Vegetation Resources Inventory

Photo Interpretation Quality Assurance Procedures and Standards

Prepared by

Ministry of Forests

Forest Analysis and Inventory Branch

March 2024

Version 4.7

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

VRI Spatial Inventory Team
Forest Analysis and Inventory Branch
PO Box 9512, Stn Prov Gov't
Victoria, BC V8W 9C2
Phone: (250) 645-9256

Digital Copies are available on the Internet at:

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/forest-cover-inventories/photo-interpretation/standards

Major Changes to Photo Interpretation Quality Assurance Procedures and Standards

1. Polygon delineation Quality Assurance delineation wording to indicate recommended linework to be reviewed only within the defined QA area. (Section 2.5, pg. 8)
2. Polygon delineation Quality Assurance delineation wording to address QA reporting and remedial action. (Section 2.5, pg.9)
3. Quality Assurance scale to begin at 1:3000, changed from 1:5000. (Section 2.5.2, pg.9)
4. Removed wording and examples pertaining to Cluster QA selection. (pages 11 to 13, tables 2-3 and 2-4, pages 20-21, Appendix D)
5. Added a requirement that the QA must provide a rationale in the comments to clarify and support the differences in interpreted estimates if a critical attribute category for a map does not meet the minimum score of 85%,. (Section 2.8, pg. 24)

Table of Contents

1.0 Introduction 1
1.1 Background 1
1.2 Objectives of Photo Interpretation Quality Assurance 1
2.0 Photo Interpretation Quality Assurance 3
2.1 Overview of Photo Interpretation 3
2.2 Process 4
2.2.1 Quality Assurance Records 5
2.3 Procedures 5
2.3.1 Systematic Errors 6
2.3.2 Delineation and Attribution Overview Assessment 6
2.4 Data Source Transfer 6
2.4.1 Historical Data Source Transfer 7
2.4.2 New Data Source Transfer 8
2.5 Polygon Delineation 8
2.5.1 Polygon Delineation Evaluation Process 9
2.5.2 Polygon Delineation Evaluation 9
2.6 Attribute Estimation 11
2.6.1 Attribute Evaluation Process 11
2.6.2 Attribute Evaluation 13
2.7 Remedial Action Procedures 22
2.8 Quality Assurance Report 24
Appendix A: Quality Assurance Records 25
Appendix B: Delineation Rating Table 26
Appendix C: Data Source Summary Table with Example Data **Error! Bookmark not defined.**
Appendix D: Attribution Rating Table for Critical Category Attributes **Error! Bookmark not defined.**
Appendix E: Attribution Rating Table for Standard Category Attributes **Error! Bookmark not defined.**

Appendix F: Attribution Rating Table for Supporting Category Attributes**Error! Bookmark not defined.**

Appendix G: Example Attribution Quality Assurance Comparison Table 27

Appendix H: Example Attribution Rating Table for D-Layer**Error! Bookmark not defined.**

Appendix I: Example Historical Data Source Transfer QA Rating Table 30

List of Tables

Table 2-1 Historical Data Source Transfer Quality Assurance Standards 7
Table 2-2 Polygon Delineation Quality Assurance Standards and Scoring 10
Table 2-3 Evaluation Attribute Categories 16
Table 2-4 Category 1 – Critical Attributes 18
Table 2-5 Category 2 – Standard Attributes 19
Table 2-6 Category 3 – Supporting Attributes 20

1.0 Introduction

1.1 Background

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

As digital imagery and the use of softcopy technology have become the common tool for VRI photo interpretation, the procedures documented here primarily reflect the use of that technology.

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.

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 five main objectives:

1. Improve the quality of photo interpretation through interactive evaluation, feedback and training.
2. Determine the performance of the individual interpreters in relation to measured and interpreted observations.
3. Ensure the maintenance of photo interpretation standards.
4. 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. Provide supporting information for contract administration (i.e. facilitate payment and 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
5. Digital capture of attributes and graphics

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 the 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. This process can be automated by transferring old digital data source locations from the historical database using softcopy technology.

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 (i.e. air calls 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, Natural Resource Operations and Rural Development or visit the website: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/forest-cover-inventories/photo-interpretation/standards.

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 database, 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 delineation 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 delineation of each polygon which is digitally merged with the attributes that were estimated in the photo estimation phase. The digital capture of the delineation 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 are referred to as Quality Assurance personnel in this document.

Quality Assurance will occur throughout all five 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 each interpreter's work, time for interpreters 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's 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.

All Quality Assurance scores must be rounded to the nearest whole number as per conventional rounding methods.

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 with each Quality Assurance report. The Ministry will be responsible for forwarding Quality Assurance results and requesting remedial actions if appropriate. See appendix B for an example of a Quality Assurance record for the delineation and attribution stages.

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
- 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 VRI 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 the Ministry.

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 batch submission delivered for subsequent Quality Assurance will be determined 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 an interpreter has misclassified a polygon or two on a map, but it does not affect the overall pass or fail determination for that map. After subsequent maps have been audited, it may become apparent that the misclassification of these two species is systematic (i.e. consistently being misclassified).

Another example of a systematic error is when an interpreter has consistently misunderstood the VRI Photo Interpretation Procedures. For example, 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 will require the Contractor to correct polygons in previous maps, and, once the maps are fixed, they are subject to further review.

2.3.2 Delineation and Attribution Overview Assessment

Prior to individual random photos or polygons selection for either delineation or attribution Quality Assurance, the entire map sheet or submission file and available adjacent map sheets must be reviewed with an orthophoto underneath in order to identify any obvious delineation or attribution issues. For example, a portion of a map may have been under-delineated or have a missing delineation that would not have been noticed during the Quality Assurance using random photo selection. During attribution Quality Assurance, it may become apparent that there are photo estimate inconsistencies between interpreters of similar types. Significant issues will be documented and reviewed with the Ministry prior to proceeding with a formal Quality Assurance process.

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 Historical Data Source Transfer

Historical data sources are relevant to current softcopy VRI projects. As most available historical attribute data is not in digital format, the requirement, as specified in the contract, for the 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." Convert values in feet or other non-metric units to metric units before recording the data.

Softcopy Historical Data Source Transfer Quality Assurance Standards (paper to digital calibration tile transfer)

Quality Assurance review 5% of the total transferred data sources on five to ten randomly selected map sheets in a project or area of a project.

Table 2-1 Historical Data Source Transfer Quality Assurance Standards

Attribute	Points Possible	Standards
Coordinates (when not previously provided)	2 0	≤ 50 m of the position, as shown on the document photo > 50m of the position, as shown on the document photo
Core Attributes: (species composition, age, height, basal area and density)	2 1 0	All attributes correctly transferred Only one attribute incorrectly transferred More than one attribute incorrectly transferred
Other Attributes (non-core attributes)	1 0	Up to one attribute incorrectly transferred More than one attribute incorrectly transferred
Total Possible	5 4	When Other Attributes are present When Other Attributes are not present

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. When there is no data assigned to "Other Attributes," this attribute is assigned as "null," and the Total Possible will be 4 points.

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 Quality Assurance 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 breakpoints 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 a logical basis for final attribute estimation.

Quality Assurance will take place within 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 on each deliverable, the Quality Assurance personnel must randomly select the number of the models required to assess 10% of each deliverable's area. 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 delineation or examples of proper placement of lines to demonstrate areas of concern to the Contractor. The Ministry reserves the right for a greater intensity of review by Quality Assurance personnel.

In addition to the models selected for delineation Quality Assurance, the Quality Assurance personnel must view the entire map digitally with an orthophoto underneath in order to record for the Ministry any obvious or systematic delineation issues.

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.

2.5.1 Polygon Delineation Evaluation Process

Polygon delineation Quality Assurance 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:
    - Randomly select models
    - Create a shapefile (.shp) to record recommended delineation corrections.
    - Capture the QA area in the shapefile by creating a box around each model reviewed.
2. Evaluate the following:
    - Accuracy of line placement
    - Polygon size; may exceed recommended standards as outlined in VPIP and contract documents
    - Type separation, consistency, and adherence to standards
3. Record the above evaluation on the Rating Table for Polygon Delineation. See Appendix B 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
    - Return the batch to the Ministry 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 aerial photography, it is expected that delineation would be performed at an approximate ground scale of 1:3,000 to maintain consistency between interpreters and for Quality Assurance purposes. This may be modified on a project-specific basis.

- Delineation 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.
- The interpreter should try to avoid significant areas where the delineation is within 40 m of other delineation, with exceptions as noted in the Photo Interpretation Procedures.

- General specifications (such as retaining 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 2-2 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 m on the ground for distinct type line breaks and ± 20 m within types that are not distinct. *Appropriate* ties to adjacent maps or projects must be exact (± 0 m)
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**		Base all scoring on the review of an entire model.

The Ministry requires a minimum score of 85% per map sheet (as an average of the rated models) for acceptable completion of work per map sheet reviewed.

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

For each stereo model reviewed, the Quality Assurance personnel must demonstrate areas of concern by re-digitizing incorrect or unacceptable delineation and by adding or deleting polygons to demonstrate Quality Assurance concerns. The Quality Assurance personnel will focus on obvious line placement errors and not refinement of polygon lines that meet the delineation guidelines.

The Contractor will review and correct any items identified by the Quality Assurance personnel.

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

2.6 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

Independent estimates performed and recorded by Quality Assurance personnel are critical to the Quality Assurance process. Quality Assurance personnel will supply independent attribute estimates for Quality Assurance scoring on each audited polygon, regardless of whether the Quality Assurance assessment determines that the interpreter's values were acceptable or not. Independent values are essential to identify trends in the interpreter's work that may still pass but are essential for the mentoring and training of interpreters (i.e. an interpreter may pass but is consistently under or overestimating ages). The evaluation process applies to all attributes, including supporting attributes.

Quality Assurance personnel are also expected to view each audit-selected polygon in relation to neighboring polygons to ensure that attributes are justifiable from one polygon to the next. Viewing a group of polygons as a unit will ensure that the relative differences between polygons for critical volume attributes are appropriate in terms of consistency and trends. Critical attributes to be considered are age, height, basal area, and crown closure. When one or more critical attribute estimates in adjacent polygons do not appear to be consistently interpreted the Quality Assurance personnel will record their observations as comments for each map sheet.

The Quality Assurance personnel must perform queries and data sorts on the attribute database for each map provided by the Ministry 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
- Missing 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 on the project must be clearly identified. Attribute listings that do not contain the interpreter's name for each polygon are 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 the "VegCap for Contractors" data validation program to ensure that data checks "clean." Any data that does not validate clean is brought to the Ministry's attention, and Quality Assurance may continue at the Ministry's discretion.
3. Load the field calibration tile and ensure that the field calibration data was captured in the attribution.
4. Load the historical data source tile and ensure that the historical calibration data was referenced correctly in the attribution.
5. Use the Ministry's Attribution QA Tool to randomly select polygons for attribution Quality Assurance. The tool uses 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 a Quality Assurance 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.
6. For each sample of VT polygons, record an independent estimate of the Contractor's Critical Attributes. Review neighbouring polygons to each sample of VT polygons to determine if the critical attributes are consistent. Record any observations of inconsistencies as comments for each map sheet.
7. Quality Assurance of the D layer attribute estimates is reported independently from the live tree layers using the same polygons selected for the VT sample set.
8. Select 40% of the polygons that were selected for Critical Attribute Quality Assurance and record the independent estimates of Standard Attribution on these same polygons.
9. Select 50% of the polygons that were selected for Standard Attribute Quality Assurance and record independent estimates of supporting attributes on these same polygons.
10. Randomly select ten Non-Treed polygons from the map for Quality Assurance, and record the independent estimates. All Critical, Standard, and Supporting attributes are Quality Assurance audited in these polygons.
11. Randomly select 10% (maximum ten) polygons with historical data sources and confirm that the data sources were utilized as appropriate in the photo estimation process. Results will be reported as comments for each map sheet.

12. Randomly select 10% (to a maximum of ten) 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 map sheet.
13. Compare the estimates of the Quality Assurance 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 (i.e. <5%) where determining tone, texture and pattern of a stand is difficult or impossible, or there is limited information that supports the Quality Assurance estimate. The scoring system provided in Table 3 will be used to conduct the evaluation.
14. Record the scoring result of every attribute by its polygon and corresponding map in a rating table. The rating tables illustrated in Appendix D, Appendix E and Appendix F must be submitted for each map reviewed.
15. Provide remedial action for any work that does not meet the minimum acceptable rating.
16. Update the Quality Assurance Record.

2.6.2 Attribute Evaluation

For mid-scale aerial photography, it is expected that Quality Assurance of tree attributes would be performed at the 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 Quality Assurance interpreter, the Quality Assurance 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.

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

Critical Attributes

Attributes in this category 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. Where a critical attribute for a map does not meet the minimum score of 85%, the Quality Assurance personnel must provide comments to clarify the differences between interpreted estimates. When 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 a score point system. Standards have been assigned to these attributes, and it is expected that the standards for these attributes are to be met. When it is found that attributes are systematically estimated below standard, re-work may be requested.

Final 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).

Dead Layer Attributes

Attributes in this category are evaluated when polygons selected in the Critical Attribute category have a dead layer. To meet the Ministry standards, attributes in this category must collectively achieve a score of 70% or greater per map, and the Layer Category must individually achieve an overall minimum score of 70% or greater for acceptable completion of work.

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 m for a leading species, and the Quality Assurance personnel has recorded 27 m, then the acceptable range is 0.15 X 27 m, and an acceptable range for the interpreter's values is between 23 m and 31 m.

The ultimate goal of Quality Assurance is to ensure a 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 the 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 recommendations for remedial action established with the Ministry and Contractor to resolve the issue.

Table 2-3 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 Tables 4, 5 and 6.

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 Points Possible" for the polygon.

The following examples provide further clarification:

1. When the interpreter misses a second species, the score for the age and height attributes of the second species is left blank. The penalty for this error is accounted for in the evaluation of the species composition attribute.
2. The score for supporting attribute(s) missed by the interpreter is included in the "Total Points Possible" for the polygon.
3. Always compare the age and/or height of the same species regardless of the difference in species order between the Contractor and Quality Assurance personnel.
4. In the case of multiple layers, once a point has been deducted for the missed or added layer error, the Quality Assurance scores the remainder of the attributes through the lens of the interpreter, like point 3 above. For example, when the interpreter called it one layer, score the remainder of the attributes as though it is one layer.

The scoring process should be jointly reviewed by the Ministry, Contractor, and Quality Assurance personnel at the project pre-work meeting.

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 map sheet scoring provided.

Table 2-4 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	Must match the Quality Assurance personnel's leading species. When the interpreter's leading and second species composition values are within 10% (e.g. Sx_{55} Bl_{45}), either is acceptable as the leading species.	
Leading species age	1	Within 15 years or 15%, whichever is greater.	Must be estimated for every tree layer of every polygon.
Leading species height	1	Within ±3 m 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 Marking Examples

Each species match between the Quality Assurance personnel and Contractor is compared by percent (%) to calculate the percent correct for species composition.

Example 1:

Quality Assurance	$S_{40}Pl_{30}Bl_{30}$	
Interpreter	$Bl_{40}S_{30}Pl_{30}$	
Matching	$S_{30}Bl_{30}Pl_{30}$	30 + 30 + 30 = 90% match: 5 points

Example 2:

Quality Assurance	$Fd_{60}S_{20}Pl_{20}$	
Interpreter	$Fd_{85}S_{10}Pl_{05}$	
Matching	$Fd_{60}S_{10}\ Pl_{05}$	60 + 10 + 05 = 75% match: 2 points

Example 3:

Quality Assurance	$Pl_{60}Fd_{30}Lw_{10}$	
Interpreter	$Fd_{55}Lw_{25}Pl_{20}$	
Matching	$Fd_{30}Lw_{10}Pl_{20}$	30 + 10 + 20 = 60% match: 0 points

Table 2-5 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 m 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 ±1 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 the calculated site index does not represent the 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%. *	Polygons 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 match the Dead Layer density when the polygon has a Dead Layer.
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 one-layer polygon, and the Quality Assurance personnel determines it is a two-layer polygon, a score of -3 is applied for the layer, but the assessment of attributes will take place assuming that the polygon is a combined single layer.

Table 2-6 Category 3 – Supporting Attributes

Attribute	Points Possible	Standards	Comments
Ecology	6	SE = same as QA value MP = same as QA value SPM = ±1 unit value. AD = same as QA value	All polygons must have ecological data: Surface expression (SE), Modifying process (MP), Site position meso (SPM), Alpine designation (AD), Soil nutrient

Attribute	Points Possible	Standards	Comments
		SNR= ±1 unit value SMR= ±1 unit value (1 point for each category)	regime (SNR), Soil moisture regime (SMR) indicated for all polygons.
Shrub height	2	In the correct shrub category (shrub tall versus shrub low) Shrub tall must be within ±3 m or apply -1 point deduction	Estimated for every polygon where shrubs are present and observable.
Shrub crown closure	1	±10 crown closure units.	Estimated for every polygon where shrubs are present and observable.
Leading non-vegetated cover type	2	When present, it must be consistent with the QA leading non-vegetated cover type.	Award 2 points when the interpreter's leading non-vegetated cover type matches the QA leading non-vegetated cover type. Award 2 points when the interpreter's leading non-vegetated cover type and the QA 2nd non-vegetated cover type match, AND the difference between the Contractor leading non-vegetated cover percent and the QA 2nd non-vegetated cover percent is ≤10%. Award 1 point when the interpreter's leading non-vegetated cover type matches the QA 2nd to 6th non-vegetated cover types. 0 points when the interpreter's leading non-vegetated cover type matches none of the QA non-vegetated cover types.
Non-vegetated cover leading percent	1	±10 cover percent units.	1 pts
Total non-vegetated cover percent	1	±15 cover percent units.	1 pts
Land cover components	1	Dominant LCC must be correct Where LCC #1 and LCC #2 are 20 % units apart or less, either may be	All polygons must have a land cover component identified.

Attribute	Points Possible	Standards	Comments
		acceptable as LCC #1.	
Snags (stems/ha)	1	Within ± 50 stems or 20%, whichever is greater. D layer ±100 stems when ≤ 300 stems/ha ± 200 stems when > 300 stems/ha	Must be estimated for every tree layer in every polygon.
Herb cover type	1	When present, consistent with the QA herb cover type interpretation.	
Herb cover percent	1	±10 cover percent units.	
Bryoid cover percent	1	±10 cover percent units.	

Table 2-7 Non-Scored Supporting Attributes

Attribute	Points Possible	Standards	Comments
Shrub cover pattern	n/a	Within ±1 SCP unit value	
Herb cover pattern	n/a	Within ±1 HCP unit value	
Non-vegetated cover pattern	n/a	Within ±1 N-VCP unit value	
Tree Cover pattern	n/a	Within ±1 TCP unit value	Must be indicated for every tree layer in every polygon.

Table 2-8 Dead Layer Attributes

Attribute	Points Possible	Standards	Comments
Layer	-2	A score deduction only (no points awarded) is applied to the total polygon score for a missed dead layer.	
Leading species	1	Must match the Quality Assurance personnel's leading species. When the interpreter's leading and	Same standards as Critical Attributes.

Attribute	Points Possible	Standards	Comments
		second species composition values are within 10% (e.g. Sx_{55} Bl_{45}), either is acceptable as the leading species.	
Leading species age	1	Within 15 years or 15%, whichever is greater.	Same standards as Critical Attributes.
Leading species height	1	Within ±3 m or 15%, whichever is greater.	Same standards as Critical Attributes.
Basal area	2	Within ±10 m^2 or 20%, whichever is greater.	Same standards as Critical Attributes.
Density (stems/ha)	1	±100 stems when $\leq$ 300 stems/ha ± 200 stems when > 300 stems/ha	

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 are required to be photo re-interpreted. For critical attributes requiring re-work, the Quality Assurance personnel must provide a rationale to clarify the differences in interpretation to assist the Interpreter in improving the quality and consistency of the final attribution. The follow-up review and rating of the re-work are to be based only on those attributes that did not meet the minimum standard or as otherwise indicated in the Quality Assurance report.

When only the polygons that were identified in the initial Quality Assurance audit are revised in a re-work, the re-work will be immediately rejected.

The quality of the re-work must be verified based on the 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.

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 scoring tables are provided in Appendix B.
- An Excel table of attribute estimates made by Quality Assurance personnel compared to the interpreter's estimates. This table must show the attributes that are required to be audited immediately below the attributes interpreted by the Contractor. There are 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 from the Attribution QA Template is provided in Appendix C.
- When required, a description of the directed remedial action and a report on the compliance with that direction; and
- A report signed off by the Quality Assurance personnel.

As well as providing immediate feedback to the interpreters and the Ministry, 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: Example Attribution Quality Assurance Comparison Table

Map_ID	POLYGON_NUMBER	Layer_ID	INTERPRETER	SPECIES1	SPECIES1%	SPECIES2	SPECIES2%	SPECIES3	SPECIES3%	SPECIES4	SPECIES4%	SPECIES5	SPECIES5%	SPECIES6	SPECIES6%	Leading_Age	Leading_Height	Basal_Area	Crown_Closure	Second_Age	Second_Height	Vert_Comp	VRI_Live_Stems_Per_Ha	Estimated_SI_SP	Estimated_SI
093Z010	554	1	CONTRACTO	HW	80	BL	15	CW	5							150	26	45	50	150	23	3	375		
093Z010	554	1	QA	HW	80	BL	15	CW	5							165	28.5	40	40						
093Z010	528	1	CONTRACTO	HW	60	CW	35	BL	5							100	15	5	8	100	14	3	150		
093Z010	528	1	QA	HW	60	B	30	CW	10							115	16.5	4	8	115	13	4	125		
093Z010	491	1	CONTRACTO	HM	60	BA	25	YC	15							130	16	15	20	120	14	3	200		
093Z010	491	1	QA	HM	80	BA	15	YC	5							115	16	5	15						
093Z010	460	0	CONTRACTO																						
093Z010	460	0	QA																						
093Z010	447	1	CONTRACTO	HW	60	BA	30	SS	5	CW	5					165	37	70	55	160	36	3	425		
093Z010	447	1	QA	HW	65	BA	20	SS	5	CW	5					180	37	70	55						
093Z010	439	0	CONTRACTO																						
093Z010	439	0	QA																						
093Z010	372	0	CONTRACTO																						
093Z010	372	0	QA																						
093Z010	337	0	CONTRACTO																						
093Z010	337	0	QA																2			3			
093Z010	274	1	CONTRACTO	BA	80	HM	20									70	9	15	30	70	9	2	500		
093Z010	274	1	QA	HM	80	BA	20									55	9	10	30	55	8	2	450		
093Z010	204	1	CONTRACTO	HM	100											60	4	2	3			2	25		
093Z010	204	1	QA	HM	100											75	4	1	4.9				100		
093Z010	172	1	CONTRACTO	BA	80	HM	20									70	6	5	10	70	6	1	100		
093Z010	172	1	QA	BA	80	HM	20									70	6	1	2	70	6	1	10		

Map_ID	POLYGON_NUMBER	Layer_ID	INTERPRETER	LCC1	LCC1_PCT	LCC1_Moist	LCC2	LCC2_PCT	LCC2_Moist	LCC3	LCC3_PCT	LCC3_Moist	Surface_Exp	Mod_Proc	Site_Pos	Alpine	SNR	VRI_Dead_Stems_Per_Ha	Shrub_Ht	Shrub_CC	Herb_Type	Herb_CC	Bryoid_%	NV1	NV1_Pct	NV2	NV2_Pct	NV3	NV3_Pct
093Z010	554	1	ONTRACTO	TC	100	4							N	N	L	N	C	5	1.4	15	HE	5			0				
093Z010	554	1	QA			5							p		f														
093Z010	528	1	ONTRACTO	TC	100	5							N	U	F	N	B	0	1.5	35	HE	25		RI	2				
093Z010	528	1	QA	TC	100	6		0			0		P	U	F	N	B	0	1.3	45	HE	25		RI	4		0		0
093Z010	491	1	ONTRACTO	TC	100	3							N	A	M	N	B	0	1.9	45	HE	5		TA	5				
093Z010	491	1	QA																										
093Z010	460	0	ONTRACTO	GL	100								N	N	U	A	A							GL	100				
093Z010	460	0	QA	GL	100								N	N	U	A	A							GL	100				
093Z010	447	1	ONTRACTO	TC	100	4							N	N	M	N	C	0	0.5	5					0				
093Z010	447	1	QA																										
093Z010	439	0	ONTRACTO	HE	70	2	TA	30	1				N	A	L	N	B		0.5	20	HE	30		TA	30	RI	6	LA	5
093Z010	439	0	QA	HE	60	2	TA	30	1	SL	10	3	N	A	L	N	B		1	20	HE	35		TA	30	RS	6	LA	5
093Z010	372	0	ONTRACTO	BR	100	0							N	F	M	N	A		1	5				BR	90				
093Z010	372	0	QA	BR	100	0							N	F	U	N	A		0.3	5	He	3		BR	90	TA	3		
093Z010	337	0	ONTRACTO	TA	100	1							N	F	M	N	A		1	3				TA	90				
093Z010	337	0	QA	TA	100	1							N	F	M	N	A		1	3				TA	90				
093Z010	274	1	ONTRACTO	TC	100	3							N	A	M	N	B	0	1.5	10					0				
093Z010	274	1	QA	TC	100	3							N	A	M	N	c												
093Z010	204	1	ONTRACTO	SL	100	3							N	A	M	N	B	0	1.5	45	HE	20		BR	10				
093Z010	204	1	QA	SL	100	3							N	A	M	N	B	0	1.8	45	HE	20		BR	7	Ta	3		
093Z010	172	1	ONTRACTO	ST	85	3	TC	15	3				N	N	M	N	C	0	2.2	35	HE	15		TA	15				
093Z010	172	1	QA	ST	100	3							N	A	M	N	C	0	4.5	45	HE	15		TA	20				

Attribution Quality Assurance 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 D: Example Historical Data Source Transfer QA Rating Table

Project _____ Contractor _____

Date _____ QA Personnel _____

Map Sheet	Flight Line Number	Photo Number.	Data Source Type	Data Source Reference Number	Data Source Year	Contractor HDST	Photo DS (QA)	Coordinate (2)	Core Attributes (2)	Other Attributes (1)	Points Obtained	Points Possible
104A040	15BCB17014	120	X	4-26	1993	Bl 100 260-26	Bl 100 260-26	2	2	X	4	4
104A040			X	4-31	1993	Bl 100 200-16	Bl 100 200-16	2	2	X	4	4
104A040			X	20-27	1975	B 100 300-30	B 100 300-30	2	2	X	4	4
104A040			X	4-23	1993	Bl 100 260-23	Bl 100 260-23	2	2	X	4	4
104A040			XO		1993	H 70 Bl 30	H 70 Bl 30	2	2	X	4	4
104A040			XO		1993	Bl 90 Hw 10	Bl 90 Hw 10	2	2	X	4	4
104A040			X	4-28	1993	Bl 90 Hw 10 200-18	No Spp 200-18	2	0	X	2	4
104A040			XO		1993	Bl 100	Bl 100	2	2	X	4	4
094D036			XO		1993	Bl 100	Bl 100	2	2	X	4	4
094D036			XGO		1975	B63 S36 160-21	B63 S36 160-21	2	2	X	4	4
										Total Points	**38**	**40**
										Rating % *		**95.0%**

Comments: