5	7	79.2	73.6	-6	-12	19	6	13
HwPl	SUNDRE	5070352066_3	36.8	45.5	9			9		37.1	70.0	33			33	
HwPl	SUNDRE	5080352114_2	48.4	47.1	-1			1		55.9	70.0	14			14	
HwPl	SUNDRE	5090331314_1	48.3	35.7	-13			13		51.8	50.0	-2			2	
HwPl	SUNDRE	5090331345_1	48.3	29.6	-19			19		45.5	30.0	-16			16	
HwPl	SUNDRE	5090380385_2	45.1	44.1	-1			1		70.5	78.5	8			8	
HwPl	SUNDRE	5090393640_1	41.3	42.9	2			2		43.3	50.0	7			7	
HwPl	SUNDRE	5100353528_2	47.8	45.2	-3			3		66.5	70.0	3			3	
HwPl	SUNDRE	5140401284_1	47.3	45.2	-2			2		50.8	69.4	19			19	
HwPl	SUNDRE	5140410681_1	44.3	42.9	-1	-3	8	1	6	39.1	66.7	28	10	15	28	14
HwSx	ALPAC	4030802542_1	57.0	34.1	-23			23		87.2	46.7	-41			41	
HwSx	ALPAC	4030803437_1	54.6	40.4	-14			14		86.9	50.0	-37			37	
HwSx	ALPAC	4040790271_2	64.2	46.2	-18			18		90.5	66.7	-24			24	
HwSx	ALPAC	4040790718_1	50.7	30.8	-20			20		88.3	35.3	-53			53	
HwSx	ALPAC	4050791287_1	50.9	30.8	-20			20		81.9	35.3	-47			47	
HwSx	ALPAC	4050791367_1	50.8	34.6	-16			16		84.4	41.2	-43			43	
HwSx	ALPAC	4050791392_1	52.2	32.0	-20			20		86.0	40.0	-46			46	
HwSx	ALPAC	4060801425_1	53.1	30.8	-22			22		85.3	37.5	-48			48	
HwSx	ALPAC	4060823034_1	53.2	36.4	-17			17		81.7	42.9	-39			39	
HwSx	ALPAC	4070811511_1	51.6	36.4	-15			15		76.8	38.5	-38			38	
HwSx	ALPAC	4070812693_2	53.5	33.3	-20			20		72.0	40.0	-32			32	
HwSx	APL	5060802532A_3	24.3	39.3	15			15		42.7	76.8	34			34	
HwSx	APL	5060802557A_2	46.6	45.2	-1			1		76.7	82.4	6			6	
HwSx	APL	5060803666A_1	48.3	45.5	-3			3		81.1	76.9	-4			4	
HwSx	APL	5060803666A_3	41.5	34.8	-7			7		64.5	74.1	10			10	
HwSx	APL	5060810162A_3	43.0	38.7	-4			4		80.5	70.7	-10			10	
HwSx	APL	5070802648A_2	45.8	46.7	1			1		76.6	75.9	-1			1	
HwSx	APL	5070803596A_1	46.0	44.1	-2	-12	10	2	13	74.3	79.2	5	-23	25	5	29
Pl	APL	4220783394A_1	37.7	5.6	-32			32		14.2	1.7	-13			13	
Pl	SUNDRE	5070351611_1	17.2	15.0	-2			2		26.6	10.0	-17			17	
Pl	SUNDRE	5070352136_3	34.0	29.6	-4			4		12.8	20.0	7			7	
Pl	SUNDRE	5070352136_4	40.4	29.6	-11			11		43.7	20.0	-24			24	

PROPORTION (SPECIES COMPOSITION)

Pl	SUNDRE	5090380465_3	44.8	29.6	-15			15		18.8	14.3	-5			5	
Pl	BRL	5110632276_1	4.6	0.0	-5			5		1.8	0.0	-2			2	
Pl	SUNDRE	5120401128_1	41.8	25.0	-17			17		22.8	20.0	-3			3	
Pl	SUNDRE	5120401196_3	31.1	14.3	-17			17		40.0	10.0	-30			30	
Pl	BRL	5120630035_2	44.5	21.7	-23			23		50.7	15.9	-35			35	
Pl	BRL	5120630035_5	34.5	7.0	-27			27		44.6	6.9	-38			38	
Pl	SUNDRE	5130400628_2	45.6	29.6	-16			16		50.7	12.9	-38			38	
Pl	BRL	5130632435A_1	17.7	9.1	-9			9		7.9	2.7	-5			5	
Pl	SUNDRE	5140401284_2	40.0	13.6	-26			26		25.0	8.3	-17			17	
Pl	SUNDRE	5140401344_2	16.9	6.3	-11			11		11.7	7.1	-5			5	
Pl	BRL	5140650469_1	8.2	0.0	-8			8		1.2	0.0	-1			1	
Pl	BRL	5140650469_2	26.7	12.2	-14			14		12.5	2.7	-10			10	
Pl	SUNDRE	5150391435_2	0.0	0.0	0			0		0.0	0.0	0			0	
Pl	SUNDRE	5150391435_3	0.0	0.0	0	-13	10	0	13	0.0	0.0	0	-13	14	0	14
PlHw	ALPAC	4030792328_1	28.9	43.5	15			15		14.7	27.3	13			13	
PlHw	SUNDRE	5070352114_3	45.6	34.5	-11			11		52.8	50.0	-3			3	
PlHw	SUNDRE	5090363150_1	11.8	18.2	6			6		7.8	10.0	2			2	
PlHw	SUNDRE	5090392679_1	42.1	33.3	-9			9		29.1	30.0	1			1	
PlHw	SUNDRE	5100351758_1	0.0	0.0	0			0		0.0	0.0	0			0	
PlHw	SUNDRE	5110352672_1	19.3	14.3	-5			5		21.6	10.0	-12			12	
PlHw	SUNDRE	5120392815_1	50.0	41.9	-8			8		57.3	60.0	3			3	
PlHw	SUNDRE	5120401196_1	36.1	24.0	-12			12		30.8	2.4	-28			28	
PlHw	BRL	5120630035_6	31.9	33.6	2			2		27.9	39.0	11			11	
PlHw	BRL	5130630148_4	16.7	19.0	2	-2	9	2	7	32.2	24.5	-8	-2	12	8	8
Sb	BRL	5130632435A_2	20.5	0.0	-21			21		11.7	0.0	-12			12	
Sw	APL	5050802193A_1	51.2	29.6	-22			22		62.2	42.6	-20			20	
Sw	APL	5050810772A_2	26.8	17.4	-9			9		46.2	20.8	-25			25	
Sw	APL	5060810162A_2	41.5	29.6	-12			12		69.6	31.9	-38			38	
Sw	BRL	5120630035_4	20.6	35.5	15	-10	15	15	16	19.8	32.4	13	-16	19	13	21
SbHw	APL	4220783394A_4	50.9	26.1	-25			25		39.8	15.0	-25			25	
SwHw	APL	4220783394A_3	46.0	19.0	-27			27		33.9	6.3	-28			28	
SwHw	APL	5050802193A_2	52.3	34.5	-18			18		66.9	50.8	-16			16	
SwHw	APL	5060803666A_2	35.4	29.2	-6			6		51.1	38.8	-12			12	
SwHw	APL	5070802416A_1	40.4	29.4	-11			11		71.0	45.5	-25			25	
SwHw	APL	5070803462A_3	46.7	32.1	-15	-17	8	15	17	70.9	48.6	-22	-21	6	22	21
Overall Average / Standard Deviation Across All Strata						-9	10		11				-12	20		18

Appendix 6: Alternative Stratification Schemes

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update

froese forestry consulting inc.

Company: Alberta Forest Growth Organization, Strata Subcommittee
From: Katrina Froese
Date: August 27, 2014
Re: Alternative Stratification Schemes

Objective

The objective of the examining alternative stratification schemes was to determine whether moving to a stocking-based scheme would improve stratum assignments, with the objective of minimizing within-stratum variability, defined in terms of predicted culmination MAIs (coniferous, deciduous and proportion).

Analysis

Five scenarios were examined:

- density 20/50/80 (baseline)
- density 20/50/90
- stocking 20/50/80
- stocking 20/50/90
- stocking 20/80 (no differentiation between mixedwood DC vs. CD).

Data from initial within-bin variability analysis plus recent data from new digital photography were used in analysis (a total of 2012 sampling units). Coniferous stocking was calculated using basic plot data since it is not part of the RSA compiler calculations; all other information was extracted from compiled data. Proportions were calculated as follows:

- Density proportion = AW density / (AW + PL + SB + SW density)
- Stocking proportion = AW stocking / (AW + conifer stocking)
- MAI proportion = DEC_MAI / (DEC_MAI + CON_MAI)

Density and stocking proportions were used to assign various strata to SU data.

Impacts of Scenarios on Stratum Assignments

Moving from density 20/50/80 to density 20/50/90 resulted only in Hw moving to mixedwood types. Moving between stocking 20/50/80 and stocking 20/50/90 resulted in only 6 differences. Moving from density 20/50/90 to stocking 20/50/80 resulted in several changes:

Density	Stocking 20/50/80										
20/50/90	Hw	HwSw	SwHw	Sw	HwPl	PlHw	Pl	HwSb	SbHw	Sb	*Total*
Hw	9	25			3			1			*38*
HwSw		230	381		3	9			3		*626*
SwHw		2	261	32		9	1				*305*
Sw			25	81		3	10			1	*120*
HwPl		8	9		43	119	1	1	1		*182*
PlHw			51	1	3	214	18		2		*289*
Pl			17	16		87	217		3	3	*343*
HwSb		6	9		1	4		11	13		*44*
SbHw			10	1		2			21		*34*
Sb				1		4	4		6	16	*31*
Total	*9*	*271*	*763*	*132*	*53*	*451*	*251*	*13*	*49*	*20*	*2012*

- A shift from deciduous-dominated to more coniferous-dominated strata in many cases; also the reverse (pine moving into the pine hardwoods and spruce into spruce hardwoods).
- A few spruce types moving into pine types; many more pine types moving into spruce.
- *These are break points proposed by the Strata Subcommittee; break points have not been examined to optimize/minimize variability in MAIs.*

Variability in MAI Metrics Under Various Scenarios

The objective of assigning sampling strata for RSA subsampling is to minimize the variability in culmination MAI.

- Mean absolute deviation and coefficient of variation (CV%) for key strata and primary species of interest (deciduous, coniferous or both) are coloured to ease of comparison.
- Moving from a 20/50/90 density scenario to a 20/50/80 stocking scenario has very little impact on variability for primary species of interest (and fewer SUs are assigned to pure deciduous).
- There is almost no difference between 20/50/80 stocking and 20/50/90 stocking, however 20/50/80 stocking lines up better with AVI break points for defining broad cover groups.
- Moving to 6 sampling strata (collapsing mixedwoods into one stratum) does increase variability somewhat, particularly for deciduous MAI. It would be prudent to investigate whether this population represents a continuum of conditions, or whether it is a bimodal distribution (a bimodal distribution might require separate strata for sampling).

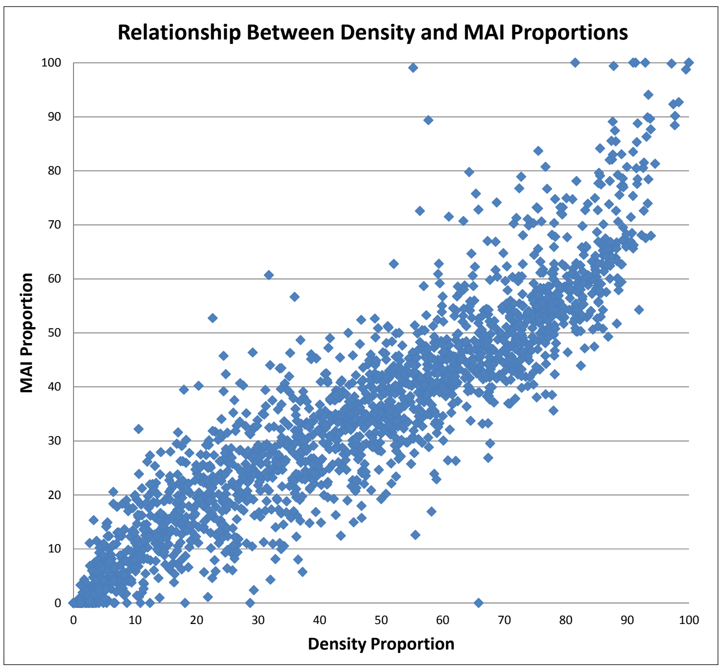
Scenario	Stratum	N	Coniferous MAI				Deciduous MAI				Proportion MAI (Dec/Tot)			
			Mean	Std	AbsDev	CV%	Mean	Std	AbsDev	CV%	Mean	Std	AbsDev	CV%
density 20/50/80	Hw	210	1.2	0.5	0.43	43	2.5	0.7	0.51	27	66.8	12.8	10.2	19
	HwSw	474	2.0	0.5	0.38	24	1.8	0.5	0.41	30	47.4	10.3	7.7	22
	SwHw	305	2.5	0.5	0.41	21	1.0	0.4	0.31	41	27.4	9.1	7.0	33
	Sw	120	3.1	0.6	0.47	21	0.2	0.3	0.23	112	7.1	7.8	6.4	110
	HwPl	168	2.2	0.5	0.48	24	1.7	0.5	0.35	30	44.3	9.8	7.8	22
	PlHw	289	2.8	0.6	0.39	22	1.1	0.4	0.42	41	27.7	9.7	7.5	35
	Pl	343	3.3	0.9	0.69	26	0.3	0.3	0.26	93	8.7	8.0	6.7	92
	HwSb	38	1.5	0.6	0.50	40	1.7	0.5	0.41	32	53.5	13.1	11.0	24
	SbHw	34	2.2	0.6	0.49	29	0.9	0.4	0.33	44	29.3	9.7	7.6	33
	Sb	31	2.5	0.9	0.73	34	0.2	0.2	0.15	80	7.7	6.4	5.3	83
density 20/50/90	Hw	38	0.6	0.5	0.36	76	2.9	0.8	0.61	28	82.7	12.3	10.3	15
	HwSw	626	1.8	0.5	0.42	29	1.9	0.6	0.48	31	51.2	12.2	9.5	24
	SwHw	305	2.5	0.5	0.41	21	1.0	0.4	0.31	41	27.4	9.1	7.0	33
	Sw	120	3.1	0.6	0.47	21	0.2	0.3	0.23	112	7.1	7.8	6.4	110
	HwPl	182	2.1	0.5	0.42	26	1.8	0.5	0.43	30	45.6	10.8	8.3	24
	PlHw	289	2.8	0.6	0.48	22	1.1	0.4	0.35	41	27.7	9.7	7.8	35
	Pl	343	3.3	0.9	0.69	26	0.3	0.3	0.26	93	8.7	8.0	6.7	92
	HwSb	44	1.4	0.6	0.53	43	1.8	0.6	0.47	32	56.1	14.5	12.2	26
	SbHw	34	2.2	0.6	0.49	29	0.9	0.4	0.33	44	29.3	9.7	7.6	33
	Sb	31	2.5	0.9	0.73	34	0.2	0.2	0.15	80	7.7	6.4	5.3	83
stocking 20/50/80	Hw	9	0.2	0.2	0.17	97	3.5	0.7	0.43	22	94.3	5.4	4.8	6
	HwSw	271	1.4	0.5	0.41	36	2.3	0.6	0.49	27	62.4	12.0	9.3	19
	SwHw	763	2.3	0.6	0.45	26	1.4	0.6	0.48	43	37.0	13.2	10.6	36
	Sw	132	3.1	0.6	0.48	20	0.3	0.3	0.22	103	7.6	7.6	6.4	100
	HwPl	53	1.7	0.5	0.40	31	2.2	0.5	0.39	24	56.8	10.0	7.9	18
	PlHw	451	2.7	0.7	0.53	25	1.2	0.5	0.44	46	30.0	11.9	9.9	40
	Pl	251	3.4	0.9	0.68	25	0.2	0.2	0.18	100	5.5	5.4	4.5	99
	HwSb	13	1.2	0.8	0.69	65	2.0	0.7	0.56	34	64.6	15.6	13.0	24
	SbHw	49	2.0	0.6	0.50	31	1.0	0.6	0.44	53	33.6	15.5	12.3	46
	Sb	20	2.3	0.8	0.67	36	0.1	0.1	0.11	126	3.4	4.3	3.5	126
stocking 20/50/90	Hw	3	0.0	0.0	0.02	173	3.3	0.2	0.15	6	99.6	0.7	0.6	1
	HwSw	277	1.4	0.5	0.42	38	2.3	0.6	0.50	28	63.0	12.6	9.8	20
	SwHw	763	2.3	0.6	0.45	26	1.4	0.6	0.48	43	37.0	13.2	10.6	36
	Sw	132	3.1	0.6	0.48	20	0.3	0.3	0.22	103	7.6	7.6	6.4	100
	HwPl	53	1.7	0.5	0.40	31	2.2	0.5	0.39	24	56.8	10.0	7.9	18
	PlHw	451	2.7	0.7	0.53	25	1.2	0.5	0.44	46	30.0	11.9	9.9	40
	Pl	251	3.4	0.9	0.68	25	0.2	0.2	0.18	100	5.5	5.4	4.5	99
	HwSb	13	1.2	0.8	0.69	65	2.0	0.7	0.56	34	64.6	15.6	13.0	24
	SbHw	49	2.0	0.6	0.50	31	1.0	0.6	0.44	53	33.6	15.5	12.3	46
	Sb	20	2.3	0.8	0.67	36	0.1	0.1	0.11	126	3.4	4.3	3.5	126
stocking 20/80	Hw	9	0.2	0.2	0.17	97	3.5	0.7	0.43	22	94.3	5.4	4.8	6
	MxSx	1096	2.0	0.7	0.54	34	1.6	0.7	0.59	46	43.4	17.2	13.7	40
	Sw	132	3.1	0.6	0.48	20	0.3	0.3	0.22	103	7.6	7.6	6.4	100
	MxPl	504	2.6	0.7	0.57	28	1.3	0.6	0.51	48	32.8	14.3	11.7	44
	Pl	251	3.4	0.9	0.68	25	0.2	0.2	0.18	100	5.5	5.4	4.5	99
	Sb	20	2.3	0.8	0.67	36	0.1	0.1	0.11	126	3.4	4.3	3.5	126

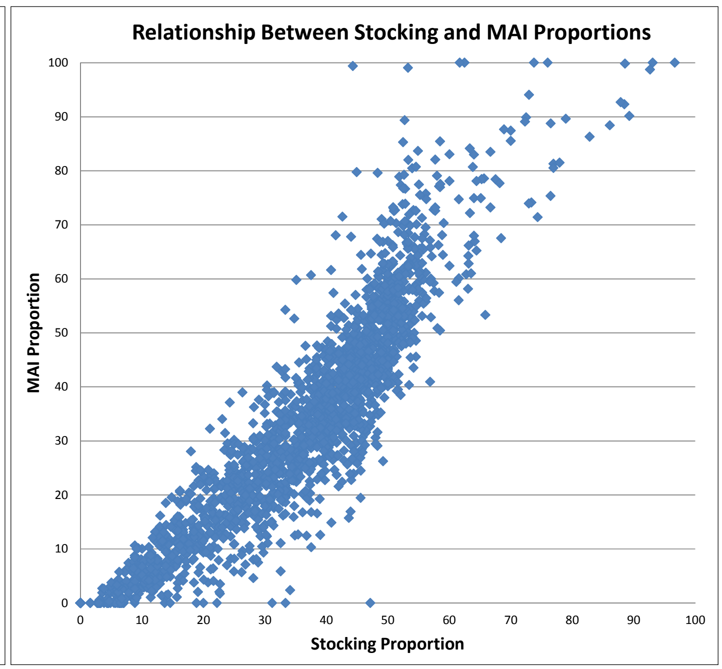
* Mean = average of all observations; Std = standard deviation; AbsDev = mean absolute deviation; CV% = coefficient of variation (Std/Mean*100).

Relationships Between Density/Stocking and MAI

Simple Pearson correlations between our variables of interest (coniferous and deciduous MAI, and MAI culmination) were created to determine whether one provided a superior linkage to MAI.   Note that:

- These are uni-dimensional comparisons and that correlations assume a linear relationship between variables.
  - For pine, density and MAI do not have a linear relationship, which confounds results.
  - For proportions, however, relationships are linear as shown in the graphs below and provide reliable indicators of correlations.
- Additional multivariate analysis is recommended to provide more accurate results but was outside the scope of analysis.





In general, the following conclusions can be made:

- Proportion of density and proportion of stocking provide almost identical correlations with culmination MAI.
- However, percent stocking is more strongly correlated with MAI than percent density is at the species level.

Stratum	Component	Variable	Culmination MAI (m^3/ha/y)		
			Conifer	Decid	Proportion
All n=2012	Proportion	Density	-0.72	0.87	0.92
		Percent Stocking	-0.70	0.86	0.92
	Coniferous	Density	0.23	-0.29	-0.31
		Percent Stocking	0.54	-0.33	-0.48
	Deciduous	Density	-0.58	0.78	0.78
		Percent Stocking	-0.62	0.87	0.88
	Pine	Density	0.24	-0.30	-0.33
		Percent Stocking	0.53	-0.43	-0.50
	Black Spruce	Density	0.02	-0.15	-0.12
		Percent Stocking	0.08	-0.21	-0.20
	White Spruce	Density	-0.02	0.08	0.07
		Percent Stocking	-0.17	0.22	0.21
MxSx n=1096	Proportion	Density	-0.69	0.77	0.86
		Percent Stocking	-0.68	0.74	0.85
	Coniferous	Density	0.32	-0.24	-0.30
		Percent Stocking	0.58	-0.21	-0.45
	Deciduous	Density	-0.50	0.70	0.70
		Percent Stocking	-0.50	0.78	0.77
	Pine	Density	0.27	-0.24	-0.28
		Percent Stocking	0.32	-0.33	-0.36
	Black Spruce	Density	-0.01	-0.16	-0.12
		Percent Stocking	0.00	-0.19	-0.14
	White Spruce	Density	0.27	-0.07	-0.16
		Percent Stocking	0.37	0.01	-0.19
MxPl n=504	Proportion	Density	-0.56	0.78	0.84
		Percent Stocking	-0.58	0.79	0.87
	Coniferous	Density	-0.02	-0.26	-0.23
		Percent Stocking	0.44	-0.25	-0.43
	Deciduous	Density	-0.49	0.73	0.75
		Percent Stocking	-0.48	0.77	0.78
	Pine	Density	-0.04	-0.23	-0.20
		Percent Stocking	0.45	-0.19	-0.38
	Black Spruce	Density	0.07	-0.23	-0.22
		Percent Stocking	0.11	-0.23	-0.24
	White Spruce	Density	0.07	-0.05	-0.06
		Percent Stocking	0.02	-0.05	-0.04

Stratum	Component	Variable	Culmination MAI (m^3/ha/y)		
			Conifer	Decid	Proportion
Sw n=132	Proportion	Density	-0.45	0.85	0.88
		Percent Stocking	-0.34	0.81	0.82
	Coniferous	Density	0.42	-0.26	-0.31
		Percent Stocking	0.33	0.07	0.01
	Deciduous	Density	-0.34	0.82	0.85
		Percent Stocking	-0.30	0.83	0.84
	Pine	Density	0.40	-0.19	-0.23
		Percent Stocking	0.43	-0.34	-0.38
	Black Spruce	Density	-0.10	-0.04	-0.01
		Percent Stocking	-0.07	-0.09	-0.07
	White Spruce	Density	0.26	-0.18	-0.21
		Percent Stocking	0.07	0.28	0.26
Pl n=251	Proportion	Density	-0.10	0.72	0.78
		Percent Stocking	0.00	0.79	0.80
	Coniferous	Density	-0.16	-0.21	-0.23
		Percent Stocking	0.36	0.01	-0.04
	Deciduous	Density	-0.07	0.69	0.71
		Percent Stocking	0.02	0.78	0.78
	Pine	Density	-0.18	-0.19	-0.21
		Percent Stocking	0.37	0.00	-0.09
	Black Spruce	Density	-0.01	-0.01	0.01
		Percent Stocking	-0.06	-0.05	-0.02
	White Spruce	Density	0.15	-0.10	-0.12
		Percent Stocking	0.09	-0.03	-0.05

Wrap Up

Digital Photography

New digital photography shows some improvements, particularly with identification of coniferous species and conifers under deciduous overstory, but several difficulties remain:

1) Characterizing deciduous in leaf-off condition, particularly when less than ~4m.
2) Identifying presence and density of smaller coniferous ingress.
3) Differentiating Sb from Sw and therefore reliance on silviculture records.
4) Accurate interpretation of density where there is patchy spatial distribution/high densities.

Stocking for Photo Interpretation

Use of stocking can assist in mitigating issues #1 and #4. It is easier to note presence than it is to interpret densities. In addition, analysis of data (July 23, 2014 memo) has indicated that, relative to density-based metrics, there is:

1) Less variability (outage) between interpreted attributes and ground data.
2) Better conceptual alignment with AVI metrics (crown closure percent).

Stratification for RSA Subsampling

Where the objective is to minimize variability in MAI (coniferous, deciduous, and proportion), using stocking for assigning sampling strata results in:

1) Similar variability (coefficient of variation) of MAIs within sampling strata.
2) Equivalent or better correlation with predicted MAI (*could/should be supported with additional analysis*).

Collapsing mixedwood CD/DC strata into a single sampling stratum results in:

3) Modest increases in variability of MAI metrics, primarily for deciduous species.

Recommendations

1) Use stocking for assigning SUs into sampling strata, based on a 20/50/80 split.
2) Mixedwood sampling strata (rather than separate DC and CD strata) may be of sufficient resolution for sampling but further investigation may be merited.
3) Re-stratifying data for FMP and stratum reconciliation purposes is essential, since these recommendations are focused solely on the objective of assigning strata for a sampling population while minimizing variability in estimated MAIs within strata.

APPENDIX 7: STOCKING-BASED STRATUM ASSIGNMENT FOR RSA AERIAL PHOTO-INTERPRETATION

STOCKING-BASED STRATUM ASSIGNMENT FOR RSA AERIAL PHOTOINTERPRETATION

RECOMMENDATIONS OF AFGO STRATA SUBCOMMITTEE TO THE RSA MANAGEMENT COMMITTEE

Early work by the Strata Subcommittee found that RSA photo-based stratum assignments resulted in a large amount of within-stratum variability in species composition based on ground survey data. The subcommittee initially expected that variably would be reduced when the new higher resolution photography was used. However, additional analysis showed that use of the new photography did not reduce variability within strata to the extent that was expected. Details of both analyses can be found in "Report to AFGO Members from the Strata Subcommittee on work conducted from September 2012 to October 2014."

Using photo-interpreted stocking to make RSA stratum assignments was assessed to determine whether it decreased within-stratum variability. Re-interpretation of 74 sampling units from 4 companies showed that using percent stocking to assign strata gave more consistent results and that interpreted stocking was better aligned with ground sampled stocking than interpreted density was with ground sampled density. However there was an overall trend towards under-calling both stocking and density, particularly in the case of deciduous content.

A number of alternative stratum assignment scenarios were assessed to determine whether moving to a stocking-based scheme would improve stratum assignments, with the objective of minimizing within-stratum variability, defined in terms of predicted culmination MAIs (coniferous, deciduous and proportion). Both a 20/50/90 split based on density and a 20/50/80 split based on stocking resulted in fewer SUs being assigned to pure deciduous but both had very little impact on variability for primary species of interest. However, 20/50/80 stocking is better aligned with AVI break points for defining broad cover groups and is more repeatable during photo interpretation.

Given that:

1. Stratum assignment in RSA is intended to group similar stands for MAI assessment and use of stocking gives equivalent or better correlation with predicted MAI;
2. Smaller patches of high density species can have a large impact on density-based assignments;
3. High densities, particularly of deciduous, are difficult for interpreters to call accurately; and
4. Stocking is more repeatable for photo interpretation and aligns better conceptually with AVI broad cover group definitions.
5. Adding interpretation for stocking will result in a negligible increase in cost

The Strata Subcommittee recommends that:

1. RSA photo-stratification be based on stocking percent instead of density percent, based on a 20/50/80 split;

2. Before official change of the RSA manual, stocking percent should be collected in addition to the regular RSA photo -interpreted data beginning immediately to collect additional test data. This information is also useful for strata reconciliation/assignment. In advance of an established standard, stocking should be recorded for deciduous overall, coniferous overall, species groups, and total stocking.

Given that deciduous in all strata are still more variable than conifer, the Subcommittee has identified that their greater variability is an issue that needs to be addressed. Possible solutions could include using silviculture records or establishment survey results, or asking interpreters to do additional self-calibration.

22 October 2014

Appendix 8: Projection of Early Stand Composition to Rotation

Projection of early stand composition to rotation

Note that the following discussion paper does not represent the consensus views of the strata subcommittee. Discussions tended to be polarizing within the subcommittee with regard to many of the technical details and the regulatory policy framework in which we currently operate. This does not represent the full suite of challenges and potential solutions that were discussed by the stratification subcommittee with regard to this topic.

Background:

Stand dynamics and successional changes of the boreal mixedwood forest are understood as follows:

Wildfire is usually the stand initiator and in most instances aspen and to some degree balsam poplar and birch will populate the site as pioneer species. White spruce recruitment often occurs during the first few years after fire when a seedbed is present, its presence and density determined by available seed source and mast year occurrence. Spruce will grow slowly in the understory until aspen starts breaking up and gaps in the canopy enable white spruce to become the dominant species. There is a fundamental difference in mortality rates between aspen and white spruce which facilitates changes in stand composition. Aspen has much higher mortality rates than spruce and stand-break-up occurs much earlier. It has also been shown that high densities of spruce can hasten aspen break-up. Stand succession transitions stands from aspen with a spruce understory to a mixedwood and eventually to pure spruce if undisturbed. Initial aspen densities, which can vary considerably, will converge at around age 30 to similar densities due to self-thinning driven by intra species competition.

In boreal forests, almost all spruce stands have regenerated naturally under a canopy of aspen or balsam poplar – note the prevalence of 60 to 80 year old aspen stands with an understory of white spruce. It is very rare to find a pure juvenile white spruce stand that has regenerated from seed, except for the very rare instances when a fire burns very hot and eliminates all aspen roots.

For young white spruce growing in the understory, aspen acts as a nurse crop. An aspen overstory will moderate the environment and protect spruce from temperature extremes, hail, wind and frost damage. Competing vegetation, especially *Calamagrostis Canadensis,* is reduced and nutrient cycling is improved. Insects such as terminal weevil and spruce budworm occur less frequently in stands with an aspen canopy. All of these factors can reduce mortality during the establishment and early growth phase of spruce. This might increase in importance under a climate change scenario.

Mixedwood stands have been shown to be more productive than single species stands which is a desirable aspect when loss of landbase is occurring due to ecological demands as well as industrial developments.

The problem:

Aspen-spruce mixedwoods undergo dynamic successional changes and the stand composition and density of trees shifts over time. Models that simulate this development must also reflect these transitions to stands of different species composition over time. Current policy does not allow for natural succession in managed stands, but instead demands establishment of a stand composition at a young age that is reflective of the stand composition at maturity. This is based upon the mistaken assumption that stands have the same relative proportion of stems of aspen and spruce at the beginning of their development as they do at maturity. However, our current understanding of ecological and successional aspects of mixedwood development reveal that stands that start out as aspen-dominated can shift to spruce-dominated over the course of a century.

In the past when yield curves have been developed some of the natural succession principles have been overlooked. This is due to several factors:

1) Absence of data from young stands;
2) Chrono-sequencing of plots that are thought to be on the same stand trajectory, i.e. only stands with a low aspen component were chosen to represent the development of CD or C stands; and
3) Models have been developed based mainly on mid- and late-stand development data

Accordingly, current yield curves for mixedwood or pure spruce stands do not reflect the initial high deciduous component in these stands and natural stand succession. While there may situations where a forestry firm wishes to impose early management interventions to shorten rotations by creating relatively pure spruce stands early in stand development, this should not be the only strategy for management of these forests. If a longer and more natural rotation is assumed there should be no reason to exclude natural successional dynamics and transitions from aspen to spruce as an appropriate Silviculture strategy.

The solution:

With rising Silviculture costs and unfavourable lumber/pulp markets, more extensive stand management modeled after natural succession has become a focal point. Common landbase and new management tools such as understory protection enables forest management that attempts to maximize productivity for both species in a mixedwood management context rather than through single species plantation management.

Yield curves that reflect natural succession will focus on stand composition at varying harvest ages. Rather than using proportions of the early aspen and spruce as is currently practice, spruce density alone will determine what trajectory a stand is following regardless of aspen density once the required minimum is achieved. Aspen density is not a driver to decide if a stand follows a mixedwood or pure spruce trajectory since extending rotation ages will allow stands to develop to the desired composition.

The following breakpoints are proposed for extensive mixedwood yield curves (spruce density and minimum harvest ages can be confirmed and/or adapted through research and data analysis once the provincial database has been established):

1) No or low spruce component (< 300 stems per ha) = D

2) Moderate spruce component (300 – 800 stems per ha) = DC with a minimum harvest age of 90 or 100 years
3) Spruce component > 800 stems per ha (> 600 stems per ha at rotation) = DC or CD with understory protection and a minimum harvest age of 60 years = DC or CD
4) High spruce component (>800 stems per ha) = CD with a minimum harvest age of 90 years or = C with a minimum harvest age of 120 years

Additionally, yield curves that reflect intensive management practices with shorter rotation ages can be developed and be part of a comprehensive forest management that embraces all options.

Stand transitions and rotation ages would be defined as part of a Forest Management Plan and RSA stratum assignment rules for "binning" will be company (yield curve) specific.

The following management strategies could be implemented to achieve a balanced mixedwood management strategy across a forest unit:

1) Herbicide intervention at early stand development will create an almost pure spruce stand similar to those after hot fires
2) After harvest of mixedwood or white spruce dominated stands, plant but do not tend the deciduous component. After harvest of a pure deciduous stand, the silviculture strategy would be to leave for natural (LFN), however, natural white spruce ingress may occur to varying degrees. Depending on management strategy or rotation age these stands will follow various trajectories
    a. Clearcut at early-rotation (min. harvest age 60 years) in stands with low or no spruce component. Will be in a D or D/C seral stage and favours deciduous volume.
    b. Aspen harvest at early stand rotation (min. harvest age 60 years) with white spruce understory protection on stands > 600 stems/ha understory. Second pass harvest primarily for spruce volume. Will be in a D/C seral stage and favours both deciduous and spruce component
    c. Clearcut at mid-rotation (min. harvest age 80 to 100 years). Will be in a DC or CD seral stage depending on spruce density and favours both deciduous and spruce component.
    d. Clearcut at late rotation (min. harvest age 120 years) will have reached the C seral stage and favours the spruce component and foregoes the aspen in the stands

The proportion of these management strategies would reflect current strata proportions and FMP transitions to accomplish strata balancing as mandated by ESRD.

Linking Performance Survey data to stand composition at rotation for purposes of strata balancing would follow the species composition reflected in the yield curves.

Spruce density shall also determine labels given to stands through aerial stratification for RSA purposes. Following the above yield curve logic, the "bins" could be described as (these spruce densities may be high):

1) D = spruce < 300 stems per ha, D > 1000 stems per ha, no upper limit
2) DC = spruce 300 – 800 stems per ha, D > 1000 stems per ha, no upper limit
3) CD = spruce > 800 stems per ha, D > 500 stems per ha, no upper limit, depending on assigned harvest age
4) C = spruce > 800 stems per ha, D 0 to no upper limit, depending on assigned harvest age

This would necessitate creation of additional RSA bins for stratification.

The alternative:

The alternative would increase the use of herbicides by companies, which may affect the ability to obtain/maintain FSC certification and could lead to silviculture practices influenced more by administrative needs rather than sound forest management.

Staying with the status quo where early stand conditions have to reflect stand condition at maturity would necessitate the use of herbicides in all stands that have been declared to pure white spruce. This may be a result of the fact that GYPSY does not project early successional stand changes well, likely due to the lack of early stand data used in model development. For example, GYPSY simulations show that only stands with <200 sph aspen at year 14 will result in pure white spruce stands at maturity.

Similarly CD stands would also require interventions to reduce aspen density and could lead to the continued practice of segregated mixedwoods as density management in this manner is more economic.

Remaining with this status quo approach will eliminate the ability to implement any silviculture strategies intended to more closely mimic natural systems.

Appendix: Response to ESRD Concerns

Caveats

1. Forest productivity should be maintained
2. Quota holder consensus is required
3. TSA sensitivity analysis is required

Response

Due to a combination of Silviculture methods (plantation management, understory protection, successional approach) a loss of forest productivity is not anticipated. TSA sensitivity analysis will reveal stand composition transitions and harvest ages that will maintain AACs that are anticipated on the current landbase. Forest productivity should not be assessed on a yield curve basis but through the TSA and resultant AACs. Quota holder consensus is part of any FMP process.

Concern

No deciduous density restrictions for conifer strata. Would prefer discrete deciduous density classes for the different strata.

Response

Creating discrete deciduous density classes would assume that stand composition at rotation needs to be a reflected at early stand age and the principle of natural succession where DC – CD – C is a continuum would not be followed. Aspen self-thinning is density dependent and it has been shown in many trials that a wide span of aspen densities will converge after 20 years. There is, however, the possibility that different aspen densities in the first 20 years may affect spruce growth to some extend that may carry through to rotation.

Since the extent of deciduous suckering cannot be predicted prior to it occurring, it is likely that many cutblocks would have to undergo density management in order to achieve the deciduous density linked to the conifer stratum the block was declared to. Creating two yield curves per conifer stratum with low and high deciduous density could reflect the potential differences in spruce growth.

For the 2015 FMP, Al-Pac may propose to create 2 yield curves for conifer strata, one with aspen density up to 5000 stems per ha and one with aspen density greater than 5000 stems per ha to allow for different degrees of suppression of spruce growth in the first 20 years.

For example:

1) Sw> 800 sph and Aw < 5000 sph will be a DC at year 80, CD at year 100 and C at year 120. A minimum D density is required for the DC and CD stratum.
2) Sw > 800 sph and Aw > 5000 sph wil be a DC at year 90, CD at year 110 and C at year 130. A minimum D density is required for the DC and CD stratum.

The cut-off points and rotation ages above are only examples at this point and will be verified though data analysis and MGM model runs during the yield curve development process.

There would also be a DC curve with lower spruce densities.

Concern

What stratum will be assigned to a successional conifer stratum?

Response

The 10 RSA base strata will be maintained as is and additional successional strata will be created.

Concern

The successional approach needs to be incorporated into the Silviculture matrix.

Response

The successional approach will be added to the Silviculture matrix.

Concern

Need to ensure that commitment to extended rotation will be maintained over time.

Response:

The successional approach, transitions and rotation age commitments would form part of the FMP and the associated TSA. These commitments will be carried over from FMP to FMP unless both stakeholders such as quota holders and ESRD agree to a change based on valid rationales.

Concern

What will happen when AVI replaces performance survey results?

Response

With new technology such as four-band imagery, it is expected that spruce understories can be adequately classified. The conifer strata that are managed based on the successional approach will most likely be classified as aspen overstories with conifer understories. Management of these understories and transitions will be a FMP commitment.

Concern

Will the successional approach and resulting landbase composition lead to tenure issues?

Response

The successional approach should not lead to any issues with tenure if common landbase principles are applied. AACs should be determined by objective rather than landbase composition at any point in time. Using the current AACs as a baseline, the objective is to maintain AACs for both deciduous and coniferous stakeholders. A potential uplift or reduction (due to shrinking landbase) would be applied proportionally. This approach would also soften large fluctuations in AACs of either species due to forest aging and disturbances.

For example, Al-Pac is exploring a common landbase approach in S18 with Alberta-Plywood and Vanderwell. Since it is unlikely that all FMUs will be under a common landbase regime in 2015, tenure issues can be avoided by determining AACs driven by objective instead of landbase composition.

APPENDIX 9: CURRENT AND POTENTIAL USES OF RSA DATA AND LIMITATIONS OF USE

CURRENT AND POTENTIAL USES OF RSA DATA AND LIMITATIONS OF USE

RECOMMENDATIONS OF AFGO STRATA SUBCOMMITTEE TO THE RSA MANAGEMENT COMMITTEE

The AFGO Strata Subcommittee, at the request of the RSA Management Committee, discussed uses and limitations of RSA data. This document summarizes their discussion and recommendations for use of the data.

Uses

RSA data has two components: survey data and stratification data. Each has different uses.

Survey data must be used:

- As a performance measure (QAC)

Survey data may also be used:

- To supplement TSPs and PSPs to develop yield curves (need consistency with how it is compiled)
- For yield curve validation
- As the basis for establishing PSPs to get repeat measures post-performance survey
- To provide feedback for silviculture practices and for aerial interpretation

Stratification must be used for:

- Polygon definition (boundaries)
- Attribute assignment until the next inventory
- Strata reconciliation

Stratification may also be used for:

- Stratum assignment for yield curve development

Limitations

RSA has the following limitations.

- Data quality and difficulty in obtaining correct ages is a concern and may be improved by quality control procedures and standardized training.
- A suggested guideline is that RSA labels be replaced by AVI labels when stands are at least 20 years old. However, caution needs to be applied when doing this to ensure that the best information available is used.
- Trees are potentially too young for stable/accurate site index estimates.

- RSA provides abundant data only for 12-14 year old stands but information is needed for stands at other ages.
- Data collected does not include the height and DBH needed for MGM (unless optional data are collected).
- Optional data doesn’t include sampling conifers <1.3m needed for MGM.
- The current sample selection process is biased and this can limit how data are used in forest management planning.
- There are issues with how advanced regeneration and low density cohorts are handled.
- RSA polygons do not necessarily match AVI polygons and there will need to be a process to resolve how to label areas not covered by RSA.
- Not all blocks have photo stratification and a process needs to be developed for labeling these blocks.
- Changes to silviculture practices need to be considered when applying RSA data to yield curve development.
- Non-photo programs may not have digital SU maps or accurate boundaries which may make linking RSA stratification to the landbase used in the timber supply problematic.

RSA data should not be used in the following ways.

- Yield curves should not be created by averaging results of all surveys. Instead, build separate curves for each individual survey year and then average across years.
- The composite label should not be used outside the RSA context.

21 October 2013

APPENDIX 10: STRATUM ASSIGNMENT AND YIELD CURVE DEVELOPMENT PROCESSES

STRATUM ASSIGNMENT AND YIELD CURVE DEVELOPMENT PROCESSES

NOTES FROM THE AFGO STRATA SUBCOMMITTEE

Ignoring pre-91, the concept is that:

1. If possible, each opening will be declared to, and managed for, a single RSA stratum (thus possibly much more similar to eventual SUs that current practice).
2. At RSA performance survey, SUs are split out and labelled based on actual strata results
3. Later, new AVI (a minimum of 20 years post-harvest) will be used to characterize and, if required, re-stratify SUs. Since the first split under RSA is based on species composition, there is some hope that linework will not change very much.

- Strata labels may change between 1 and 3, but scale is expected to be relatively similar due to item #1.
- Until a performance survey is completed, the declaration (or re-declaration) is our "best guess" of what the opening will be.
- At RSA performance, the aerial label is our best estimate of what it is/ will be.
- The AVI label is an update to that label - sometimes it will change when moving from RSA to AVI, but it's no different than changing from one AVI to the next.

Data for yield curve development will come from two sources:

1. RSA performance surveys
2. TSPs in older stands. TSPs will be stratified by AVI where possible. Where NOT POSSIBLE, they will be stratified by silviculture regime/establishment survey results as the best approximation.

- RSA performance survey and AVI TSP data may be combined as long as it's shown that the two populations being sampled are similar.
- If silviculture practice has changed, data may not be applicable for developing yield curves since these are applied to all current and future blocks.

APPENDIX 11: USE OF RSA AERIAL STRATIFICATION FOR MAI ASSESSMENT AND STRATA RECONCILIATION

USE OF RSA AERIAL STRATIFICATION FOR MAI ASSESSMENT AND STRATA RECONCILIATION

RECOMMENDATIONS OF AFGO STRATA SUBCOMMITTEE TO THE RSA MANAGEMENT COMMITTEE

Data from RSA aerial programs is expected to be used for the strata reconciliation process. However, it is the recommendation of the strata subcommittee that its use for this purpose be differentiated from use to assess MAI in regenerating stands. The original intent of the RSA performance survey aerial stratification was to characterize and group areas that are similar for the purposes of subsampling sampling units (SUs) and assessing MAI. However, because the RSA process provides up to date inventory information, there is a desire to use this information for landbase assignment for timber supply analysis and strata reconciliation.

Given that:

1. ESRD requires a standardized approach for assessing MAI as a part of the RSA process;
2. Strata reconciliation and landbase assignment is FMA-specific and must be consistent with transitions and yield strata described in each company's FMP; and
3. Strata currently defined through the RSA process are difficult to link to expected future conditions.

The Strata Subcommittee recommends that:

- If aerial stratification data is used for strata reconciliation and landbase assignment, this must be done using process that is distinct and separate process from subsampling and MAI assessment.

Details of the two processes are described below.

MAI Assessment:

- The intent of these subsampling strata is to reduce variability within the groups used for MAI assessment and in the subsequent MAI outputs.
- Objective is to minimize within-bin variability in MAI results in order to achieve the desired allowable error.
- Important to aerial programs only because ground surveys are at the block level and subsampling strata are irrelevant to MAI assessment.
- Needs to be a standardized (provincial) set of subsampling strata for use by all companies.

Strata Reconciliation:

- The intent is to assign a yield stratum that best represents the trajectory that the stand is on, for purposes of strata reconciliation (planned future forest condition).
- Methods for assigning yield strata must align with company-specific yield groups in order to allow strata reconciliation consistent with FMP commitments.
- The yield strata can be derived from either photo (aerial) or ground (non-photo) attributes and must be linked to expected future condition.

30 June 2014

APPENDIX 12: MAI AS LINK BETWEEN EARLY STAND PERFORMANCE AND YIELD CURVE

MAI AS LINK BETWEEN EARLY STAND PERFORMANCE AND YIELD CURVES

RECOMMENDATIONS OF AFGO STRATA SUBCOMMITTEE TO THE RSA MANAGEMENT COMMITTEE

The AFGO Strata Subcommittee was asked by the RSA Management Committee to address a number of questions around the link between RSA and growth and yield. The subcommittee agreed that, of these questions, the highest priority question to answer was:

1. *Is MAI the 'best' data to be used as a regeneration standard to link early performance to the DFMP/AAC/TSA?*
    a. *If yes, then is culmination MAI the right MAI to set as a standard given culmination is not always where harvesting will occur? For example, late harvesting of C in mixedwoods may be a DFMP imposed harvest limitation to achieve other values.*

In response to this question, the Subcommittee has three recommendations:

1. Culmination MAI should continue to be used as a regenerations standard to link early performance to the DFMP.

2. Culmination of total MAI should be an option to set targets in mixedwoods.

3. Where later rotation harvesting is planned, a minimum harvest age should be allowed when selecting culmination MAI.

The remainder of this document provides a rationale for these recommendations.

It is necessary to establish a link between early stand performance and the Detailed Forest Management Plan (DFMP). This allows an evaluation of growth to the assumptions made in the existing timber supply analysis. It can also help develop yield curves for subsequent forest management plans.

The silviculture matrix was discussed as one other possible way to make the link between performance and the DFMP. However, because this link needs to assess growth, the silviculture matrix is not a suitable basis.

Because of the importance of growth in establishing the link between early stand performance and yield assumption, the subcommittee was not able to identify any link that would be more suitable than culmination MAI. It is consistent, measureable and useful in all cases. If MAI is used to establish the link between early stand performance and the DFMP, it is critical that standards are set in the same way they are evaluated.

Culmination of total MAI may be a better link for mixedwoods. Age at which culmination occurs would be based on total MAI, but companies would still be accountable for meeting separate targets for the deciduous and coniferous components. It was likely originally separated by conifer and deciduous because of tenure, but issues around tenure would not be a factor in a common landbase.

Where culmination MAI does not reflect intended species composition (e.g. later rotation harvesting), a minimum harvest age may be appropriate for selecting MAI targets. For example, culmination MAI would only be selected only after the minimum harvest age is achieved.

GYPSY is currently the only approved model to evaluate MAI targets at performance surveys. However, if empirical yield curves or yield curves generated with MGM are used, the GYPSY projections may not match the yield target from that yield curve (due to differences in curve form, culmination MAIs can be quite different). If differences between GYPSY and other yield curves are significant, it may be necessary to evaluate using the same model to set the MAI target as was used to project the yield curves.

21 October 2013

APPENDIX 13: QUESTIONS FOR THE GYPSY ADVISORY COMMITTEE AND THE MGM STRATEGIC DEVELOPMENT TEAM

Do GYSPY and MGM 'accurately' predict the linkage between early performance and DFMP objectives, and if not, what are the modeling concerns that will need to be addressed to increase the accuracy to a necessary level?

General:
- Do we need a spatial model or a semi-spatial model to project piece size, etc?
- The least accurate parts of projections are early stand and break up.
- Ingress and mortality functions may need to be improved.
- Should advanced trees be included in the models?
- Should average density be used? Should density be used since large density plots skew the mean?

GYPSY:
- Is there a need to track species versus species groups?
- Should there be separate groups for jack pine and lodgepole pine?
- Are there plans to enhance GYPSY for mulit-cohort stands? And for multiple treatments or entries?
- GYPSY appears to over-predict aspen.

MGM:
- Which species are modelled accurately? Is aspen site index used for all deciduous?
- MGM appears to over-predict conifer

Are the correct data being collected by the RSA survey to best make the link between early performance and DRMP objectives, or should different and/or additional data be collected to better make the link?

General:
- Where should top height be used versus average height? Is there an alternative to site index?
- Is stocking the best way to measure spatial distribution?
- What data would be needed for understory protection standards? How would site index be assessed?
- What is the impact of choosing the largest tree for top height when it might be advanced growth?
- Is there a potential to develop a birch site index curve?
- Projections need to include piece size and species-specific volume.
- RSA data doesn't give stable site index estimates. If we sample in older managed stands with TSPs, how can we get percent stocking?
- When is stocking no longer relevant?
- What is the minimum plot size needed to run a projection from an individual plot?

MGM:
- What will happen to MGM is Shongming changes formulas?
- What is the minimum amount of data needed for an MGM tree list?
- RSA doesn't collect what is needed for MGM: conifers <1.3 m and height distribution are missing.