Vegetation Resources Inventory

Photo Interpretation Quality Assurance Procedures and Standards

Prepared by
Ministry of Forests, Lands and Natural Resource Operations
Forest Analysis and Inventory Branch

March 2017

Version 4.1

For questions concerning the content of this publication please contact the:

Manager, Forest Inventory
Forest Analysis and Inventory Branch
PO Box 9512, Stn Prov Gov't
Victoria, BC V8W 9C2
Phone: (250) 387-3650 Fax: (250) 387-5999

Digital Copies are available on the Internet at:

http://www.for.gov.bc.ca/hts/inventory.htm

March 2017

Major Changes to Photo Interpretation Quality Assurance Procedures and Standards

1. Historical Data Source Transfer guidelines have been updated to remove hardcopy to hardcopy procedures.
   (Section 2.4.1 Historical Data Source Transfer)
2. Missed or added Layer D score sheet updated to reflect correct layer scoring.
   (Appendix G)

Comment [A1]: Make sure this is correct.

Table of Contents

List of Tables

1.0 Introduction

1.1 Background

This document contains the Photo Interpretation and Quality Assurance Procedures and Standards for photo interpretation projects undertaken using the British Columbia Vegetation Resources Inventory (VRI) Photo Interpretation Procedures. It is intended to be used by individuals involved in the planning, implementation and quality assurance of VRI photo interpretation projects.

As digital imagery and the use of softcopy technology has become the common tool for VRI photo interpretation, the procedures documented here primarily reflect the use of that technology. Some of the hardcopy photo interpretation quality assurance process has been moved to Appendix A.

A scoring system has been developed to evaluate the checked polygons, and a passing grade is provided to assist in the evaluation. Some of the standards are not applicable to softcopy technology, as described within the document. If the VRI contractor's score(s) do not meet or exceed the minimums required, remedial action must be taken.

1.2 Objectives of Photo Interpretation Quality Assurance

The objectives of conducting quality assurance for photo interpretation encompass the determination of both consistency and accuracy. Specifically, there are four (4) main objectives including:

1. To improve the quality of photo interpretation through interactive evaluation, feedback and training.
2. To determine the performance of the individual interpreters in relation to measured and interpreted observations.
3. To ensure the maintenance of photo interpretation standards.
4. To ensure the data is validated and will load to Ministry corporate data systems and meet the business needs of government, industry and other data users.
5. To provide supporting information for contract administration; i.e., to facilitate payment and to document the quality for future use of the data.

2.0 Photo Interpretation Quality Assurance

2.1 Overview of Photo Interpretation

The work that leads to the production of a vegetation resource inventory data set consists of five major stages:

1. calibration data review and transfer;
2. polygon delineation;
3. field calibration;
4. attribute estimation; and
5. digital capture of attribute and graphic.

Implementation of data source transfer, the first stage of photo interpretation, can be quite different depending on whether softcopy technology or hardcopy photos are being used. Data source transfer consists of preparation of aerial photos or softcopy models and the migration of historical air and ground-based data to the inventory photos or VRI coverage/models from which the new photo interpretation will be made. This source information is useful in photo interpretation calibration. Using softcopy technology, this process can be automated by transferring old digital data source locations from the historic database.

During the polygon delineation stage, boundaries are drawn around areas with uniform vegetated and non-vegetated cover. This process creates vegetation cover polygons.

The field calibration stage is used to further familiarize the photo interpreter with the local vegetation conditions and to provide reference or calibration points to assist in photo interpretation. This familiarization is accomplished by the interpreter selecting representative areas within selected polygons for which they anticipate having difficulty in attribute estimation or where the current inventory requires additional field support. By visiting these land cover types, the photo interpreter builds a mental picture of what attributes should be assigned to stands of similar structure, tone and texture on aerial photographs.

Data collection procedures and quality assurance standards for the collection of field calibration (air and ground calls) data and the quality assurance rating processes and forms are located in the VRI Field Calibration Procedures for Photo Interpretation.

For a copy of the current version of the VRI Field Calibration Procedures for Photo Interpretation document, contact the Ministry of Forests, Lands and Natural Resource Operations or visit the web site: http://www.for.gov.bc.ca/hts/vri/standards/index.html.

The attribute estimation occurs after the field calibration stage. At this stage, the interpreter uses the historical data, their field calibration experience, with calibration point locations transferred to the new data base, and interpretive skills to photo interpret species composition, height, age, density, basal area and other vegetation and ecological attributes for each delineated polygon. VRI attributes are entered directly into a digital format. Initial delineation may be modified into a final format during the attribute estimation stage.

In softcopy, the process for digital capture of the polygon line work is ongoing throughout the VRI project and is essentially complete at the polygon delineation phase. For hardcopy photos, the final stage of the inventory process involves the digital capture of the graphic line work of each polygon which is digitally merged with the attributes that were estimated in the photo estimation phase. The digital capture of the line work is the subject of other documents and is separate from this quality assurance process.

2.2 Process

Quality assurance must be performed by Certified VRI Photo Interpretation personnel that are independent of the primary contractor and sub-contractors undertaking the inventory project. The independent quality assurance staff is referred to as quality assurance personnel in this document.

Quality assurance will occur throughout all five (5) stages of the interpretation process. Each stage has products and deliverables that can be evaluated on an individual basis or in combination. As payment is usually based on deliverables of each stage, quality assurance is more appropriately completed on a phase by phase basis. To ensure quality products and timely payment, the primary contractor and the quality assurance personnel should schedule the submission of products in batches at planned points throughout the duration of the contract. The ensuing quality assurance schedule should allow for an appropriate assessment of the contractor's work, time for the contractor to improve the product quality if required, and enable payment to be authorized in a timely and efficient manner.

As the contractor submits each completed set of maps, the quality assurance personnel must obtain samples of the work and check to ensure that Ministry standards are being met. The products produced by the separate stages of the photo interpretation process must be assessed at the start of and throughout each stage, and for the various photo interpreters involved with each stage.

Internal Quality Control must be maintained by the contractor Quality Control personnel. Any work carried out by the photo interpreter that is assigned Quality Control responsibility must be independently reviewed by a qualified senior photo interpreter assigned to the project.

2.2.1 Quality Assurance Records

To facilitate efficient monitoring and create a record of the third-party quality assurance of each map, a "Quality Assurance Record" must be maintained by the quality assurance personnel for the delineation and attribution stage of the photo interpretation process. An updated record must be submitted to the Ministry representative with each quality assurance report. The Ministry will be responsible for forwarding QA results and requesting remedial actions if appropriate. See appendix B for an example of a quality assurance record for delineation and attribution stage.

The minimum information to be maintained in the record includes:

- Map sheet reference number;
- Photo interpreter name;
- Submission date;
- Submission Identification Number (SID);
- Date of quality assurance completion;
- Number of polygons attributed per map sheet;
- Number of stereo models or polygons checked per map sheet;
- Rating achieved; and
- Comments.

Each submission of maps for the quality assurance is to be divided by the photo interpreter and numbered in sequential order by a unique submission identification number (SID). In order to identify any delineation or attribution issues early in the project, the first submission of maps must be kept to one full map equivalent (FME) per interpreter. The prime contractor should obtain quality assurance feedback for each photo interpreter's batch submission prior to submission of additional maps for quality assurance to ensure project objectives are being achieved.

2.3 Procedures

Quality assurance must be conducted throughout all stages on every map sheet of the VRI photo interpretation process as outlined in this document and as agreed to by the quality assurance personnel and Ministry representative.

In order to identify any potential work quality issues early on in the project, quality assurance must be requested by the contractor within three working days after the completion of each interpreter's first full map equivalent in the delineation and attribution stage of the project. The size of each submission of maps submitted for subsequent quality assurance will be determined for each project at the project pre-work meeting.

2.3.1 Systematic Errors

Systematic errors are reproduced inaccuracies that are made consistently in the delineation and attribution stage over a project, portion of a project, or by a specific interpreter. These may be difficult to determine on a map by map basis.

An example of a systematic error would be where an interpreter is consistently interpreting Aspen as being another species (Birch for example). In this case, the Quality Assurance personnel may have noticed that a crew has misclassified a polygon or two on a map, but it does not affect the overall pass/fail determination for that map. After subsequent maps have been audited, it may become apparent that the mis-classification of these two species is systematic (i.e., consistently being misclassified).

Another example may occur when an interpreter has consistently misunderstood the VRI Photo Interpretation Procedures. If an interpreter is consistently confusing Meso slope with Macro slope, Quality Assurance on any individual map may not determine that there is a problem due to the random selection of polygons, and the number of polygons that may have the correct value *by chance*. Over the course of performing Quality Assurance on several maps, it may become apparent that there has been a consistent misunderstanding of the VRI Photo Interpretation Procedures.

In instances such as this, the Ministry representative will require the contractor to correct polygons in previous maps and, once the maps are fixed, they are subject to further review.

2.4 Data Source Transfer

Traditional photo preparation is not required for a softcopy VRI, other than acquiring the digital imagery and associated model files. Traditional document photos are no longer required as the digital work captured can be digitally draped over the current softcopy imagery being used or any new photos in the future.

2.4.1 Historic Data Source Transfer

Historical data sources are relevant to current softcopy VRI projects. As the majority of available historical attribute data is not in digital format, the requirement, as specified in the contract, for transfer of the data into a standardized Ministry template is determined at the VPIP stage of the project. Transfer of the attribute data into digital format must be completed prior to submission of a field calibration plan and/ or attribution.

All data sources should be transferred except when a justifiable case can be made to remove them (such as a major disturbance, large stand structure changes, or as defined in the contract document). Softcopy quality assurance involves documenting whether all data source transfer has occurred and the reasons if it has not. Ages and heights that are only available in "classes" should not be transferred directly into the

age and height fields on the calibration spreadsheet. The mid-pointed age and height for that class will be entered into the comments field, with the suffix "Age/height from mid-pointed classes"

Soft copy Data Source Transfer Quality Assurance Standards (paper to digital calibration tile transfer)

5% of the total transferred data sources will be assessed on 5 – 10 randomly selected mapsheets in a project, or area of a project.

Attribute	Points Possible	Standards
Coordinate (where not previously provided)	2	Within 50m, of the position as shown on the document photo
Core Attributes	2	Species Comp, Age, height, Basal Area, density All attributes correctly transferred – 2 One attribute incorrectly transferred – 1 point More than one attribute incorrect – 0 points
Other attributes	1	One attribute incorrectly transferred – 1 point More than one attribute incorrect – 0 points
Total Possible	**5**	All scoring is based on the review of the entire data source transfer batch.

A minimum of 85% must be scored to accept the work.

2.4.2 New Data Source Transfer

As a part of the review of attribute estimation, quality assurance personnel must ensure that new inventory data source locations have been captured digitally in the field calibration summary table. The field data attributes must be made available to the QA personnel by the contractor for review of the final attribute estimations. Office corrected/completed field data will match the calibration summary table exactly to be considered acceptable.

2.5 Polygon Delineation

Polygon delineation provides boundaries for similar or "like" vegetated or non-vegetated land cover. Accurate delineation provides logical units for the estimation of attributes.

The purpose of polygon delineation quality assurance is to determine whether a photo interpreter is using the photo interpretation guidelines for identifying polygon boundaries appropriately. In many cases, polygon boundaries have no sharp, distinguishable boundaries, and each interpreter must use their judgment to determine where the lines are drawn. The lines should, however, follow logical break points such as potential changes in site productivity or changes in species composition and meet project specific delineation objectives. Quality assurance individuals determine if delineation is "reasonable" and will permit for a logical basis for final attribute estimation.

The end product of polygon delineation is a graphical demarcation of similar vegetated and non-vegetated cover. A quality assurance report will be produced by quality assurance personnel and submitted to the Ministry with the rating obtained, the pass/fail status based on the standards, and a recommended

description of remedial action required if applicable. The Ministry will determine any remedial actions necessary and determine payment based on this report. Quality assurance will take place on a randomly selected sample of models.

Using softcopy technology and depending on the scale of photography, the number of models per map available for review will vary. To assess delineation, the quality assurance personnel must randomly select at least 10% of the model set-ups per map. The number of models assessed in partial mapsheets can be prorated down from 3 based on the percentage full mapsheet equivalent. In the softcopy environment, the quality assurance personnel should review the entire model area and make notes based on the quality assurance criteria outlined below. In the case of line placement, the quality assurance personnel should indicate corrected line work or examples of proper placement of lines to demonstrate to the VRI contractor areas of concern. There is no maximum sample size for quality assurance, and a greater intensity of review may be undertaken as deemed necessary by the QA authority.

In addition to polygons selected for delineation quality assurance, the QA personnel must view entire map digitally with an orthophoto underneath in order to record for the Ministry any obvious or systematic delineation or attribution issues.

2.5.1 Polygon Delineation Evaluation Process

The quality assurance on polygon delineation should proceed as indicated below. Reference to polygon delineation guidelines is provided in the VRI Photo Interpretation Procedures. The VPIP and contract documents must specify any additional requirements such as areas with distinct features below minimum polygon sizes that may be described as valuable aids for navigation, etc.

1. Select models for evaluation
    - Describe the methods for selecting models and if the map sheet is a partial.
2. Evaluate the following:
    - Accuracy of line placement;
    - Polygon size; may exceed recommended standards as outlined in VPIP and contract documents; and
    - Type separation; consistency and adherence to standards.
3. Record the above evaluation on the Rating Table for Polygon Delineation. See Appendix C for an example of a rating table that must be submitted for each map reviewed.
4. Sign off the quality assurance report:
    - Approve the product that achieves a passing score; and
    - Return the batch to the Ministry representative with recommended remedial action instructions regarding items that do not meet standards and that are to be re-done.

2.5.2 Polygon Delineation Evaluation

For normal mid-scale digital photography (1:15,000-1:20,000 or 20-30cm Ground Sampling Distance), it is expected that delineation would be performed at an approximate ground scale of 1:5,000 in order to maintain consistency between interpreters and for Quality Assurance purposes. This may be modified on a project specific basis.

- Line work must appear “smooth”, follow natural polygon boundaries and not have sharp non-natural edges.

- All polygons must close.
- Polygon size must be consistent with the delineation guidelines set in the Photo Interpretation Procedures.
- No polygon may be less than 0.5 hectares
- The interpreter should try to avoid significant areas where line work is within 40m of other line work, with exceptions as noted in the Photo Interpretation Procedures.
- General specifications (such as retain outer polygon line or specified internal polygon line requirements) for silviculture polygons must be outlined in the VRI Photo Interpretation Project Implementation Plan (VPIP) and contract documents.
- Polygons must be checked to ensure that they edge tie to adjacent maps inside the project and outside the project as determined in the VPIP or contract specifications.

Table 1 - Polygon Delineation Quality Assurance Standards and Scoring

Within the entire area of each model reviewed, the following criteria will be assessed.

Attribute	Points Possible	Guidelines	Standards
Accuracy of line placement	7 5 0	>90% polygons correct 85 – 90% correct < 85% correct	Subjectively, within +/- 10 meters on the ground for distinct type line breaks and +/- 20 meters within types that are not distinct. *Appropriate* ties to adjacent maps/projects, ties must be exact (+/- 0 meters)
Polygon size	3 1 0	>95% correct 90% to 95% correct <90% correct	Minimum polygon guidelines are adhered to and any additional contract requirements have been met such as significant features for field navigation.
Type separation	7 5 0	>90% polygons correct 85 – 90% correct <85% lines correct	Based on the Photo Interpretation Procedures to guide the process of delineating polygons.
Total Possible	**17**		All scoring is based on the review of an entire model.

A minimum score of 85% per map sheet (as an average of the models that are rated) is required for acceptable completion of work, per map reviewed.

Grouping of partial maps by interpreter to the one nearest full map sheet equivalent (FME) must be carried out in order to score minimum 10% of full models on a normal FME. If no additional partial maps are available by interpreter in the project, scoring a minimum of one model is acceptable.

For each stereo model reviewed, the quality assurance reviewer must demonstrate areas of concern by re-digitizing incorrect or unacceptable line work and by adding or deleting polygons to demonstrate quality assurance concerns. The contractor is expected to review/correct any items identified by the quality assurance reviewer.

Additional quality assurance of final delineation of vegetated treed polygons is completed during the attribution stage, as described in the attribute evaluation section, Section 2.6.2

2.5.3 Overview Delineation Evaluation

In addition to individual polygons/models selected for delineation QA, the entire mapsheet or submission file, and available adjacent mapsheets must be reviewed digitally with an ortho-photo underneath in order to record for the Ministry any obvious delineation or attribution issues. For example there may be a part of a map that has had missing delineation or is under-delineated that would not have been picked up during random polygon checks. Or it may become apparent that there are inconsistencies between interpreters as to the level of delineation being undertaken. Edge ties should be checked at this stage with surrounding projects and between submission files (maps). Issues will be documented in each delineation QA report.

2.6 Attribute Estimation

Both graphic and attribute data, including the new data source information, will be submitted by the contractor for quality assurance to the quality assurance personnel in a digital format. The contractor must provide the first map completed by each project photo interpreter immediately as it becomes available to the quality assurance personnel. Quality assurance is primarily conducted through photo interpretation checks. The photo interpretation evaluation considers all photo interpreted attributes.

2.6.1 Attribute Evaluation Process

Quality assurance will be undertaken on every map sheet in the project area and re-work applies to the entire QA batch of maps. The evaluation process applies to all attributes including supporting attributes. The QA personnel must perform queries and data sorts on the attribute database for each map provided by the Ministry project manager, prior to attribute evaluation. Items to be reviewed are finalized at the pre-work meeting, but will include data sorting and queries using MS Access to observe:

- Odd combinations of age and height
- Species not likely to be in the project area
- Unusual crown closure, basal area and height attribute combinations
- Duplicate species for the same polygon
- Missed attributes
- Alpine designated polygons with tree crown closure present

The attribute evaluation process is as follows:

1. Digital graphics files and attribute listings of delineated polygons on each map must be submitted by the contractor in a format as specified in the contract. The work of each photo interpreter in the project must be clearly identified. Attribute listings that do not contain the interpreter's name for each polygon is unacceptable and must be populated correctly prior to the quality assurance personnel beginning the checks on the attributes.
2. Conduct a data validation of each attribute file prior to polygon selection using "VegCap for Contractors" data validation program to ensure that data checks "clean". Any data that does not validate clean is sent back to the VRI contractor. This ensures that the VRI contractor is not penalized during the attribute evaluation process for missing values that would have been caught

during data validation. The QA contractor must notify the Ministry contact when files are returned to the VRI contractor.

3. Randomly select a minimum 5% or 10 polygons, whichever is greater, of the Vegetated Treed (VT) polygons per map using one of the following two methods:

   Method I - using the attribute listing for each map sorted by polygon number, establish a starting random "seed" polygon number for each map. The "seed" polygon may be QA personnel generated or Ministry provided polygon. Beginning with the "seed" polygon number, systematically select every 30th consecutive VT polygon until the target number of polygons is reached.

   Method II - select polygons using another method other than method I that is repeatable, auditable and clearly documented prior to beginning the quality check and that the attribution of all photo interpreters listed in each map is reviewed proportionately. This polygon selection method must be approved in writing by the Ministry prior to start of the QA attribution stage.

4. Grouping of multiple partial maps by interpreter into a single QA batch until a minimum of 500 polygons or a half of full map equivalent is reached is acceptable with Ministry approval. Each group of partial maps is considered a unique QA batch and is scored on one scoring sheet. Any re-work applies to the entire batch of maps. If no additional partial maps are available by the interpreter in the project, select a minimum 5% or ten polygons, whichever is greater, of the total polygons in the batch of partial maps.
5. For each sample of **VT** polygons, obtain an independent estimate of the Critical Attributes. The quality assurance personnel must not in any way have prior knowledge of the estimates of the original contractor.
6. Quality assurance of the D layer attribute estimates are reported independently from the live tree layers.
7. Select 40% of the polygons that were scored for Critical Attribute QA and perform Standard Attribute Quality Assurance on these same polygons.
8. Select 50% of the polygons that were scored for Standard Attribute QA (in point 7 above) and perform Supporting Attribute Quality Assurance on these same polygons.
9. Randomly select 1% (minimum 10) of the **Non Treed polygons** from the map for QA (all attributes are QA'd in these polygons including critical, standard and supporting attributes).
10. Randomly select 10% (maximum 10) polygons with historical data source and confirm that the data sources were utilized as appropriate in the photo estimation process. Results will be reported as comments for each mapsheet.
11. Randomly select 10% (to a maximum of 10) polygons with history disturbance from the previous inventory, and confirm the disturbance dates were utilized in the photo estimation process. Results will be recorded as comments for each mapsheet.
12. Compare the estimates of the QA personnel with those of the interpreter for each map and evaluate the difference between the two estimates. Due to the subjective nature of photo interpretation, the quality assurance attributes may be modified at this point with consideration of what is "reasonable", especially in stands with low crown closure (IE <5%) where determining tone, texture and pattern of a stand is difficult or impossible, or there is limited information that supports the QA estimate. The scoring system provided in Table 3 will be used to conduct the evaluation.

13. Record the scoring result of every attribute by its polygon and corresponding map in a rating table. The rating tables shown in Appendix D and Appendix E must be submitted for each map reviewed.
14. Provide remedial action for any work that does not meet the acceptable minimum rating.
15. Update the Quality Assurance Record.

2.6.2 Attribute Evaluation

For normal mid-scale digital photography (1:15,000-1:20,000 or 20-30cm Ground Sampling Distance), it is expected that estimation quality assurance of tree attributes would be performed at a largest ground scale of approximately 1:3,000 in order to maintain consistency between interpreters and for Quality Assurance purposes. This may be modified on a project specific basis.

- In cases where there is a discrepancy in photo estimation between the photo interpreter and the QA interpreter, the QA interpreter will adjust the viewing to a larger scale in order to better assess the original estimate. VRI attributes will be estimated for all polygons within a project area.
- Photo estimated attributes must be in an acceptable data structure.
- Photo estimated data must conform to the acceptable specifications.
- Attributes from adjacent projects should be carried over unless otherwise stated in the contract; however it is the interpreter's responsibility to ensure attributes meet VRI standards.

To ensure an effective attribute evaluation process, each attribute type is assigned to one of three evaluation attribute categories. The three categories are: Critical Attributes, Standard Attributes and Supporting Attributes.

Critical Attributes – attributes must individually achieve an overall minimum score of 85% per map to achieve the Ministry standards. These attributes are critical to the use of the data in forest management. If the standards are not met for any one of these attributes, remedial action must be taken and follow-up quality assurance must be carried out.

Standard Attributes - attributes in this category must collectively achieve a score of 85% or greater per map and, with the exception of a tree layer, must individually achieve a score of 70% or greater per map to achieve the Ministry standards. Although these attributes are important, they are not critical to the use of the data for forest management purposes.

The average score per map for the standard category attributes is calculated independently from the critical and supporting category attributes.

Supporting Attributes - attributes in this category must collectively achieve a score of 70% or greater per map and must individually achieve a score of 50% or greater per map to meet the Ministry standards.

Non- Scored Attributes – attributes in this category are not evaluated using score point system. Standards have been assigned to these attributes and it is expected that the standards for these attributes are to be met. If it is found that attributes are systematically estimated below standard, re-work may be requested.

Delineation – delineation of the treed polygons selected in the standard attribute quality category is assessed based on the three delineation criteria (line placement, polygon size, type separation).

The Quality Assurance values are always assumed to be the "correct" values. When scoring attributes, the correct calculation must be applied. The acceptable range for an attribute is based on the acceptable tolerance applied to the Quality Assurance value. For example if the interpreter has recorded a height of 23 meters for a leading species, and the Quality Assurance personnel has recorded 27 meters then the acceptable range is 0.85*27m, and an acceptable range for the interpreter are values between 23 and 31 meters.

The ultimate goal of quality assurance is to ensure high standard of the final photo estimates for the forest inventory. Where it is incidentally discovered that a map holds an unacceptably higher rate of inaccuracy of photo estimates than what the sample of randomly selected polygons revealed, the quality assurance report must identify the attribute(s) in question and provide for recommendations for remedial action established with the Ministry representative and contractor to resolve the issue.

Table 2 - Evaluation Attribute Categories

Category 1 Critical Attributes	Category 2 Standard Attributes	Category 3 Supporting Attributes
1. Species Composition 2. Leading species 3. Leading species height 4. Leading species age 5. Crown closure 6. Basal area	1. Second Species age 2. Second species height 3. Vertical complexity 4. Estimated site index species 5. Estimated site index 6. Tree Layer 7. Density 8. Final Polygon delineation	1. Ecology 2. Shrub height 3. Shrub crown closure 4. Non- vegetated cover type 5. Non-vegetated cover percent 6. Land cover components 7. Tree cover pattern 8. Snags 9. Shrub cover pattern 10. Herb cover percent 11. Herb cover pattern 12. Bryoid Cover percent 13. Non-vegetated cover pattern

The category and score points assigned to each attribute and the minimum standards for attribute estimation are listed in Table 3.

The "Total Points Possible" in the rating table for attributes in the Standard and Supporting Attribute categories is based solely on the specific attributes that constitute a complete VRI label for the polygon. The score fields for attributes that are not required in the VRI label are left blank in the rating table and therefore do not contribute to the 'Total Possible Score" for the polygon.

The following examples provide further clarification:

1. If the interpreter misses a second species, the score points for age and height attributes of the second species are left blank. The penalty for this error is accounted for in the evaluation of the species composition attribute.
2. The score points for missed supporting attribute(s) by the interpreter are included in the "Total Points Possible" for the polygon.

The scoring process should be jointly reviewed by the Ministry representative, contractor and QA personnel at the project pre-work meeting.

Table 3 - Category, Point and Standards for Attribute Estimation

Polygons sourced from RESULTS must match RESULTS data exactly, with a "reasonableness" test. Dead layers will be scored independently from live layers, with a separate mapsheet scoring provided.

Category 1 – Critical Attributes

Attribute	Points Possible	Standards	Comments
Species composition	5 2 0	≥ 80% correct ≥ 70% correct < 70% correct Must include only species codes from the VRI tree species list and must always add up to 100%.	Must be estimated for every tree layer of every polygon.
Leading species	1	Where leading and second species are within 10 %, either is acceptable as the leading species.	
Leading species height	1	Within +/- 3 meters or 15%, whichever is greater.	Must be estimated for every tree layer of every polygon.
Leading species age	1	Within 15years or 15% whichever is greater.	Must be estimated for every tree layer of every polygon.
Crown closure	1	+/- 10 crown closure units	Must be indicated for every live tree layer in every polygon.
Basal area	1	Within +/- 10 m^2 or 20%, whichever is greater.	Must be estimated for every tree layer of every polygon.

**Species Composition Examples:*

Quality Assurance	Contractor	
$S_{40}Pl_{30}Bl_{30}$	$Bl_{40}S_{30}Pl_{30}$	Species composition correct=90%;
$Fd_{50}S_{40}Pl_{10}$	$S_{50}Fd_{40}Pl_{10}$	Species composition correct=90%;
$Pl_{60}Fd_{30}Lw_{10}$	$Fd_{55}Lw_{25}Pl_{20}$	Species composition correct=60%;

Category 2 – Standard Attributes

Attribute	Points Possible	Standards	Comments
Second species age	2	Within 15 years or 15% whichever is greater.	Must be estimated for every tree layer of every polygon where a second species is present.
Second species height	2	Within +/- 3 meters or 15%, whichever is greater.	Must be estimated for every tree layer of every polygon where a second species is present.
Vertical complexity	1	Within +/- one unit value.	Must be indicated for every tree layer.
Estimated site index species	1	Must be present for stands under 30 years and stands where calculated site index does not represent actual site.	Must be a species that could occur naturally in the applicable polygon.
Estimated site index	1	+/- 20% of the height at breast height age 50 years. Must be present for stands under 30 years.	Must be accompanied by an Estimated Site Index Species and an Estimated Site Index Source.
Tree layer	-3 -1	A score deduction only (no points awarded) is applied to the total polygon score for a missed layer or unacceptable layers with crown closure ≥10%. * A score deduction only (no points awarded) is applied to the total polygon score for a missed layer or unacceptable layers with crown closure ≤9%. *	Polygon with more than one layer must meet the multi-layered criteria outlined in the photo interpretation procedures.
Density (stems/ha)	1	Within 200 stems or 20%, whichever is greater.	Must be estimated for every live tree layer of every polygon.
Final Polygon Delineation	1.5	Subjective review to ensure that the polygon meets delineation standards	Must meet all three delineation criteria, partial points not awarded.

* For example, when an interpreter calls a 1 layer polygon and the Quality Assurance Personnel determines it is a two layer stand, -3 is applied for the layer, but the assessment of attributes will take place assuming that the polygon is a combined single layer.

Category 3 – Supporting Attributes

Attribute	Points Possible	Standards	Comments
Ecology	6	SE = same as QA value MP = same as QA value SPM = +/- one unit value. AD = same as QA value SNR= +/- one unit value SMR=+/- one unit value (1 point for each category)	All polygons must have ecological data: Surface expression (SE), Modifying process (MP), Site position meso (SPM), Alpine designation (AD), Soil nutrient regime (SNR), Soil moisture regime (SMR) indicated for all polygons.
Shrub height	2	Must be in the correct shrub category (shrub tall versus shrub low). Shrub tall must be within +/- 3m (minus 1 point partial deduction)	Must be estimated for every polygon where shrubs are present and observable.
Shrub crown closure	1	+/- 10 crown closure units.	Must be estimated for every polygon where shrubs are present and observable.
Non-vegetated cover type	2	When present must be consistent with the BC Land Cover Classification Scheme code.	Maximum 2 points, if more than 1 land cover component then prorate to a total of 2 points. Do not prorate points if the total non-veg is less than 10%; any matching value will be given full points. If each individual type is less than 5% by QA, then full points if in the correct 3 "Classes" of non-veg (IE Water Cover codes, PN & GL, all other codes). Systematic errors may require re-work.
Non-vegetated cover percent	2	+/- 10 percent units	
Land cover components	1	The dominant LCC must be correct Where LCC #1 and LCC #2 are 20 % units apart or less, either may be acceptable as LCC #1.	All polygons must have a land cover component identified.
Snags (stems/ha)	1	Within +/- 50 stems or 20%, whichever is greater. <u>D layer</u> Within +/-100 stems $\leq$300sph Within +/-200 stems >300sph	Must be estimated for every tree layer in every polygon.

Attribute	Points Possible	Standards	Comments
Herb cover type	1	Must be consistent with the BC Land Cover Classification Scheme code.	
Herb cover percent	1	+/- 10 cover percent units.	
Bryoid Cover percent	1	+/- 10 cover percent units.	

Non-Scored Supporting Attributes

Attribute	Standards	Comments
Shrub cover pattern	Within +/- one SCP unit value.	
Herb cover pattern	Within +/- one HCP unit value.	
Non-vegetated cover pattern	Within +/- one N-VCP unit value.	
Tree Cover pattern	Within +/- one TCP unit Value	Must be indicated for every tree layer in every polygon.

2.7 Remedial Action Procedures

Where the outcome of the quality assurance identifies a need for re-work, all polygons on the affected map must be re-worked for the identified attributes. The map must be resubmitted for quality assurance when the re-work is complete. A new set of randomly selected polygons will be used to verify the quality of the re-work.

In cases where the results of the quality assurance identify the need for a re-work, it must be specified in the quality assurance report as to which maps and type of attributes that are required to be photo re-interpreted. The follow-up review and rating of the re-work is to be based only on those attributes that did not meet the minimum standard or as otherwise indicated in the quality assurance report.

If only the polygons that were identified in the initial QA are revised in a re-work, the re-work will be immediately rejected.

The quality of the re-work must be verified based on a second set of randomly selected polygons, a re-selection of models for delineation or a new selection of data sources as appropriate. An example of a quality assurance record is shown in Appendix B. Quality assurance personnel may be asked to provide comparisons between previous and re-work attribution or delineation.

The contractor must review and correct items identified in the random sample of work evaluated by the quality assurance personnel, as requested by the Ministry.

Any additional work on maps that meet the minimum scoring requirements is to be carried out under a written request of the Ministry project manager.

2.8 Quality Assurance Report

Each quality assurance report must include the following:

- An up-to-date Quality Assurance Record;
- Tabulated scoring results for delineation or attribution. Examples of delineation and attribution tables are shown in Appendix C, D and Appendix E;
- An Excel table of attribute estimates made by QA personnel compared to the VRI photo interpreter's estimates. This table must show the attributes that are required to be audited immediately below the attributes interpreted by the primary contractor. There are a few additional attributes in this table that are not required to be audited, but need to be added as well. Any items requiring auditing according to this document AS WELL AS all attributes listed in the example spreadsheet must be recorded. ALL attributes for each polygon are to be recorded on a single line for each layer in this spreadsheet. A single table is required. An example is shown in Appendix F.
- If required, a description of the directed remedial action and a report on the compliance with that direction; and
- A report signed off by the QA personnel.

As well as providing immediate feedback to the contractors, MFR and project coordinator, the results of the Quality Assurance process are included as part of the Project Completion Report deliverable.

Appendix A: Quality Assurance Records

Delineation Quality Assurance Record

Map	Interpreter	Date Submitted	Date Checked	Number of Photos or Models Checked	Passed or Failed	Comments

Attribution Quality Assurance Record

Map	Interpreter	Date Submitted	Date Checked	Number of Polygons		Passed or Failed	Comments
				Attributed	Checked		

Appendix B: Delineation Rating Table

VRI Delineation Rating Table

Project:_____ **QA personnel:**_____

Interpreter:_____

Map	Model / Photo		Line Placement 7	Polygon Size 3	Type Separation 7	Points Obtained	Points Possible 17		Comments

Total % =

Appendix C: Attribution Rating Table for Critical Category Attributes

Map:		Critical Attributes					
Model or Photo Number	**Polygon**	**Species Comp. (5)**	**Leading Species (1)**	**Leading Species Age (1)**	**Leading Species Ht. (1)**	**BA (1)**	**CC (1)**
Total Points Obtained							
Total Points Possible							
	Percent						

Critical attributes must individually achieve an overall minimum score of 85% per map for acceptable completion of work

Comments:

Interpreter:_____ QA Personnel:_____

Date:_____ Accept:_____
(Yes/No)

Appendix D: Attribution Rating Table for Standard Category Attributes

Map:			Standard Attributes								
Model / Photo	Polygon	*Tree Layer (-3)	Second Species Age (2)	Second Species Ht. (2)	Vertical Complexity (1)	Density (1)	Est. SI Species (1)	Est. SI (1)	Delineation (1.5)	Points Obtained	Points Possible
Total Points Obtained											
Total Points Possible											
	Percent										

Standard attributes and delineation, with the exception of Tree Layer, must individually achieve a minimum overall score of 70% per map and collectively achieve an overall minimum score of 85% per map for acceptable completion of work

Comments:

Interpreter:_____ QA Personnel:_____

Date:_____ Accept:_____
(Yes/No)

Appendix E: Attribution Rating Table for Supporting Category Attributes

Map:		Supporting Attributes											
Model (Photo)	**Polygon**	**LCC (1)**	**Ecology (6)**	**Snags (1)**	**Shrub height (2)**	**Shrub crown closure (1)**	**Herb cover type (1)**	**Herb cover percent (1)**	**Bryoid cover percent (1)**	**Non-vegetated cover type (2)**	**Non-vegetated cover percent (2)**	**Total Points Obtained**	**Total Points Possible**
	Obtained												
	Possible												
	Percent												

Note: Total points possible are based on attributes evaluated only. Leave score blank if points are not assigned. Attributes in this category must collectively achieve a score of 70% or greater per map and must individually achieve a score of 50% or greater per map to meet the Ministry standards.

% Correct _____

Interpreter:_____ QA Personnel:_____

Date:_____ Accept:_____
yes/no

Appendix F: Example Attribution QA Comparison Table

Note: All attributes for a given polygon/layer listed on this and the next page must appear on one line in the spreadsheet.

Map_ID	POLYGON_NUMBER	FOREST_COVER_OBJET_ID	POLYGON_AREA	Opening_ID	INVENTORY_STD_CD	INTERPRETER	INTERPRETATION_DATE	REFERENCE_YEAR	FREE_TO_GROW_IND	Surface_Exp	Mod_Proc	Site_Pos	Alpine	SNR	LCC1	LCC1_PCT	LCC1_Moist	LCC2	LCC2_PCT	LCC2_Moist	LCC3	LCC3_PCT	LCC3_Moist	Layer_ID	CROWN_CLOSURE
093Z010	1	-1	15.9		V	XX XXX	12/13/2008	2007	N	U	N	M	N	C	TC	100	4							1	30
093Z010	1	-1				QA																			
093Z010	8	-8	17.7		V	XX XXX	12/13/2008	2007	N	U	N	M	N	C	TC	100	4							1	10
093Z010	8	-8				QA																			
093Z010	17	-26	34.7		V	XX XXX	12/13/2008	2007	N	U	N	M	N	C	TC	100	4							1	8
093Z010	17	-26				QA																			
093Z010	25	-42	62.3		V	XX XXX	12/13/2008	2007	N	U	N	M	N	C	HG	60	4	HG	40	6					
093Z010	25	-42				QA																			

Attribute QA spreadsheet continued.

Vert_Comp	Tree_CP	Estimated_SI_SP	Estimated_SI	SPECIES1	SPECIES1%	SPECIES2	SPECIES2%	SPECIES3	SPECIES3%	Species – 4, 5, etc.	Leading_Age	Leading_Height	Second_Age	Second_Height	Basal_Area	VRI_Live_Stems_Per_Ha	VRI_Dead_Stems_Per_Ha	Shrub_Ht	Shrub_CC	Shrub_Pattern	Herb_Type	Herb_CC	Herb_Pattern	Bryoid_%	NV1	NV1_Pat	NV1_Pct	NV2, % , Pattern, ,3 % etc.
4	8			FD	60	PL	40				40	11	35	11	10	1400	0				HG	40	8					
3	5			FD	100						250	25			10	50	10				HG	10	8					
3	5			FD	100						220	29			7	40	0				HG	15	8					
																					HG	100	9					

Appendix G: Example Attribution Rating Table for D-Layer

Mapsheet	Polygon	Layer (-2)	Leading Species (1)	Leading Species Age (1)	Leading Species (1)	Leading Species (2)	Density (1)		
092Z001	1		1	1	1	2	1		
	2		1	1	1	2	1		
	3		1	1	1	2	1		
	4		1	1	1	2	1		
	5	-2	na	na	na	na	na		
	6		na	na	na	na	na		
	7		1	1	1	2	1		
	8		1	1	1	2	1		
	9	-2	na	na	na	na	na		
	10		na	na	na	na	na		
	11		na	na	na	na	na		
	12	-2	na	na	na	na	na		
	13		1	1	1	2	1		
	14		na	na	na	na	na		
	15		0	0	0	0	1		
	16	-2	na	na	na	na	na		
	17	-2	na	na	na	na	na		
	18		1	1	1	2	1		
	19		na	na	na	na	na		
Total Points Obtained		9	8	8	8	16	9	**58**	
Total Possible Points		19	9	9	9	18	9	**73**	
		47%						**79%**	**Pass**
		Fail							

Must collectively achieve an overall minimum score of 70% or greater for acceptable completion of work

AND Layer Category must individually achieve an overall minimum score of 70% or greater for acceptable completion of work