Vegetation Resources Inventory

Photo Interpretation Standards and Quality Assurance Procedures

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1. Introduction

1.1. Background

This document contains the Photo Interpretation Standards and Quality Assurance Procedures 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. The use of softcopy technology has become a more common tool for VRI photo interpretation. Conventional hard copy photography is still used in some cases, but the procedures documented here are updated to primarily reflect softcopy technology, as well as combine the standards and procedures for quality assurance into one document. 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. Generally, the objectives can be stated as follows:

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 specified Ministry of Forests and Range (MoFR) photo interpretation standards prior to payment to a contractor.

4. To ensure the data will load to MoFR corporate data systems and meet the business needs of government, industry and the general public.

2. Photo Interpretation Quality Assurance

2.1. Overview of Photo Interpretation

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

1. data source transfer. This stage can be quite different in the process implemented depending on whether softcopy technology or hardcopy photos are being used;

2. polygon delineation;

3. field calibration;

4. attribute estimation; and

5. digital capture of attribute and graphic information.

The first stage, 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 familiarize the photo interpreters with the local vegetation conditions and to provide reference or calibration points to assist in photo interpretation. This is accomplished by the interpreter selecting representative areas within selected polygons for which they anticipate having difficulty in attribute estimation. By visiting these stands, they build a mental picture of what attributes should be assigned to stands of similar structure, tone and texture on aerial photographs.

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

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 that are 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 stages of the interpretation process. The various stages all have products that can be evaluated on an individual basis or in combination. 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 should allow a quick assessment of the contractor's work, improve the product quality and enable payment to be authorized in a timely and efficient manner.

As the contractor submits each completed batch of photo interpretation work, the quality assurance personnel should 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 should be assessed at the start of and throughout each stage, and for the various photo interpretation personnel involved with each stage.

Regardless of the specific project management arrangement regarding the development of VRI photo interpreted inventory products, the MoFR must receive copies of all quality assurance reports. By providing these reports to the MoFR, government staff are able to track project deliverables and provide a final audit function prior to the data being loaded to the corporate data storage systems. If required, MoFR can act as an impartial arbitrator over any disagreements over the quality assurance assessment.

2.3. Procedures

Quality assurance procedures for VRI photo interpretation, using softcopy technology are different from the traditional procedures used for hardcopy photos. To reduce confusion between the two methods of conducting VRI photo interpretation and the quality assurance processes required, the procedures for evaluating photo preparation and data source transfer for hardcopy have been moved to Appendix A.

Quality assurance must be conducted throughout all stages of the VRI photo interpretation process, as outlined in this document and as agreed to by the quality assurance personnel, MoFR VRI staff and the project proponent. For all stages of the photo interpretation process, a minimum score of 85% per model is required for acceptable completion of work, per batch (map) reviewed. A batch is considered to be three stereo models per map.

Field Calibration

Procedures for the collection of field calibration (air and ground calls) data and quality assurance rating processes and forms are located in other documents. For a copy of these documents, contact the Ministry of Forests and Range or visit the web site: http://www.for.gov.bc.ca/hts/vri/standards/index.html

2.3.1. Photo Preparation and 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. Quality assurance procedures for photo preparation and data source transfer for traditional hardcopy photo interpretation is described in Appendix A.

Historic Data Source Transfer

Traditional, hardcopy photo, data source transfer of historic reference points (see Appendix A) is not relevant to a softcopy VRI. For all historic inventory field data (air call, ground call, 70mm air call temporary sample plot (TSP) or permanent sample plot (PSP)), the location coordinates, with sample number, year of establishment, etc. were contained on the historic digital forest cover files and have been stripped out of these map files. This data currently exists in an ASCII and mdb file format, with data up to about 1999 captured. A “Sample Tile” is under consideration as a permanent storage location for this data.

The location of these historic data points has already been captured (level 14 of FC1) from past inventories and all that is required is to move this data to a new VRI’s digital files. The locations along with the corresponding sample point symbology and sample number can be re-established in the new data base and used or not, as the VRI photo interpreter deems necessary. The historic data source attribute records (old PSYU field summary books) are not digital and are still required.

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.

Cruise data information can be biased, so care is required when using this type of data.

New Data Sources

As a part of the review of attribute estimation, quality assurance personnel must ensure that new inventory data source locations have been transferred to the new digital VRI files to assist the VRI contractor as reference or calibration points to estimate attributes. With the assistance of the field data digital location and attribute file, the quality assurance personnel should be able to determine if this component of the work has been completed properly and will have the field data attributes available for review of the final attribute estimations. There is no scoring system in place for this, as this step is evaluated as being either completed or not completed.

2.3.2. General Polygon Delineation Standards

- All polygons must close
- Polygon size must be consistent with the Photo Interpretation Standards. No polygon may be less than 0.5 hectares and no polygon may be narrower than 40 meters (2.0 mm at 1:20,000).

- General specifications (such as retain outer polygon line or specified internal polygon line requirements) for silvicultural polygons must be outlined in the VRI Photo Interpretation Project Implementation Plan (VPIP) and contract documents.

2.3.3. Evaluation of 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 used the photo interpretation guidelines for indicating 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.

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 and the proponent (licencee) with a pass/fail recommendation and a description of remedial action needed if applicable. The Ministry and proponent will determine payment based on this report. Quality assurance will take place on a randomly selected sample of polygons.

Using softcopy technology and depending on the scale of photography, the number of models per map available for review will vary. To assess preliminary delineation the quality assurance personnel must randomly select at least three model set-ups per map. 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.

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

1. Evaluate the following:

    - Accuracy of line placement.

    - Minimum polygon size; may exceed recommended standards as outlined in VPIP and contract documents.

    - Type separation; consistency and adherence to standards.

    - Neatness, consistency, smoothness and completeness of line work.

2. Record the above evaluation on the Rating Table for Polygon Delineation.

3. Sign off the quality assurance:

    - Approve the product.

    - Return the batch to the contractor with instructions regarding items that do not meet standards and that are to be redone.

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% lines correct 85 – 90% correct < 85% lines correct	Subjectively, within +/- 10 meters on the ground for distinct type line breaks and +/- 20 meters within types that are not distinct.
Minimum polygon size	5 3 0	>95% correct 90% to 95% correct <90% correct	Minimum polygon standards are adhered to and any additional contract requirements have been met such as significant features for field navigation.
Type separation	7 5 0	>90% lines correct 85 – 90% correct <85% lines correct	Based on the Photo Interpretation Procedures to guide the process of delineating polygons.
Neatness	3 0	acceptable unacceptable	Neat, smooth line work and all polygons must close, as per Photo Interpretation Procedures.
Total Possible	**22**		All scoring is based on the review of an entire model.

A minimum score of 85% per model is required for acceptable completion of work, per batch (map) reviewed. A batch is considered to be three stereo models per map.

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

2.3.4. General Photo Attribute Estimation Standards

- VRI attributes will be estimated for all polygons.

- Photo estimated attributes must be in an acceptable data structure.

- Photo estimated data must conform to the acceptable specifications.

2.3.5. Attribute Estimation Evaluation

Both graphic and attribute data will be submitted for quality assurance in a digital format. The quality assurance for attribute estimation must start immediately upon completion of the first VRI batch as determined on a project basis and for each photo interpreter involved in any particular VRI project. This quality assurance is primarily conducted through photo interpretation checks. Further submission of completed work must be agreed to by the VRI contractor and quality assurance personnel, with the approval of MoFR VRI staff. The photo interpretation evaluation considers all photo interpreted attributes.

Quality assurance will be undertaken on the full extent of the project area. The process is as follows:

1. Digital graphics files and attribute listings of delineated polygons on each map sheet must be submitted by the contractor in a format as specified in the contract. The work of each interpreter in the project must be clearly identified.

2. Randomly select 2% of the total polygons from each batch (map) using a minimum of three stereo models per batch (map) and per interpreter for evaluation.

3. For each sample polygon, obtain an independent estimate of all attributes as appropriate. The quality assurance personnel must not in any way have prior knowledge of the estimates of the original contractor. The quality assurance personnel must determine a complete polygon description as per the VRI procedures.

4. Compare the estimates of the interpreter with those of the contractor (by interpreter). Evaluate the difference between the two estimates. The scoring system provided in Table 2 will be used to conduct the evaluation.

For the attribute estimation evaluation, a minimum score of 85% per model is required for acceptable completion of work, per batch (map) reviewed. A batch is considered to be three stereo models per map. Additionally, the following three attributes must individually achieve a minimum score of 85% per model when that attribute is evaluated in isolation in each model:

- species composition;
- leading species age;
- leading species height.

Table 2 – Pass / Fail Points Standards for Attribute Estimation

Attribute	Points Possible	Standards	Comments
Ecology	5	SE = same as QA value MP = same as QA value SPM = +/- one unit value. AD = same as QA value SNR= +/- 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), indicated for all polygons.
Crown closure (CC)	3	+/- 10 crown closure units	Must be indicated for every tree layer in every polygon.
Tree layer	*10	Tree layer number must be correctly denoted. *Note that this will be applied to the batch as a deduction only, not to the individual polygon. For any number of polygons that have incorrect tree layer, 10 points will be deducted, to a maximum of 10 points.	Tree layer must be indicated for every tree layer in every polygon.
Species composition	7	Must include only species codes from the VRI tree species list and must always add up to 100%. Contractor species composition must agree with at least 80% of the quality assurance tree species in order to be considered correct.	Must be estimated for every tree layer of every polygon.
Leading species	4	Where leading and second species are within 10 %, either is acceptable as the leading species.	
Leading species age	6 3	Within 10 years or 15% whichever is greater. Within 10 years or 20% whichever is greater.	Must be estimated for every tree layer of every polygon.
Leading species height	10 6	Within +/- 3 meters or 15% whichever is greater. Within +/- 4 meters or 20% whichever is greater.	Must be estimated for every tree layer of every polygon.

Second species age	4 2	Within 10 years or 15% whichever is greater. Within 10 years or 20% whichever is greater.	Must be estimated for every tree layer of every polygon where a second species is present.
Second species height	8 5	Within +/- 3 meters or 15% whichever is greater. Within +/- 4 meters or 20% whichever is greater.	Must be estimated for every tree layer of every polygon where a second species is present.
Basal area	7 4	Within +/- 10 m^2 Within +/- 15 m^2	Must be estimated for every tree layer of every polygon.
Density (stems/ha)	2	Within 100 stems or 20%, whichever is greater.	Must be estimated for every tree layer of every polygon.
Shrub height	1	+/- 0.5 m for shrubs 0.1 m to less than 2 m. +/- 1 m for shrubs 2m to less than 4 m. +/- 2 m for shrubs more than 4 meters.	Must be estimated for every polygon where shrubs are present and observable.
Shrub crown closure	3	+/- 10 crown closure units.	Must be estimated for every polygon where shrubs are present and observable.
Non-vegetated cover type	1	When present must be consistent with the BC Land Cover Classification Scheme code.	
Non-veg cover percent	2	+/- 10 percent units	
Total Possible	63		

Table 3 – Supporting Information Attributes

Standards have been assigned to all other attributes which are considered as supporting information. It is still expected that the standards for these attributes are to be met. If it is found the attributes are repeatedly measured or conducted below standards, the photo interpreter may be required to revisit the batch to ensure project standards are attained.

Attribute	SCORE		
	Points Possible	**Standards**	**Comments**
Land cover components	2	Each component % must be +/- 10% The sum of all LCC percents must = 100 Where LCC #1 and LCC #2 are 15 % units apart or less, either may be acceptable as LCC #1. Each SMR must be within +/- one SMR unit value.	All polygons must have a land cover classification identified.
Vertical complexity	1	Within +/- one unit value.	Must be indicated for every tree layer.
Tree cover pattern	1	Within +/- one TCP unit value.	Must be indicated for every tree layer in every polygon.
Snags (stems/ha)	1	+/- 20% of the quality assurance value.	Must be estimated for every tree layer in every polygon.
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	2	+/- 20% of the height at breast height age 50 years. Must be present for stands under 30 years and stands where calculated site index doesn't	Must be accompanied by an Estimated Site Index Species and an Estimated Site Index Source.

Attribute	SCORE		
	Points Possible	Standards	Comments
		represent actual site.	
Shrub cover pattern	1	Within +/- one SCP unit value.	
Herb cover type	1	Must be consistent with the BC Land Cover Classification Scheme code.	
Herb cover percent	2	+/- 10 cover percent units.	
Herb cover pattern	1	Within +/- one HCP unit value.	
Bryoid Cover percent	2	+/- 10 cover percent units.	
Non-vegetated cover pattern	1	Within +/- one N-VCP unit value.	

2.3.6. Final Quality Assurance Report

A final quality assurance report will be submitted at the end of the project indicating the following:

- A listing of batches checked in the project;
- What was checked in each batch, and the results of the check;
- The photo interpreters checked in each batch;
- Remedial action directed and report on compliance with that direction;
- Suggested improvements to the quality assurance or photo interpretation process;
- Documentation of dispute resolution if applicable; and
- General comments on the project and process.

2.4 Dispute Resolution Process

In rare cases, disputes may arise between the photo interpreter and the quality assurance personnel when evaluating the quality of the work. In order to ensure that data has met the standards established by the Ministry, the parties involved may develop a method to resolve disagreements. This process must be determined in writing and submitted to the Ministry for approval.

Appendix A: Hardcopy Photo Preparation and Data Source Transfer

To simplify the quality assurance process, both the photo preparation and data source transfer are combined with the polygon delineation quality assurance. Polygon delineation quality assurance is identical in Softcopy so the procedures for softcopy delineation quality assurance are not repeated here. A sample of document photos from a submitted batch is selected for evaluation. The selection is conducted as follows:

1. Determine the number of inventory photos in the batch.

2. A minimum of 30 photos (or stereo pairs) or 10% of the submitted stereo pairs is selected for evaluation.

3. Obtain a listing of photo numbers by flight line.

4. Number the photos sequentially by flight line and photo sequence. The numbers should range from 1 to the total number of inventory photo pairs.

5. Use a random number generator to produce as many random numbers as the sample size determined in step 2 above. The random numbers should be constrained to range from 1 to the number of inventory photo pairs. Each random number identifies the photo set to be included in the sample.

6. The sample document photos are evaluated for accuracy of photo preparation, data source transfer and polygon delineation.

7. This quality assurance process should be conducted expediently so as not to hamper subsequent photo interpretation processes.

Air photo preparation evaluation

The purpose of the air photo preparation quality assurance is to ensure that the placement of principal point and fiducial marks, the definition of the flight line and the framing of the stereo overlap area, meet the MoFR standards. Lack of accuracy in photo preparation results in the production of inaccurate maps. The steps outlined below should be used in evaluating the photo preparation process (if applicable).

1. Evaluate the following:

    - line numbering;

    - north/south orientation;

    - unit boundary transfer on applicable photos;

    - marking of the principal point;

- accuracy of the transfer of the conjugate points;
- preparation and marking of the effective photo interpretation; and
- transfer and extension of polygon boundaries across unit (project boundaries).

2. Record the above evaluation on the Photo Preparation Quality Assurance Rating.
3. Sign off the quality assurance:
    - Approve the product.
    - Return the batch to the contractor with instructions regarding items that do not meet standards and that need to be redone.

Table A1 - Air Photo Preparation Quality Assurance Standards

Attribute	Points Possible	Standards
Line numbering	1	Completed properly
North / south orientation	1	Completed properly
Unit boundary transfer	2	Within ± 10 mm
Principle point marking	2	Within ± 2 mm
Conjugate point marking	2	Within ± 5 mm
Mapping effective area	2	Good 2 Fair 1 Poor 0
Transfer of polygon at boundaries	4	Good 4 Fair 2 Poor 1
Total Possible	**14**	

Data source transfer evaluation

Data source transfer primarily involves four types of inventory data, which are:

- air call;
- ground call;
- temporary sample plot (TSP); and
- permanent sample plot (PSP) data.

The existence of any of this information in a delineated polygon is useful for calibration purposes. The assessment of the quality of the data source transfer is completed using a statistically random sample of points. It is suggested that this quality assurance be completed in conjunction with the polygon delineation quality assurance.

1. Evaluate the following:

    - accuracy of data source placement;
    - extent;
    - symbology;
    - completeness of data; and
    - legibility.

2. Record the above evaluation on the Rating Table for Data Source Transfer.

3. Sign off the quality assurance:

    - Approve the product.
    - Return the batch to the contractor with instructions regarding items that do not meet standards and that are to be redone.

Table A2 - Data Source Transfer Quality Assurance Standards

Attribute	Points Possible	Standards
Accuracy of placement	2	Within $\pm$ 5 mm
Extent	1	Good 1 Poor 0
Symbology	2	Good 2 Fair 1 Poor 0
Completeness of data	4	Good 4 Fair 2 Poor 1
Legibility	1	Good 1 Poor 0
Total Possible	**10**	