Canada's National Forest Inventory Business Process

Version 8.0

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Introduction

Canada's National Forest Inventory (NFI) is a strategic-level, long-term forest monitoring program. It provides statistical information on the state of Canada's forests and trends since NFI establishment.

Most countries maintain NFI programs, with permanent field sampling units measured either periodically or continuously (on a rotating basis) to provide the data needed for unbiased national forest assessment and reporting with quantified precision. Canada's NFI consists of a small network of permanent field sampling units (referred to as "ground plots") and a larger network of remote sensing survey units ("photo plots"). Remote sensing survey methods are used because ground plots are extremely expensive to establish and maintain in remote forests.

NFI plot establishment began in the year 2000. Ground plots and photo plots were installed over a seven year period (2000-2006). Data collected during this period were used to produce a series of baseline reports, first published on the NFI website (nfi.nfis.org) in 2009. The baseline period, sometimes called the establishment period, is referred to herein as T0 (time period 0). First re-measurement (T1) was undertaking during 2008-2017. Second re-measurement (T2) began in 2018 with scheduled completion in 2027.

The NFI is maintained by provincial and territorial governments in partnership with the Canadian Forest Service (CFS) of Natural Resources Canada (NRCan). The NFI Project Office headquarters are located at the CFS's Pacific Forestry Centre (PFC).

This document describes the current NFI business processes and illustrates the relationships among processes to provide clarity on how NFI data are currently being collected, processed, managed, used to produce statistical reports for Canada and served to clients.

Overview of the NFI Business Processes

The overall NFI business process has been divided conceptually here into 14 distinct processes (Figure 1)*[Note: all figures can be found at the end of this document]*. These may be grouped into three main types of activity: (i) data collection (Processes 1 through 6), (ii) data processing (7 through 11) and (iii) reporting (12 through 14).

Data Collection

Survey design (Process 1) was completed prior to T0. It continues to be elaborated and refined as circumstances evolve, but it is a framework and guide for ongoing operational business rather than part of it. The NFI has two data collection streams, one for photo plots and one for ground plots.

Photo plot data collection is done on a ten-year cycle. The objective is to complete the photo plot survey once every ten years. First, aerial photo or very high spatial resolution (VHSR) satellite images are acquired and archived (Process 2). Acquisition is typically done by contractors working for provincial or territorial governments or the CFS, and images are sent to PFC for archiving. Centralized archiving only recently became part of the NFI business process and there is still a backlog of imagery to archive. Aerial photo image archiving in particular is challenging because of the many different formats and metadata conventions in use since NFI establishment. Once

acquired, photo plot imagery is manually interpreted (Process 3) to create NFI photo plot land cover data and then thoroughly validated (Process 4) for loading into the NFI database. Land use, ownership and protection status data are also collected for photo plots. Some provinces and territories prepare data for all 4 photo plot data layers together while undertaking the photo plot survey; others prepare land use, ownership and protection status data separately in a single batch for their entire jurisdiction once during each measurement cycle. National datasets are also used in some cases.

Ground plots are measured (Process 5) following a continuous monitoring approach where the plots last measured longest ago are given the highest priority for measurement each year. This approach is followed in principle while allowing flexibility to take logistical, financial, and technical capacity considerations into account when designing annual field campaigns in each jurisdiction. The aim is to visit approximately ten percent of forested NFI ground plots each year and to measure each plot once every ten years, on average. Ground plot data validation (Process 6) is done using the NFI Ground Plot Utility and a series of additional NFI Project Office checks.

Data Processing

A series of databases[1] are created to manage data (Process 7) as they pass through the various NFI data processing steps. The objective is to ensure data integrity and report reproducibility. The photo plot projection process (Process 8) is used to produce current information for plots not measured during the current cycle or reporting period. Measured or projected data are then compiled (Process 9 for photo plots; Process 10 for ground plots) and used, together with supporting data, to produce statistical estimates (Processes 11a and 11b).

Reporting

Statistical reporting involves the production of a standard suite of reports and the occasional production of special-purpose reports to meet user needs, as these arise. Web reporting services (Process 12) provide open access to NFI reports and survey status reporting information for NFI partners (Process 13). People who require data or reports that aren't openly available may do so through the NFI data request services (Process 14).

Detailed Description of the Business Processes

Process 1 – Survey Design

Canada's NFI survey was designed to provide an unbiased probability sample of Canada's forests for long-term strategic monitoring purposes. The target population is Canada's entire non-Arctic land area. A National Terrestrial Monitoring Framework (NTMF) was created by establishing a systematic

[1] Technically, the NFI Project Office maintains one database on each of four servers ('database', x-network, staging and production – for internal data processing, development, testing and web applications, respectively); within each database, multiple 'schemas' are set up to manage data in different parts of the business process (e.g. schemas for photo plot data, ground plot data, support data for compilations, projection system data, etc.). Throughout this document the term 'database' is used generically instead of 'schema', and representation in diagrams is simplified.

4 km by 4 km sampling grid over all of Canada from a random offshore point. Prior to T0, NFI partners determined that the NFI program would be able to affordably achieve its mission by establishing a 2 km by 2 km (400 ha) "photo plot" at every fifth sampling point on the NTMF (i.e. every 20 km), thereby providing a one percent sample of the target population. This sampling intensity was considered sufficient for national reporting and possible to sustain over the long term with anticipated funding.

Photo plots were established across Canada during 2000-2006 (T0). There are 26,139 photo plot survey locations on the 20 km by 20 km grid, of which 18,570 lie inside the target population area.

NFI photo plot survey data are stratified by "NFI Unit" for standard estimation and reporting purposes. NFI Units were created by the geographic intersection of Canada's 10 provinces, 3 territories and 12 non-Arctic terrestrial ecozones (Figure 2). Estimates produced for NFI Units are rolled up to produce standard reports for ecozones, jurisdictions (provinces and territories) and Canada. Some NFI Units are too small to produce robust estimates for with the current sampling intensity, so NFI Unit estimates are not publicly reported. Prince Edward Island (PEI) Atlantic Maritime, for example, is PEI's only NFI Unit and it is small (1% sampling intensity achieved with only 19 photo plots), so the NFI avoids publishing provincial reports. Information consumers are encouraged to use official statistics produced by provincial and territorial governments for the forests in their jurisdictions. Most provinces are large, however, and the current NFI sampling intensity is sufficient for producing robust NFI reports for those jurisdictions. Special estimation reports can be produced using different ecological or administrative strata, such as the Boreal Zone, or the Managed Forest.

NFI photo plots are surveyed on a ten-year cycle. During first re-measurement (T1; 2008-2017), survey intensity was reduced to one photo plot every 40 km across northern Canada (Figure 3) because of budget limitations. A 2-panel survey approach was initially followed during T1 to enable geographically unbiased mid-cycle estimation and reporting, but this approach was later abandoned because of budget limitations and no mid-cycle T1 estimates were produced. The T2 survey (2018-2027) is also being conducted without panels.

NFI ground plots were also established during 2000-2006 at randomly selected photo plot centroids, where these were found to be forested. Ground plots will be established at selected non-forest sites if they become forested. Access challenges make NFI ground plot sampling logistically challenging and expensive, so sampling intensity was set at ten percent of the photo plot sampling intensity and ground plots were only established in NFI Units where partners determined that these plots could be maintained going forward (re-sampled continuously on a 10-year cycle to track changes). Partners also determined that at least 50 ground plots should be established in an ecozone for the sampling to be worthwhile. Consequently, several ecozones and NFI Units have no NFI ground plots yet. NFI ground plots are removed from sampling plans when biased treatment is suspected or when they are deforested. Procedures for handling refused access, difficult access, hazardous situations and partially forested plots are provided in Appendix D of *Canada's National Forest Inventory Ground Sampling Guidelines*, Version 5.0.

The small number of established NFI ground plots makes this dataset inadequate for national estimation or reporting purposes, but the measurements and samples taken are highly valuable for science and, as such, generate considerable value for Canada.

Process 2 – Image Acquisition and Cataloguing

Image acquisition is undertaken by provinces and territories in their respective jurisdictions, and the CFS can be called upon to acquire imagery for photo plots that are beyond the reach of provincial and territorial acquisition programs. The bounds of the CFS zone of acquisition responsibility are adjusted as needed in response to changes in provincial and territorial image acquisition programs.

In the Provincial/Territorial zones of acquisition responsibility, where provinces and territories manage the majority of imagery capture, the NFI Project Office annually receives photo plot lists for planned acquisition areas before the start of the imagery acquisition season. Planning considerations include the forest inventory priorities of each jurisdiction, such as time since last capture in the inventory cycle or regions of greatest forest change, and the availability of resources (budget, qualified contractors). In most cases, the imagery captured is high resolution (<30 cm) aerial stereo imagery, which is best suited to digital stereoscopic forest inventory interpretation.

After the imagery acquisition season, a second photo plot list is delivered to the NFI Project Office identifying the photo plots where imagery has been successfully acquired. At this point, the imagery is either delivered to the NFI Project Office, where it is added to the forest interpretation contracting stream, or the jurisdiction retains the imagery and contracts out the interpretation or interprets the imagery in-house for delivery to the NFI Project Office.

In the CFS zone of acquisition responsibility, the NFI Project Office acquires Very High Spatial Resolution (VHSR) satellite imagery from satellite imagery vendors. A photo plot target list is generated according to financial resource availability, sampling priorities and maximizing the distance between targeted plots in order to provide wide geographic coverage. The list is refined based on operational requirements and how long it has been since the plot was measured. Using a Regional Individual Standing Offer (RISO), the target list of photo plots is provided to satellite imagery vendors. Over the course of the imagery acquisition season (June 15th – August 31st), VHSR panchromatic (<0.75 m spatial resolution) and associated multispectral imagery (usually ~2 m spatial resolution) are collected simultaneously. Successfully captured images of photo plots are then provided to the NFI Project Office for vetting to the NFI imagery specification (Annex A of RISO). Imagery is then purchased from vendors on a highest rank (lowest price) basis. The image acquisition process is illustrated in Figure 4.

Logistical considerations as well as smoke and weather conditions occasionally impede successful imagery acquisition. Plots that are targeted but not captured in a given year are added to acquisition priority lists for future acquisition seasons. If no capture is possible during a measurement cycle, then data from the previous measurement may be projected forward using the NFI Projection System (Process 8) or other statistical techniques may be employed during estimation (Process 11) to address survey gaps.

The NFI Project Office archives and catalogues all photo plot imagery received, including aerial photography and satellite imagery (VHSR), raw and orthorectified imagery, panchromatic and

multispectral, stereo pairs and single images. Operationally, imagery is not always received during Process 2 because partner business processes are not all the same. VHSR imagery is the most straight-forward case because these data are acquired directly by the NFI Project Office during Process 2. Imagery acquired by partners and sent to the CFS for interpretation (Process 3) is archived and catalogued when received. Imagery acquired and interpreted by partners may be received by the NFI Project Office before or after interpretation. Until recently, some partners archived imagery themselves and these data were not included in the NFI Project Office's archive or catalogue.

Image archive storage would ideally be located on a cloud or enterprise data server for accessibility. Current server capacity at PFC is limited, however, so image storage and archiving is done using an offline, portable hard-drive system and the plan is to have imagery backed up in Natural Resources Canada's Earth Observation Data Management System (EODMS). The imagery are not freely available from EODMS, however, because of licensing restrictions.

The NFI Image Catalogue Service interface provides users with spatial and metadata tools to discover available NFI imagery. Users can search by location, sensor type, acquisition date, etc. Imagery requested by users is uploaded from the hard-drive system to a temporary network storage location for download.

Process 3 – Photo Plot Interpretation

Some photo interpretation is done by CFS contractors using imagery acquired by jurisdictions or purchased by the CFS from satellite imagery vendors. These contracts are awarded under a Supply Arrangement (SA) using a competitive bidding process. The SA defines a list of eligible bidders with the required skills and experience to complete land cover interpretation to the NFI standard, defined in the *National Forest Inventory Phot Plot Data Handling Process*. Work packages are built based on the imagery type (i.e. stereo or mono imagery) and the SA zone where the photo plots are located. SA zones were created by grouping ecozones where distinct regional photo-interpretation expertise is required. Imagery captured for the current measurement cycle and spatial and attribute data collected during previous measurement cycles are bundled in the package delivered to the successful bidder. Professional judgement of the interpreter is used to determine if a photo plot requires simple attribute updating, minor line-work adjustment or complete re-interpretation relative to data from the previous measurement. The photo plot interpretation process is illustrated in Figure 5.

Photo interpretation is also done by NFI partners using contractors or in-house staff. When partners are administering NFI interpretation, they complete the work by interpreting directly to the NFI standard or by interpreting to their own standards and then translating data to the NFI standard. In either case, photo plot data packages are delivered to the NFI Project Office for Photo Plot Validation (Process 4).

Process 4 – Photo Plot Validation

Interpretation quality and accuracy is of utmost importance because the NFI photo plot program is a 1% statistical sample of Canada's forests. All photo plot data packages received by the NFI Project

Office are validated to ensure spatial, relational and database constraint rules are adhered to. A geometry validation procedure is performed, verifying the spatial integrity of the photo plot data provided. The Quality Assurance (QA) module within the Photo Plot Data Entry Utility ensures delivered data are packaged to the NFI standard and adhere to all attribution and relational constraints defined in the *National Forest Inventory Photo Plot Data Dictionary*. The module generates a report of any errors or warnings that may need correction. Data that fail geometry or QA checks are returned to the partner or contractor for correction. Interpretation contracted by the NFI Project Office also goes through an interpretation review whereby photo plot segmentation and attribution (e.g. disturbance/treatment, land cover type, species, age, height, density, etc.) are vetted using various available reference materials. Noted concerns are forwarded to contractors for corrections. Photo Plot data packages provided by partners are assumed to have gone through a similar validation process prior to delivery to the NFI Project Office. Data that pass the NFI QA process are loaded to the Raw Plot Database.

The photo plot validation process is illustrated in Figure 6.

Process 5 – Ground Plot Measurement

Canada's NFI has 1114 forested ground plots. Ground plots are measured following a continuous monitoring approach where the plots last measured longest ago are given the highest priority for measurement each year. This approach is followed in principle, while still allowing for the flexibility to take logistical, financial, and capacity considerations into account when designing annual field campaigns in each province and territory. The aim is to visit approximately 10% of Canada's forested ground plots each year and to measure each plot once within a 10-year period.

The number of NFI ground plots in each province and territory varies, from as few as 2 (Prince Edward Island) to as many as 268 (British Columbia). Some jurisdictions target 10 percent of their NFI ground plots annually for measurement while others find it more practical to measure NFI ground plots over a condensed time period. Federal funding is generally required to cover the incremental costs incurred to collect measurements unique to NFI ground plots and to measure NFI plots that are located outside of the provincial or territorial forest inventory area. Each year, NFI partners meet to discuss the proposed annual field campaigns across the country. If plans require more federal funding than is available for the ground plot program in a given year, funding is prioritized where it would most benefit the NFI ground plot program nationally.

Prior to heading out into the field, jurisdictions retrieve and review data from the previous measurement of the plots scheduled for re-measurement. This aids in field crew preparation and enables on-site quality assurance (QA) checks. Data from the previous measurement can be accessed from the database or by obtaining a copy of the field cards from the previous measurement.

NFI ground plots are measured using the methodology for ongoing measurement described in *Canada's National Forest Inventory Ground Sampling Guidelines*. Collected data are field-validated against the data from the previous measurement of that plot.

Most jurisdictions collect data on paper field cards. These data must be converted to a digital format. This can be achieved by entering data directly into the NFI Ground Plot Utility, a tool

designed for data entry and quality assurance of NFI ground plot data. Alternatively, data may be submitted as a series of .csv files that conform to the table structures, naming conventions, and rules outlined in the *NFI Ground Plot Data Dictionary*.

Development of digital field forms would increase data quality and consistency by eliminating transcription errors and enabling automated data checks while crews are still on-site. Office time would also be reduced by eliminating the need to digitize data collected on paper forms.

The ground plot measurement process is illustrated in Figure 7.

Process 6 – Ground Plot Sample Analysis and Data Validation

The ground plot data validation process (Figure 8) is initiated once field validated data have been entered into digital format and uploaded to the NFI Ground Plot Utility as a project that includes plot data, field card scans, photos and metadata.

The NFI Ground Plot Utility contains a series of automated validation routines that compare the loaded data against the standards and rules described in the *NFI Ground Plot Data Dictionary*. The validation routines check to ensure proper codes have been used, that values are within acceptable bounds and that relationships among data fields are consistent and make sense. An error report is generated each time the validation routines are run. The report identifies any data not conforming to the standards and rules outlined in the data dictionary. NFI partners run the automated validation routines on their uploaded data, correct the issues identified in the error report and repeat the process until an error-free report is generated. Once an error free report is generated the project is exported and submitted to the NFI Project Office.

The NFI Project Office completes additional QA checks to confirm data entry is complete and all project components have been submitted, to identify unexpected inconsistencies or trends in the data when compared to data from the previous measurement, and to detect any data values that are unlikely to be correct from a forestry perspective. The findings of these checks are documented in a QA report, which is returned to the partner. The partner reviews the report and addresses any issues or questions. Once all issues are resolved to the mutual satisfaction of the partner and the NFI Project Office, the field data are considered validated.

Field samples – including soil samples, forest floor samples, vegetation samples and tree cores – are sent to laboratories for analysis. NFI laboratory analyses are completed and lab data are reported directly from the labs to the NFI Project Office where they are imported into the data submission. The project is then loaded into the NFI Ground Plot Utility and run through the validation routines to ensure that the addition of the lab reported data has not introduced any errors. The NFI Project Office, in cooperation with the various labs, works to investigate and resolve any issues identified. This process is repeated until an error-free report is generated.

Ground plot data are considered validated when the project is complete and has passed the validation checks of the NFI Ground Plot Utility and the NFI Project Office. Validated data are loaded to the NFI ground plot database.

Process 7 – Database Creation

A number of databases[2] are created to manage NFI data as they are collected and processed. Photo plot and ground plot measurement data are loaded into the Raw Plot Database after validation (Processes 4 and 6). There may be multiple versions of each plot data package because the plot data can be loaded into the Raw Plot Database multiple times due to corrections or updates. When all the data have been loaded, the most current version for each plot is extracted from the Raw Plot Database to create a Snapshot Dataset. Compilations (Processes 9 and 10) are performed on the Snapshot Dataset to generate a Compiled Plot Dataset. Estimation procedures (Processes 11a and 11b) are run on compiled plot data to create the Reporting Plot Database. NFI reporting services (Processes 12 and 14) use the Reporting Database to generate reports.

Additional databases are created to support photo plot projection (Process 8). For analytical purposes, reports are generated from the Reporting Plot Database using the re-measured data only, from the Reporting Projection Database using the projection only, and from combination of measured and projected data, where projected data are used to fill gaps in the measured data. The final published Reporting Database consists of the combination of the re-measured data and the projected data.

Process 8 – Photo Plot Projection

The photo plot projection process (Figure 9) is used to produce current data for plots not measured during the current cycle or reporting period by combining previous measurement data with data describing (i) disturbances that occurred since the previous measurement, (ii) growth expectations, and (iii) rules describing changes to stand attributes that would be expected to occur given events during the time period through which plots are being projected (from previous to current measurement cycle).

Several input datasets must be prepared in advance to support the photo plot projection process, including a disturbance database, a growth curve database and a set of projection rules. Different projection methods may be employed in different circumstances. For example, faster, simpler methods can be employed for simple volume projection situations (no disturbance during the projection period, or stand-replacing disturbance only) while more complicated methods can be employed for more complicated situations (growth loss or partial stand mortality caused by insect outbreaks or other factors during the projection period).

Processes 9 and 10 – Photo Plot and Ground Plot Compilation

The compilation processes for photo plots (Figure 10) and ground plots (Figure 11) both involve two steps: firstly, attributes that cannot be photo-interpreted or measured directly during photo- or ground plot data collection, respectively, such as stand volume or tree volume, are derived using existing relationships (e.g., provincial or territorial tree volume equations) and added to the Compiled Plot Database. Next, raw layer-level photo plot data are aggregated to produce polygon

[2] Refer to footnote 1 for explanation of how the term 'database' is used in this document and notes about simplifications.

summaries, and the above- and below-ground ground plot data are aggregated to produce per hectare estimates of volume, biomass and carbon content and then added to the Compiled Plot Database. Measured and projected photo plot data are compiled separately and managed in separate databases, but the compilation procedures are identical.

The NFI compilers utilize provincial and territorial compilation tools to the greatest extent possible. Where these tools are incomplete or unavailable, regional and national tools are developed and utilized.

Process 11 – Estimation

Process 11a – Estimation of baseline and re-measurement statistics.

The process of estimating baseline (T0) or re-measurement statistics (T1, T2) involves calculating point estimates for attribute (area, volume, biomass) totals and averages of the target population. The estimation process (Figure 12) generates the estimates of area and other attribute totals, averages and variances by classifier class. The estimation approach considers the sampling design and any available auxiliary information and includes three steps.

Before estimation, all spatial data layers must be intersected to create a single GIS 'resultant' dataset so that all spatial relationships are determined before data are loaded into SAS for estimation. Photo plots have 4 layers (land cover, land use, ownership and protection status) and there may be several stratifications used in addition to the standard, NFI Units (e.g. Boreal Zone, Managed Forest, North American Forest Ecozones, etc.).

The first step is estimating the attribute totals, averages and variances for each area of interest (AOI) unit by classifier class (domain) using the photo or ground plot observations that are located within the AOI unit, the ratio-of-means (ROM) estimator, and the known AOI unit area. The "NFI Units" described in Process 1 are the standard AOI units. Classifiers are defined by categorical variables including forest land, land use, ownership, and protection status. The ROM estimator is calculated as the ratio of the sum of the attribute in a classifier class in all plots to the sum of the total area of all plots in the AOI unit. The attribute total is calculated by multiplying the ROM estimate (proportion or average) in a classifier class by the AOI unit total area.

The second step is summing the individual AOI unit totals and their associated variances to the AOI, jurisdictional (province or territory), or national level.

The third and final step is producing internally consistent tabulations of AOI attribute totals and averages and their associated variances by classifier class.

A more complete description of the estimation process is provided in *Canada's National Forest Inventory Estimation Procedures* (Version 1.13, September 3, 2004), *Canada's National Forest Inventory Small Area Estimation: A Discussion Paper* (Version 2.0, April 18, 2005) and *Canada's National Forest Inventory Imputation of Missing Plot Observations: A Discussion Paper* (Version 2.0, April 26, 2005).

Process 11b – Estimation of change statistics

Change estimation is the process that generates estimates of annual or periodic change in attributes (e.g., area, volume and biomass) (Figure 12). Estimates are generated for an AOI unit. The estimation steps are similar to those in Process 11a.

The first step is estimating the annual or periodic change in the area, volume or biomass in an AOI unit for a classifier class by multiplying the estimated change in proportion of area (or attribute average) in a given classifier class (based on photo plots) by the known AOI unit total area. The estimated change in area proportion, or change in attribute average or per-hectare value, is obtained using data from the combined sets of photo plots measured in successive periods – e.g. baseline (T0) and first re-measurement (T1). The temporally indifferent estimator is calculated as the ratio of the sum of the periodic/annual change in an attribute in a classifier class in all plots to the sum of the total area of all plots in the AOI unit. Photo plots that are not re-measured are imputed through the NFI projection system or Multiple Imputation (MI) techniques.

The second step is summing the individual AOI unit totals and their associated variances to the AOI, jurisdictional (province or territory), or national level.

The third and final step is producing internally consistent tabulations of AOI attribute totals and averages and their associated variances by classifier class.

A more complete description of the change estimation process is provided in *Canada's National Forest Inventory Change Estimation Procedures based on Fixed Annual panels* (Version 1.08, August 8, 2006) and *Updating Canada's National Forest Inventory with multiple imputations of missing contemporary data* (Magnussen *et al*., 2017, Forestry Chronicle 93(03):242-245).

Process 12 – Web Reporting Services

Process 12a – Statistical Reports

The NFI web reporting services provide access to standard statistical reports in static and dynamic formats (Figure 13). Static standard NFI reports are produced for individual NFI Units and combinations of NFI Units (e.g., all NFI Units in an ecozone). These static reports are pre-generated through the Published NFI Reporting Database, which is a multi-year database of past compiled and projected plot information and NFI Unit summaries. The NFI standard reports can be viewed and downloaded at https://nfi.nfis.org/en/standardreports.

NFI website also provides an interface for users to build reports for selected attributes and classifiers in a pre-defined area of interest. Authorized users can log in to produce reports that aren't openly available to the public; for example, a provincial government forester can log in to produce reports for their jurisdiction. This dynamic reporting tool can be found at https://nfi.nfis.org/en/customized_report.

Process 12b – Biomass Calculation Services

The NFI website provides biomass calculators for individual trees, merchantable stands, and non-merchantable stands. Individual tree biomass models are compiled from the published scientific

literature and stand biomass models are developed by the NFI Project Office. These stand models are also used in other modelling tools, such as the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) and Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS).

NFI biomass calculator users can calculate biomass either by entering the required parameters through the web interface or by uploading a pre-formatted file for batch processing (Figure 14). These services can be found at https://nfi.nfis.org/en/biomass.

Process 12c – Plot Data Download Services

Authorised users can download the NFI ground plot and photo plot data through the NFI website at https://nfi.nfis.org/en/datadownloadtool (Figure 15).

Process 13 – Survey Progress Reporting

NFI photo plot survey progress tracking and reporting is done using the NFI Tracking System so that partners know the survey status of every photo plot. Tracking System data are used to produce maps and tabular reports. These are used to guide planning and coordinate partner activities to ensure smooth collaboration. Photo plots are passed from one partner to another during data collection, sometimes multiple times, as they work their way through Processes 2 through 4. It is therefore important for partners to know the status of each plot, including those they are working on and those being worked on by other partners on their behalf.

Survey status codes are used to track where each plot is on the sequence of processes. Eleven statuses are tracked for photo plots (Table 1). Tracking the status of each plot ensures that plots are prepared for the appropriate next step of the sequence by the appropriate partner. The NFI Project Office conducts national tracking and survey progress reporting for all partners. Tracking done independently by partners for plots in their jurisdictions is not described here. Ground plot survey status tracking is done in a simple manual system because there are fewer steps in the ground plot data collection processes and fewer hand-offs between partners along the way.

TABLE 1. PHOTO PLOT SURVEY PROGRESS TRACKING STATUS LIST.

Photo plot survey status code	Description
0	Re-measurement not planned
1	Planned
2	Imagery acquired
3	Imagery received by NFI Project Office
4	Imagery sent for interpretation
5	Interpretation data received
6	Data not passed quality assurance (QA)
7	Data passed QA
8	Data (including treed polygons) loaded to database without volumes
9	Data (including treed polygons) loaded to database with volumes
10	Data (no treed polygons) loaded to database
11	Data projected

Process 14 – Data Request Services

The NFI Project Office provides data request services. Anyone wishing to request NFI data or information may contact NFI Project Office staff or partners, or enter their request directly into the NFI request tracking system using the form available at https://nfi.nfis.org/en/datarequest. Requests are processed according to a series of rules used to govern data accessibility (Figure 16). Some request tracking information is retained by the NFI Project Office to facilitate data use and impact reporting. Information about how NFI data are used and what impact they are having outside the NFI program is useful for informing government program funding decisions.

NFI Ground Plot data are in especially high demand. Plot data are widely shared, but precise plot locations are not. The NFI program has good reason to be cautious about who knows where NFI plots are located. Like NFI programs in other countries, plot locations are kept secret for two reasons: (1) to protect land-owner privacy, and (2) to avoid tampering or biased treatment. Failure to protect land-owner privacy can result in lost access to plots on private land. Failure to avoid tampering or biased treatment would undermine our ability to monitor the state of Canada's forests. Rounded or fuzzed ground plot locations are adequate for many client needs, but not for many remote sensing applications. The NFI therefore shares precise locations of plots located on public land when the user has legitimate need for precise locations and agrees in writing to not visit the plots or share their precise locations with third parties.

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Figures

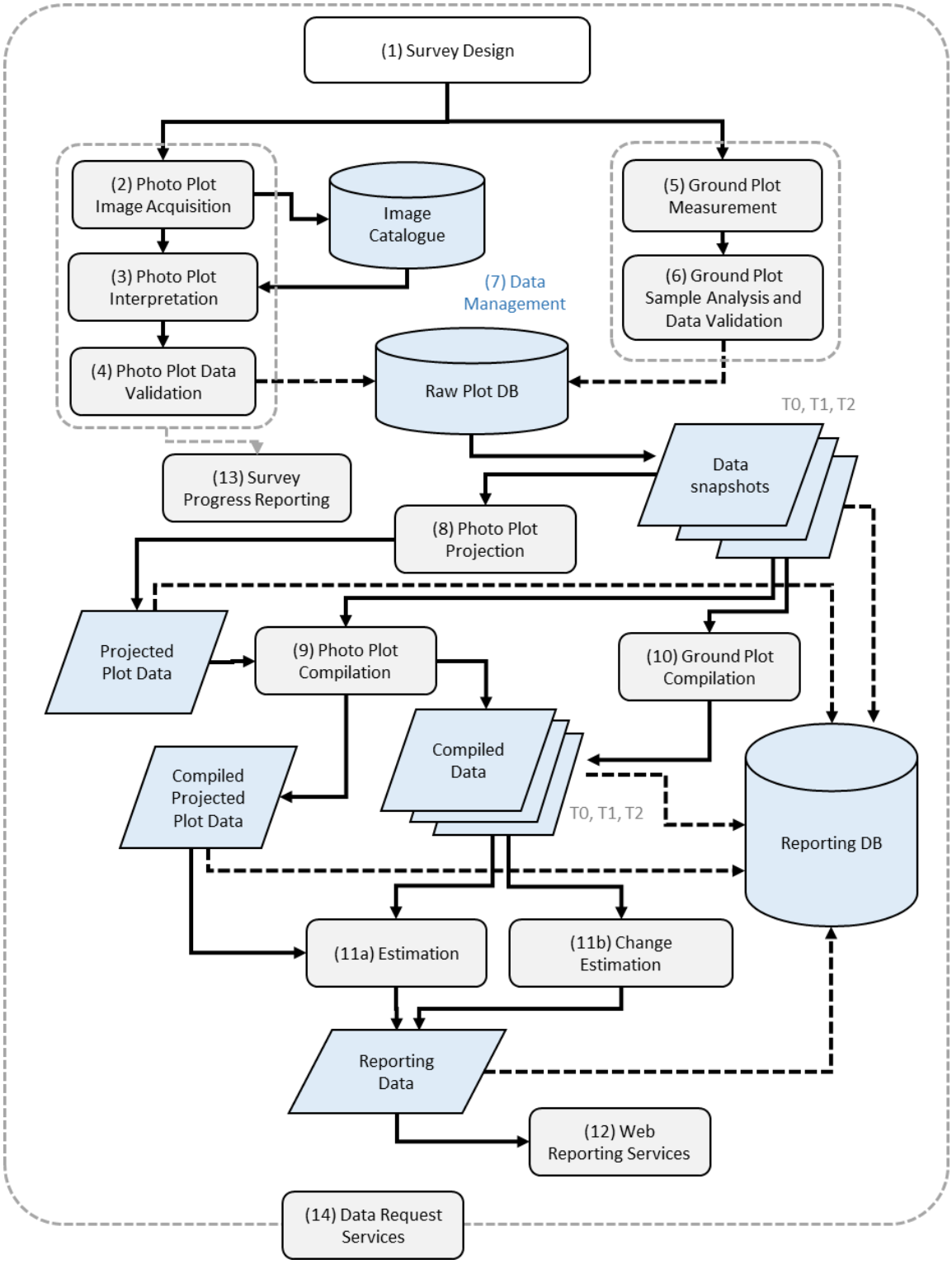

FIGURE 1: OVERALL NFI BUSINESS PROCESS

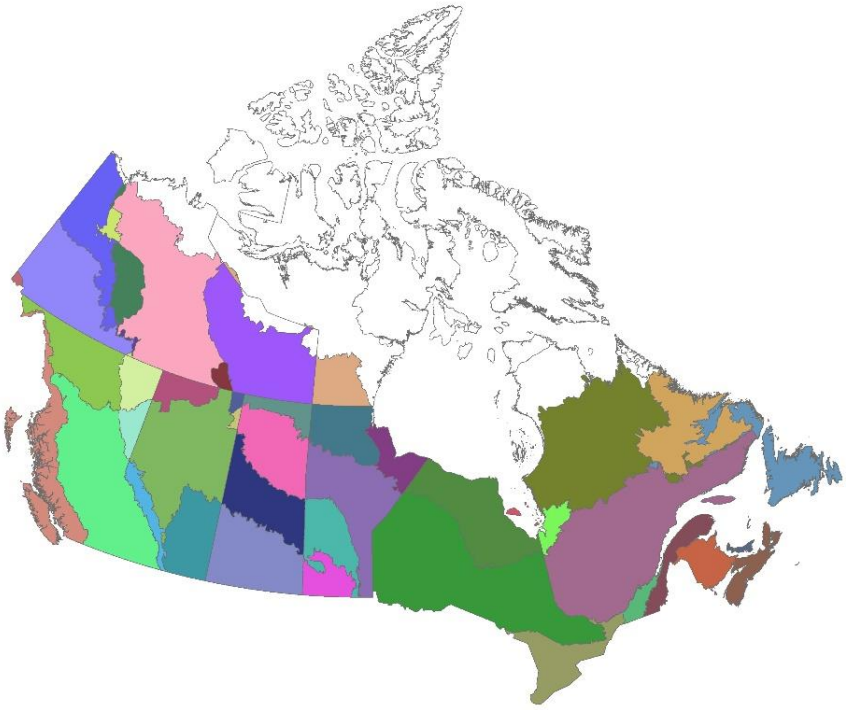

FIGURE 2: NFI UNITS FOR STANDARD ESTIMATION AND REPORTING

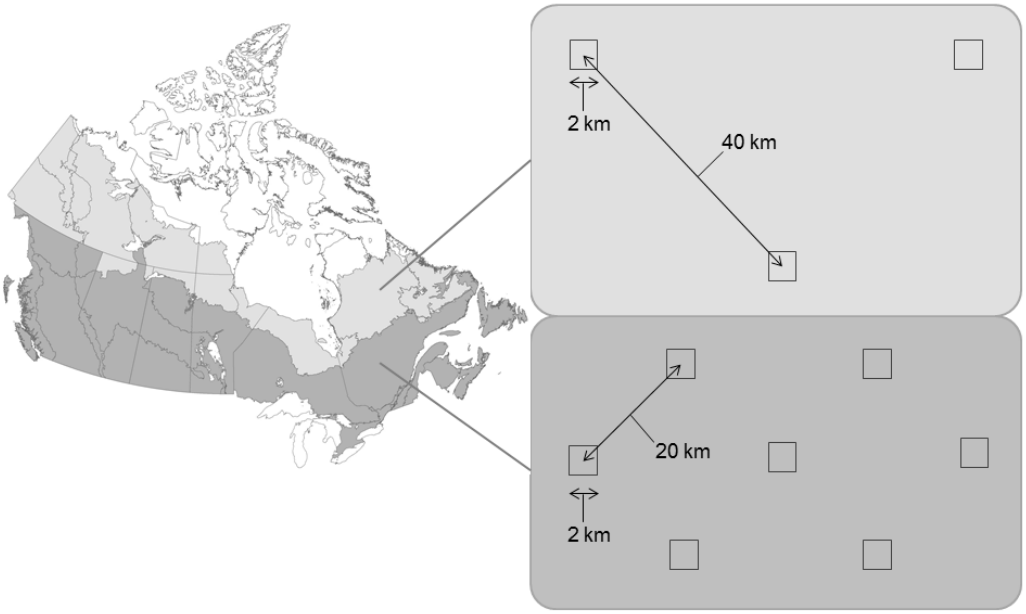

FIGURE 3: NFI PHOTO PLOT SURVEY

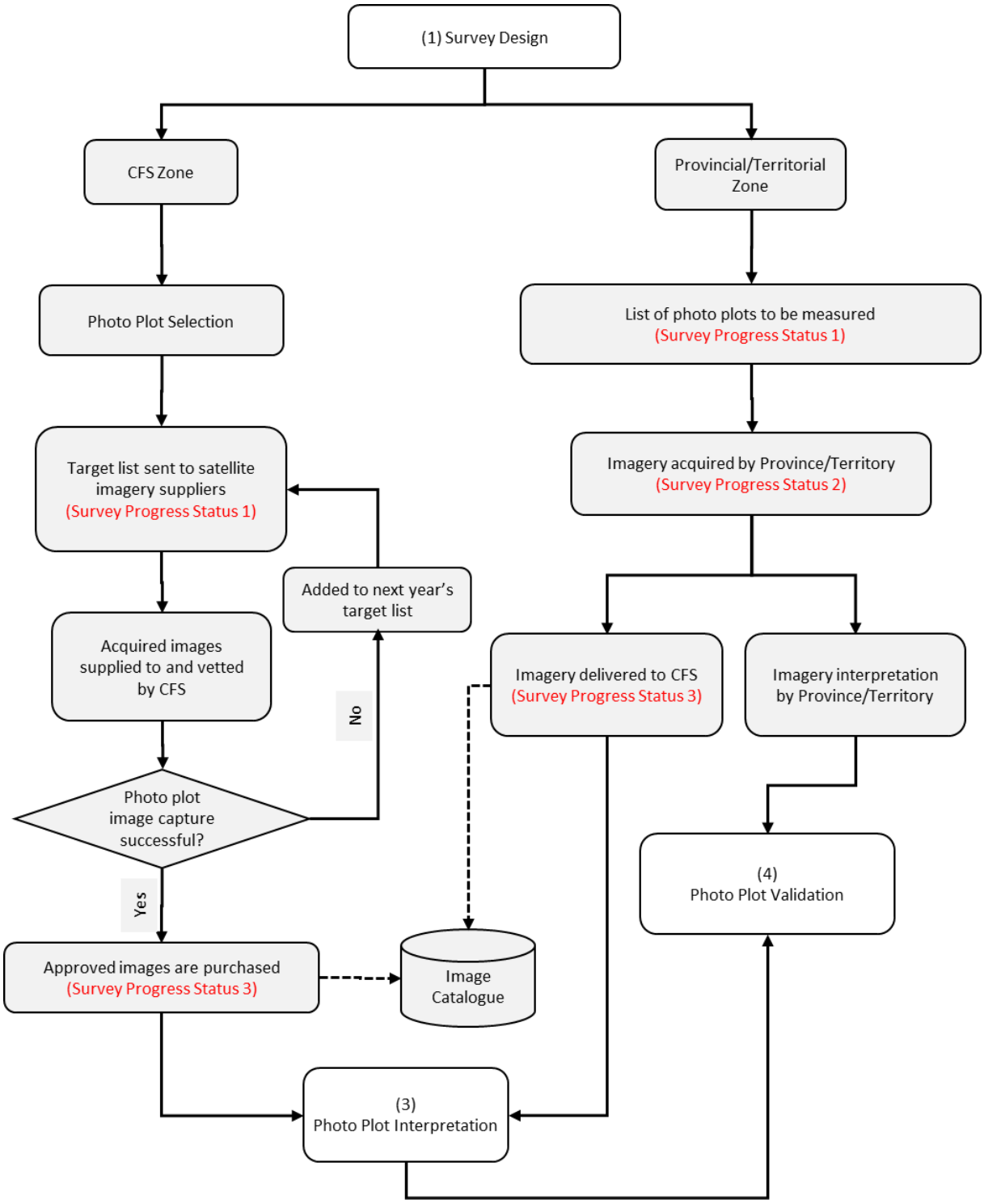

FIGURE 4: NFI BUSINESS PROCESS 2 - IMAGE ACQUISITION AND CATALOGUING

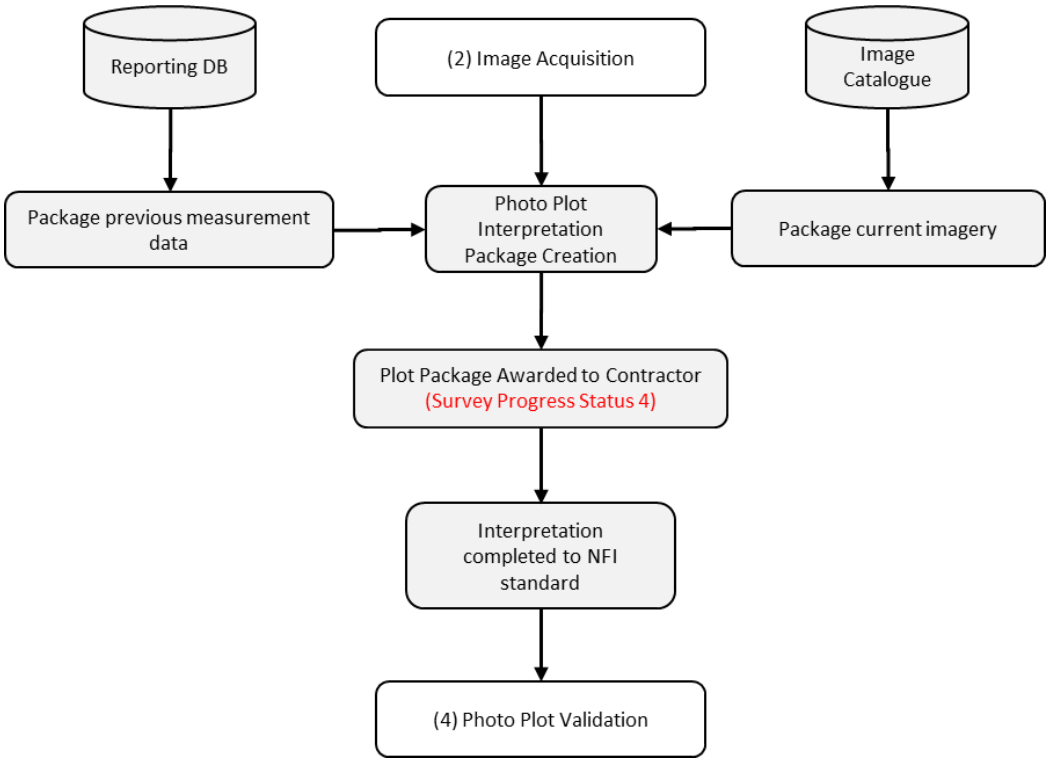

FIGURE 5: NFI BUSINESS PROCESS 3 - PHOTO PLOT INTERPRETATION

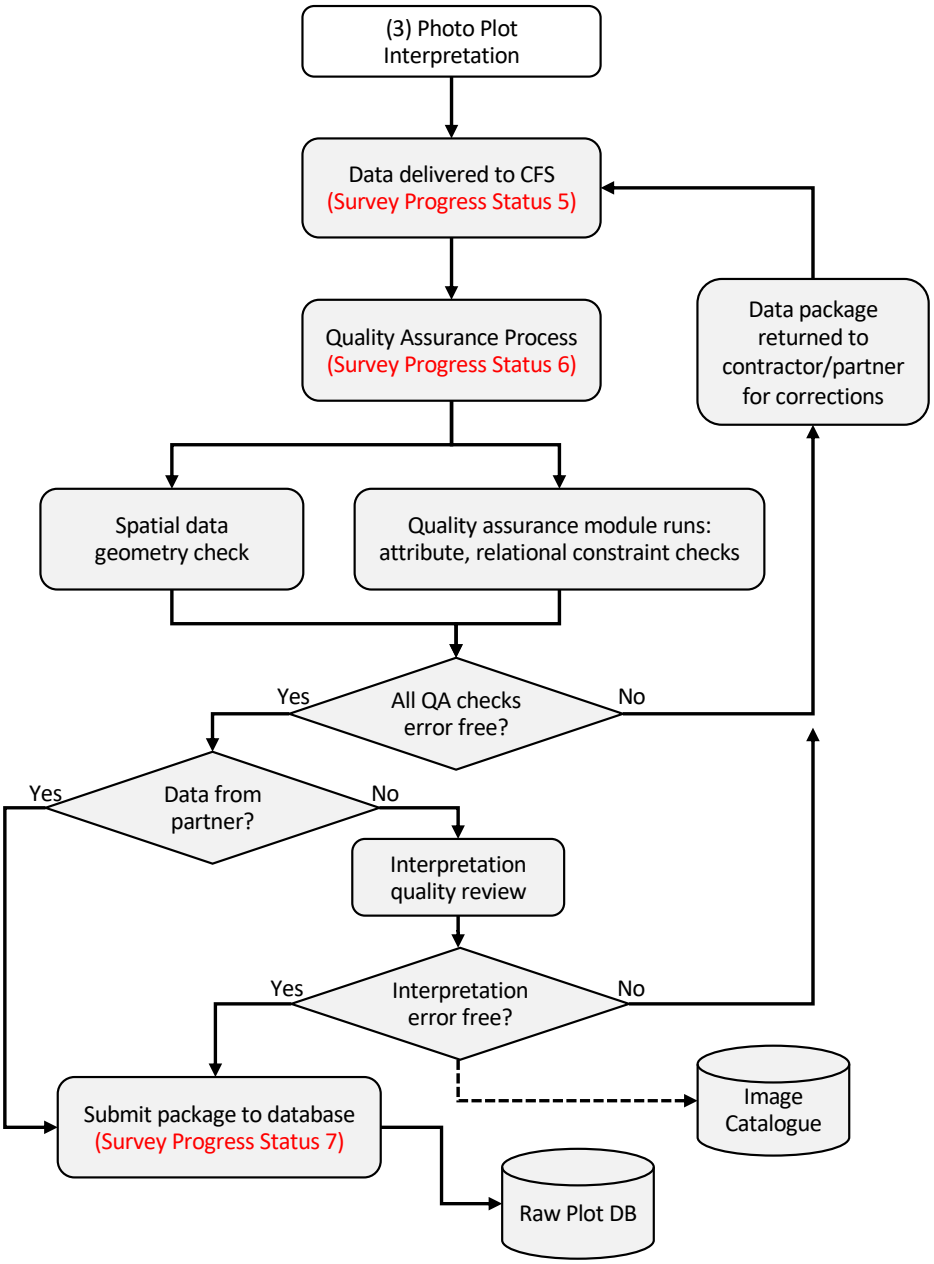

FIGURE 6: NFI BUSINESS PROCESS 4 - PHOTO PLOT VALIDATION

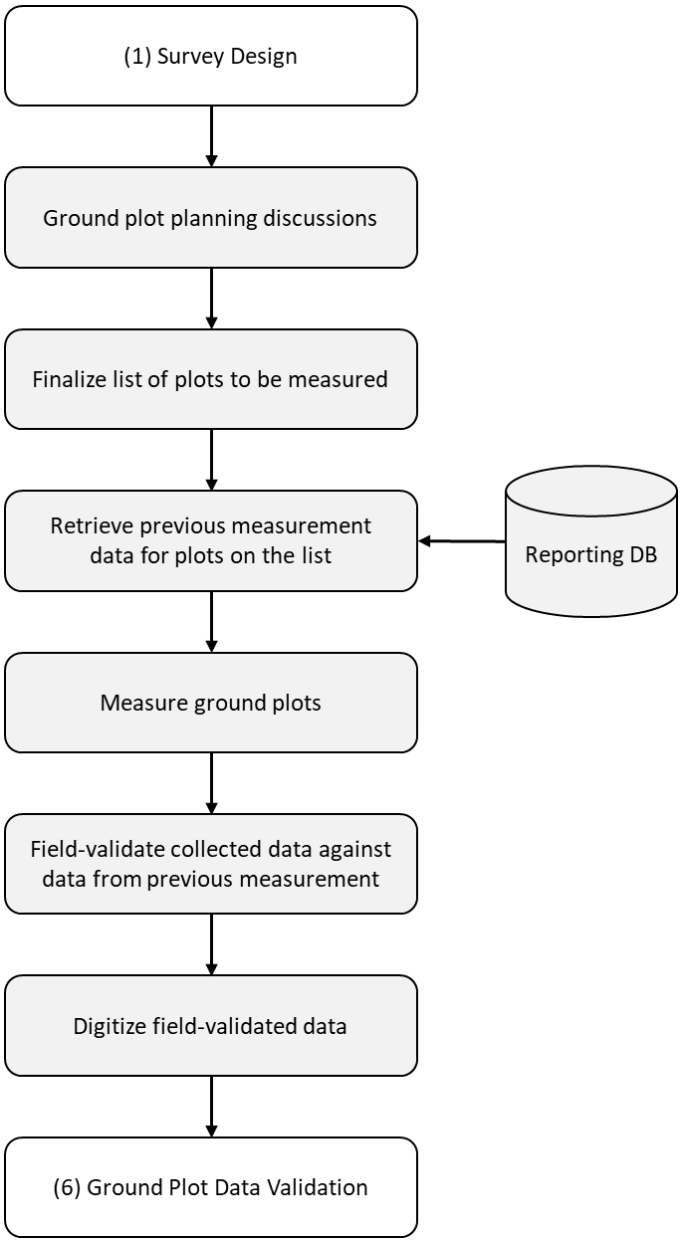

FIGURE 7: NFI BUSINESS PROCESS 5 - GROUND PLOT MEASUREMENT

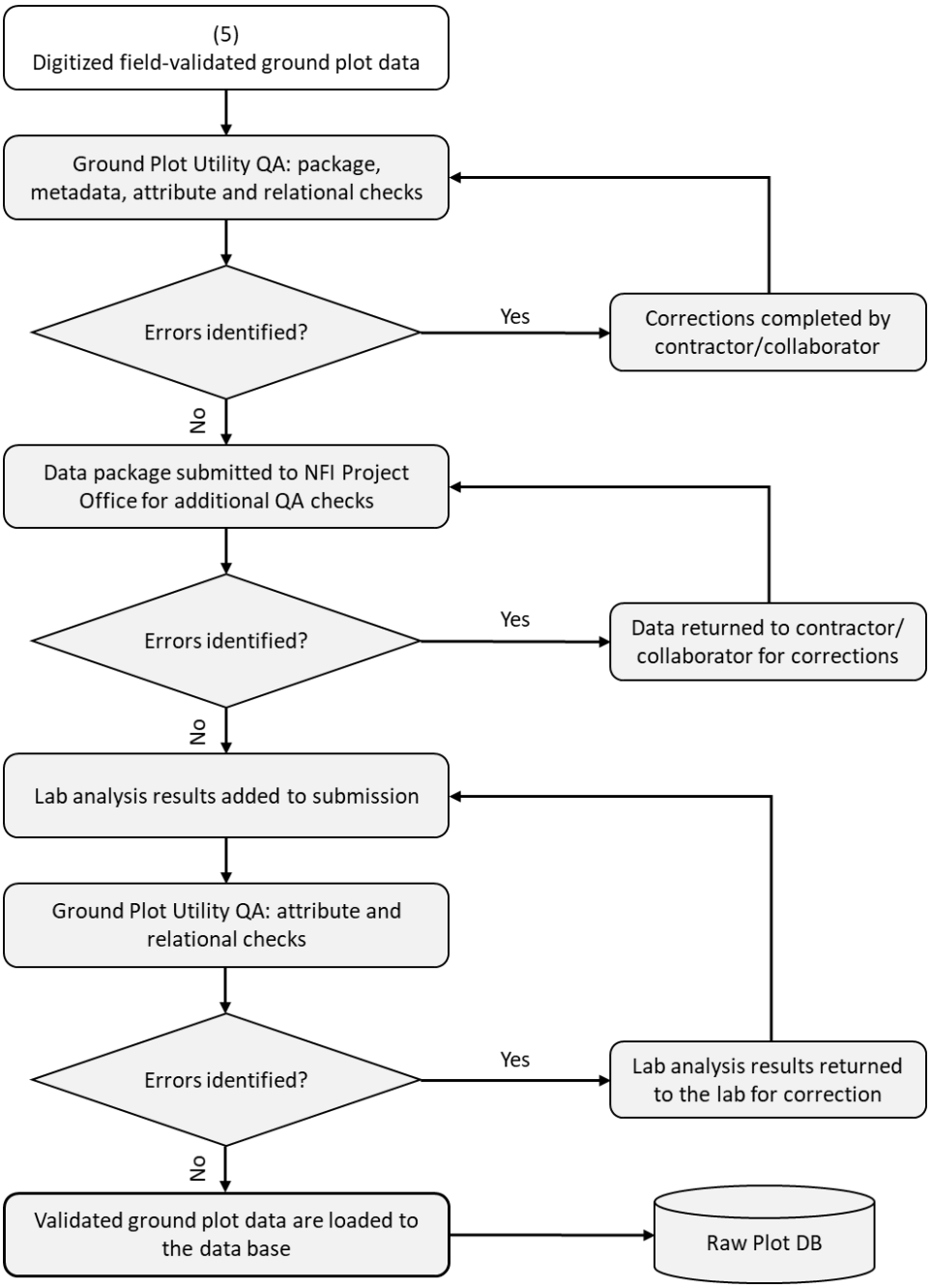

FIGURE 8: NFI BUSINESS PROCESS 6 - GROUND PLOT DATA VALIDATION

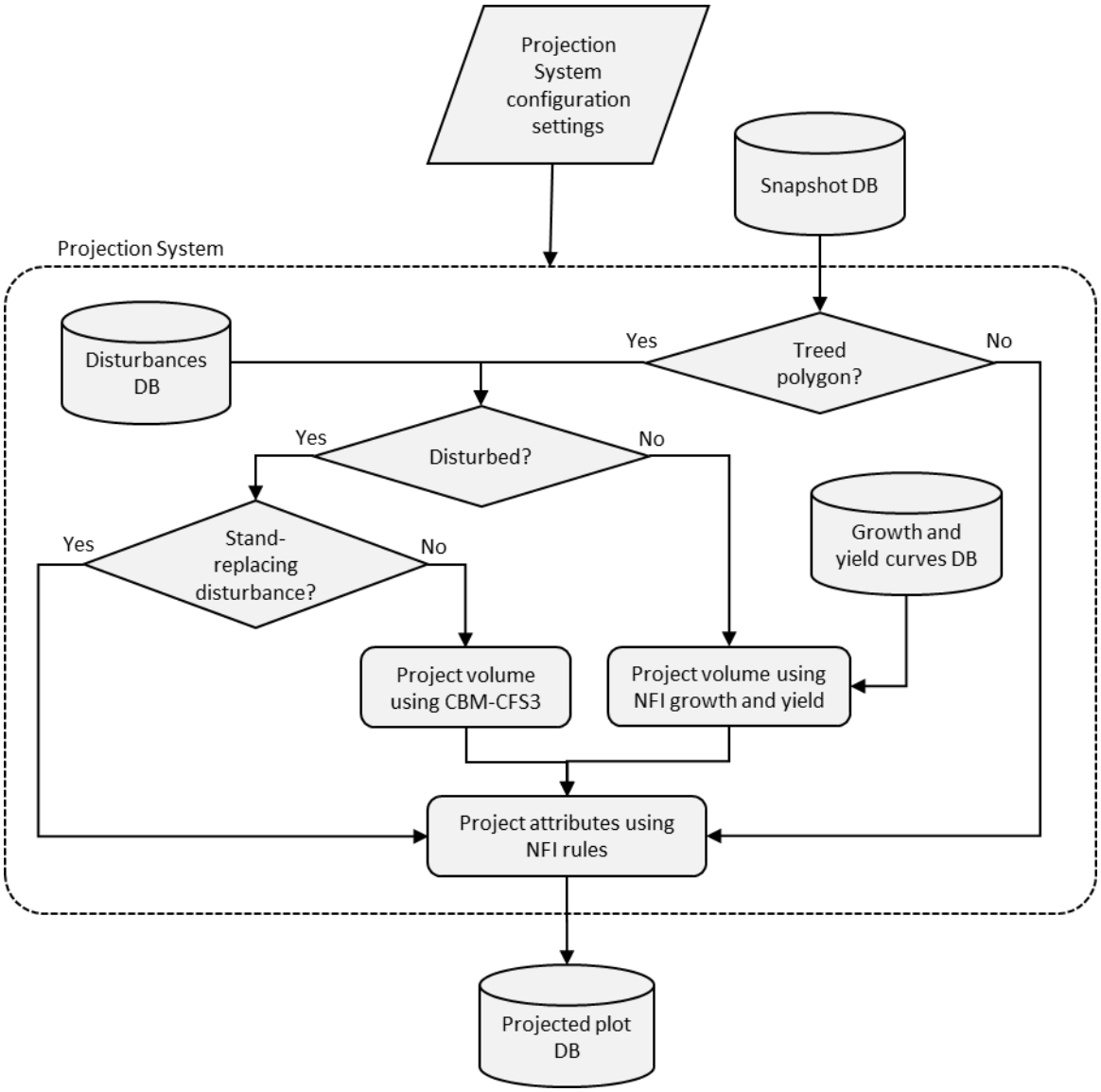

FIGURE 9: BUSINESS PROCESS 8 - PHOTO PLOT PROJECTION

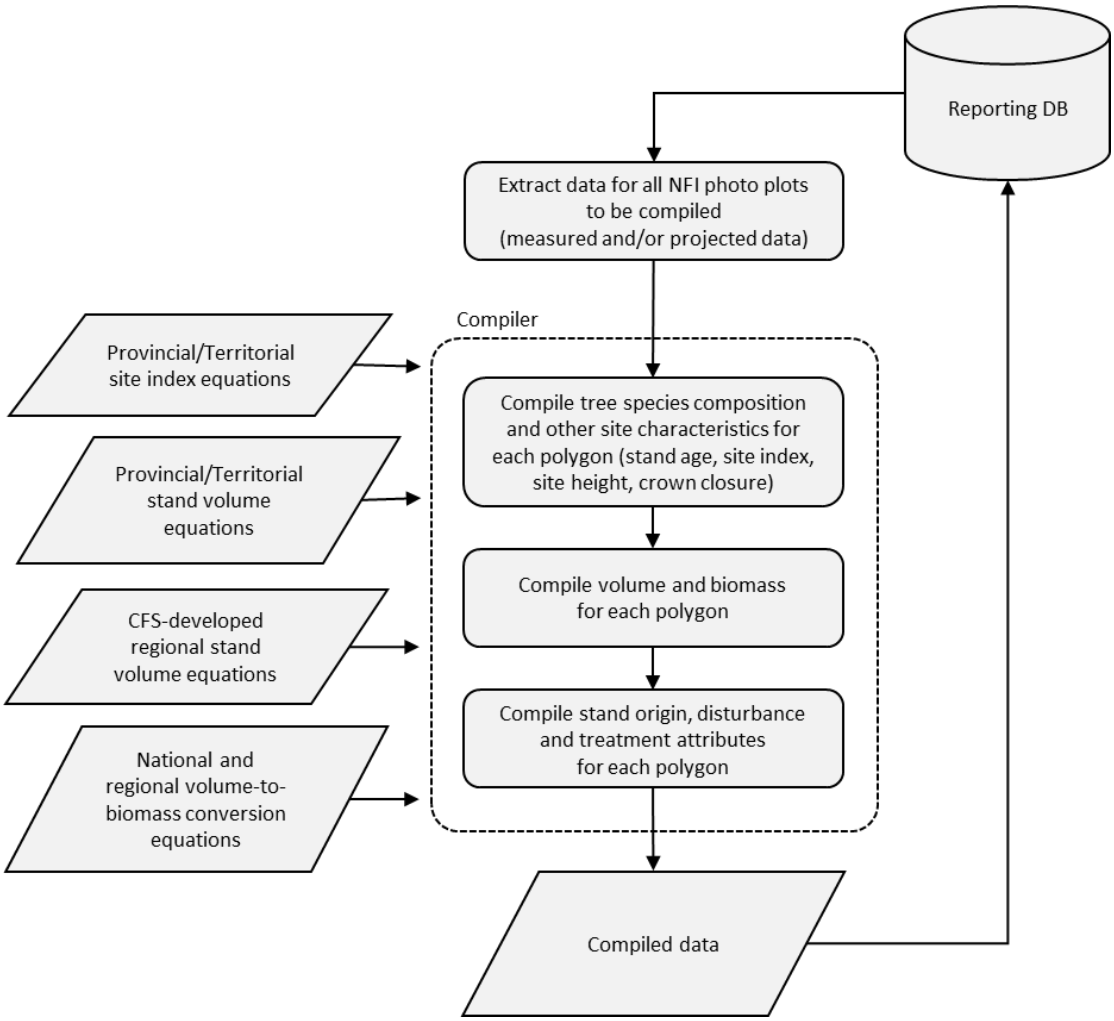

FIGURE 10: NFI BUSINESS PROCESS 9 - PHOTO PLOT COMPILATION

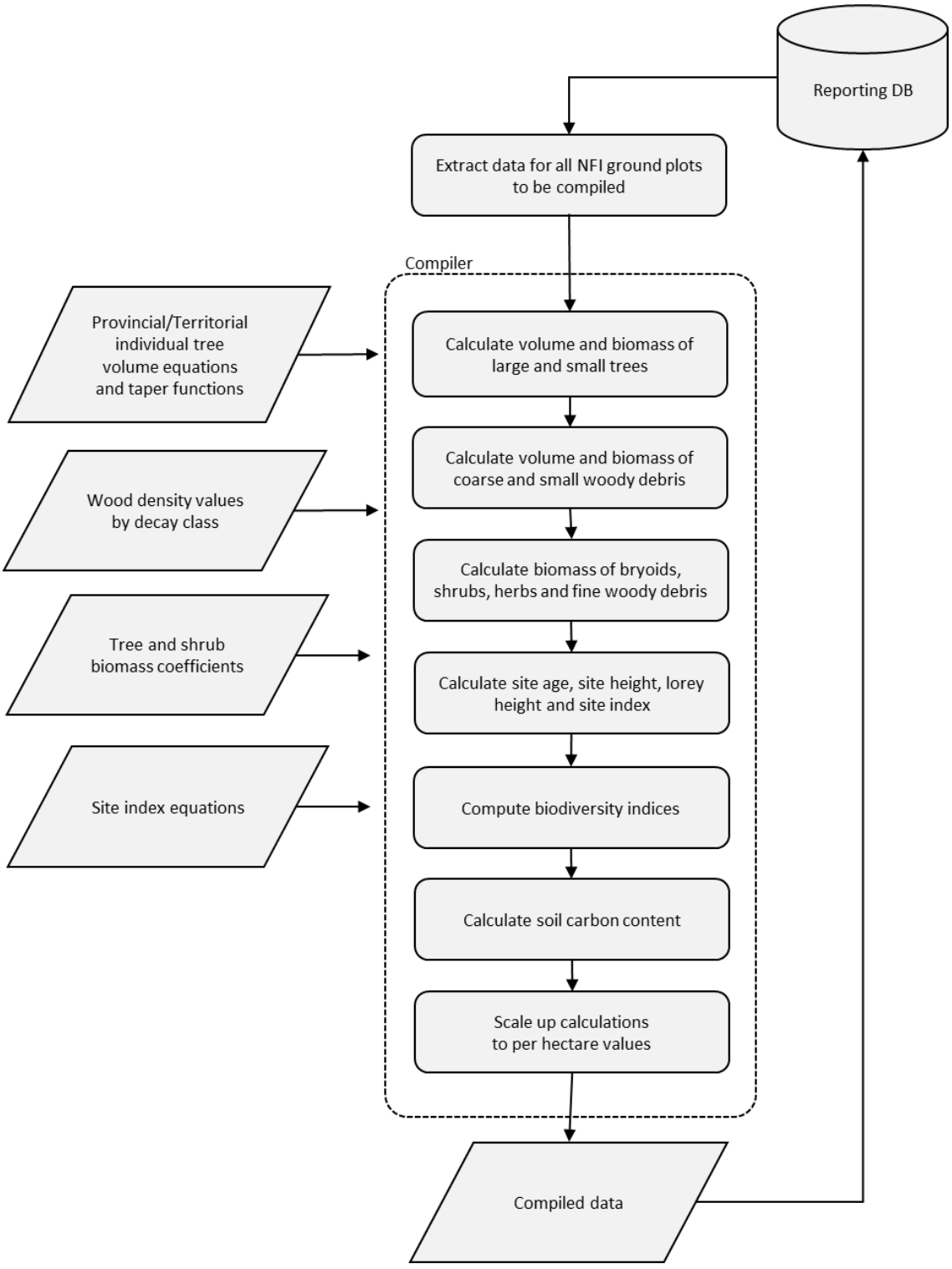

FIGURE 11: NFI BUSINESS PROCESS 10 - GROUND PLOT COMPILATION

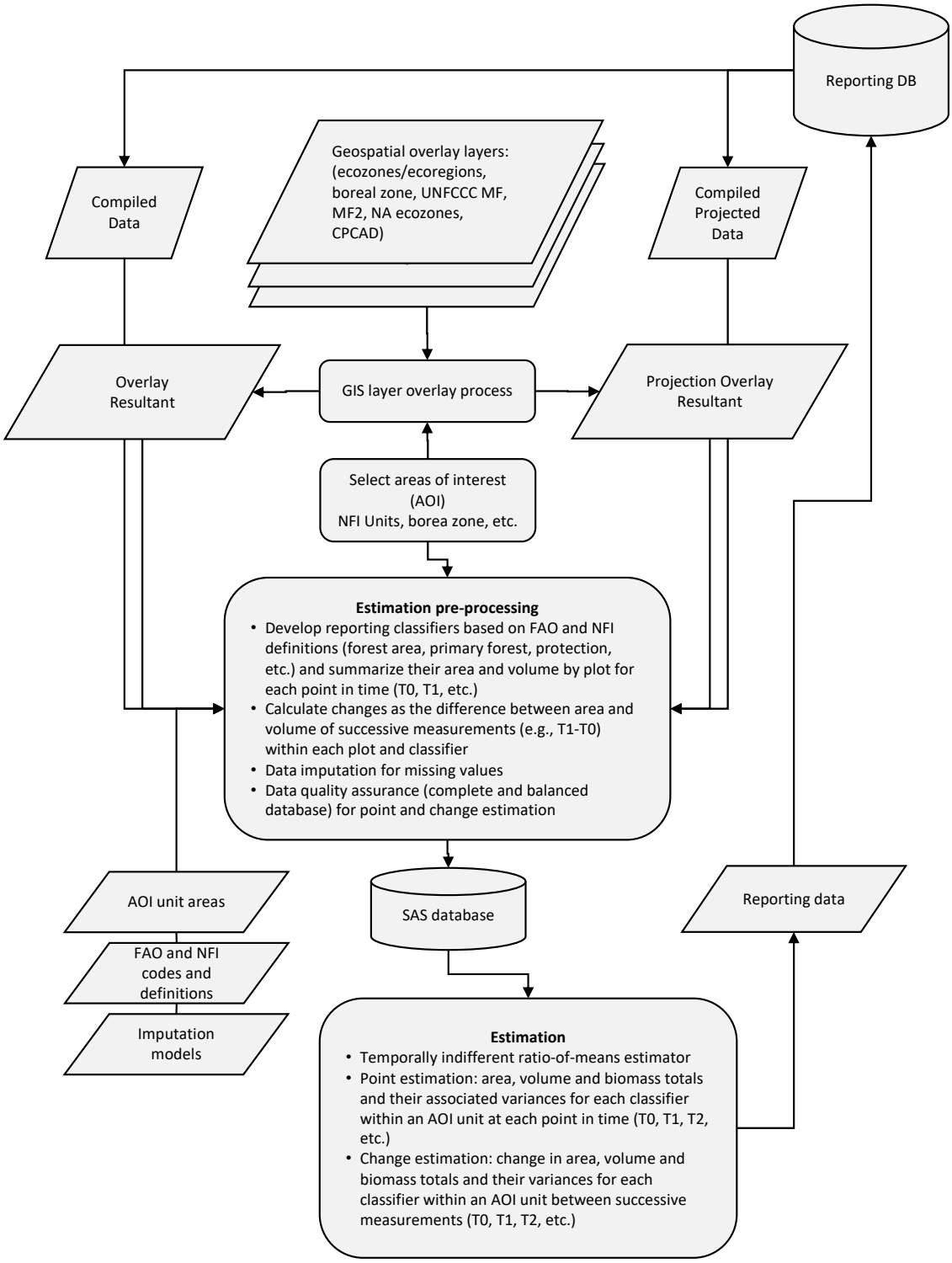

FIGURE 12: NFI BUSINESS PROCESS 11 - ESTIMATION

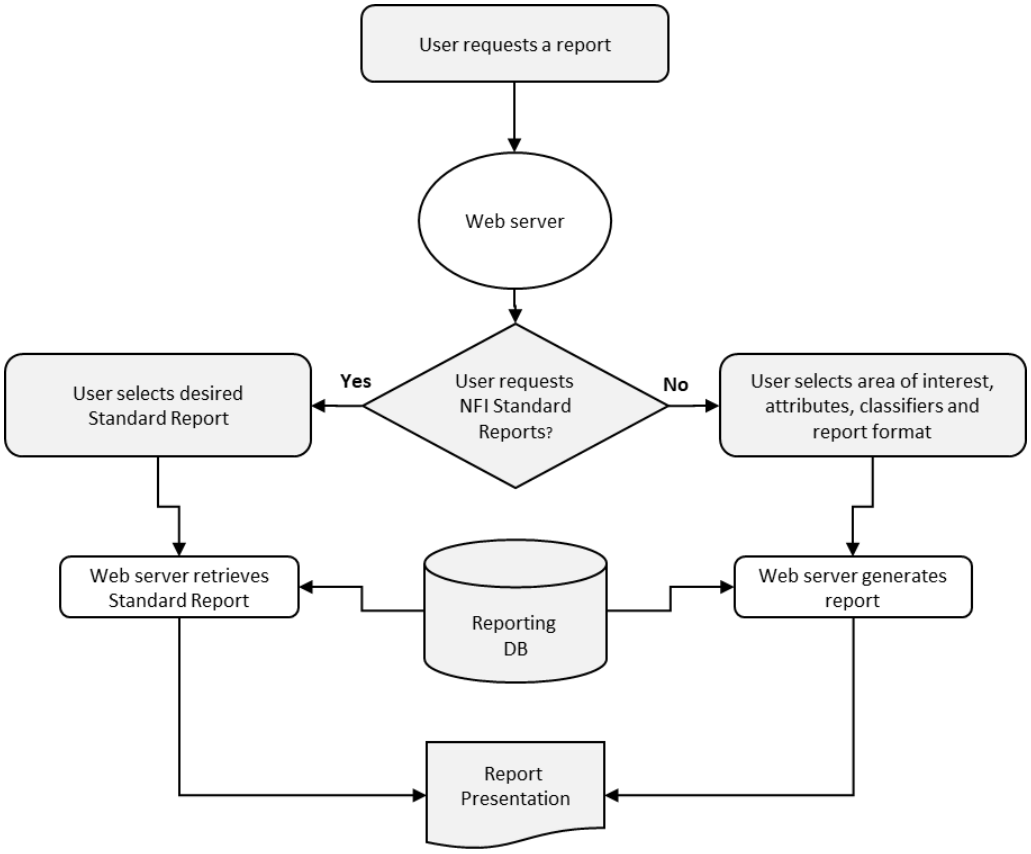

FIGURE 13: NFI BUSINESS PROCESS 12A - WEB REPORTING SERVICES FOR FOREST STATISTICAL REPORTS

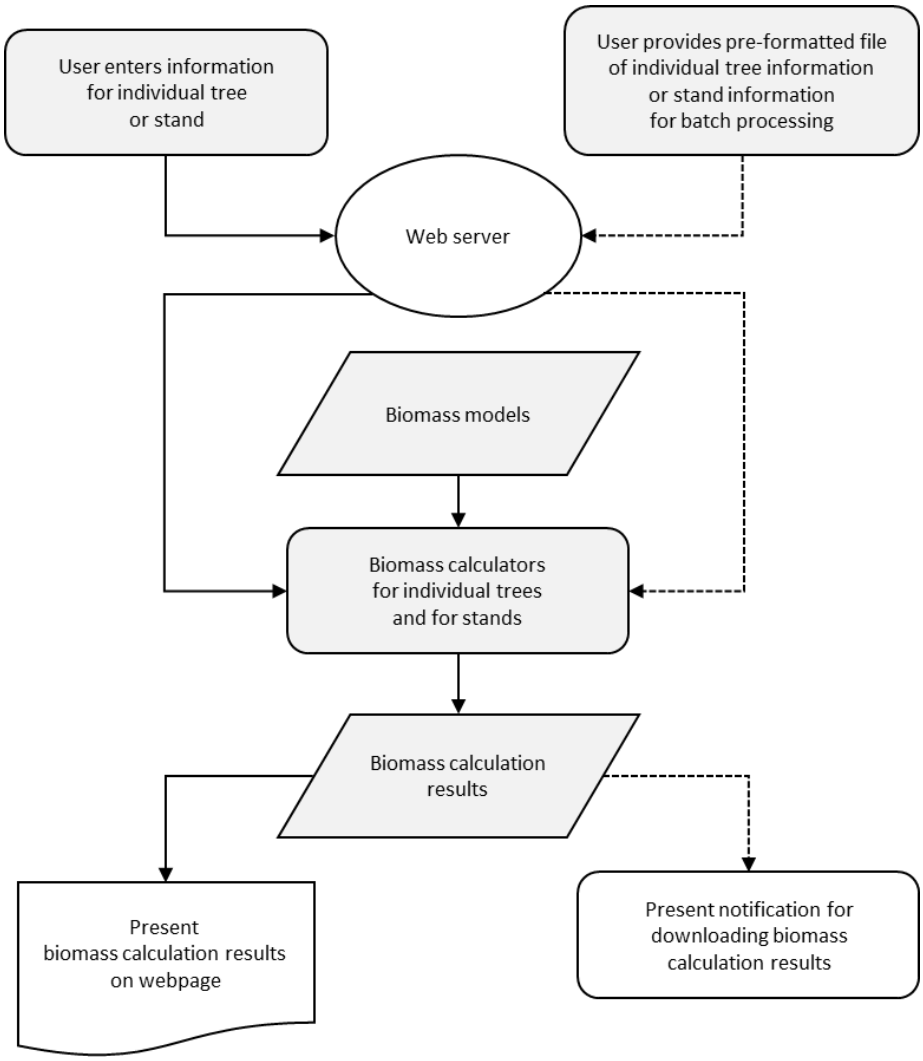

FIGURE 14: NFI BUSINESS PROCESS 12B - BIOMASS CALCULATOR

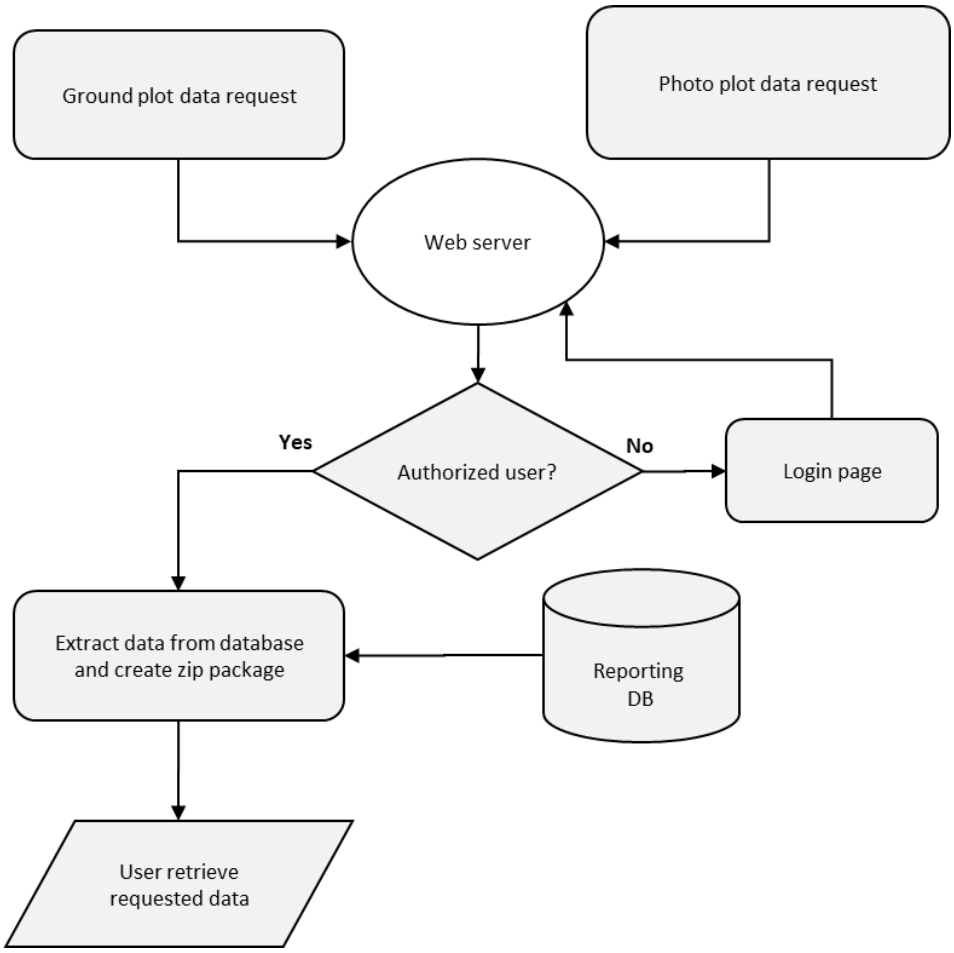

FIGURE 15: NFI BUSINESS PROCESS 12C - DATA DOWNLOAD

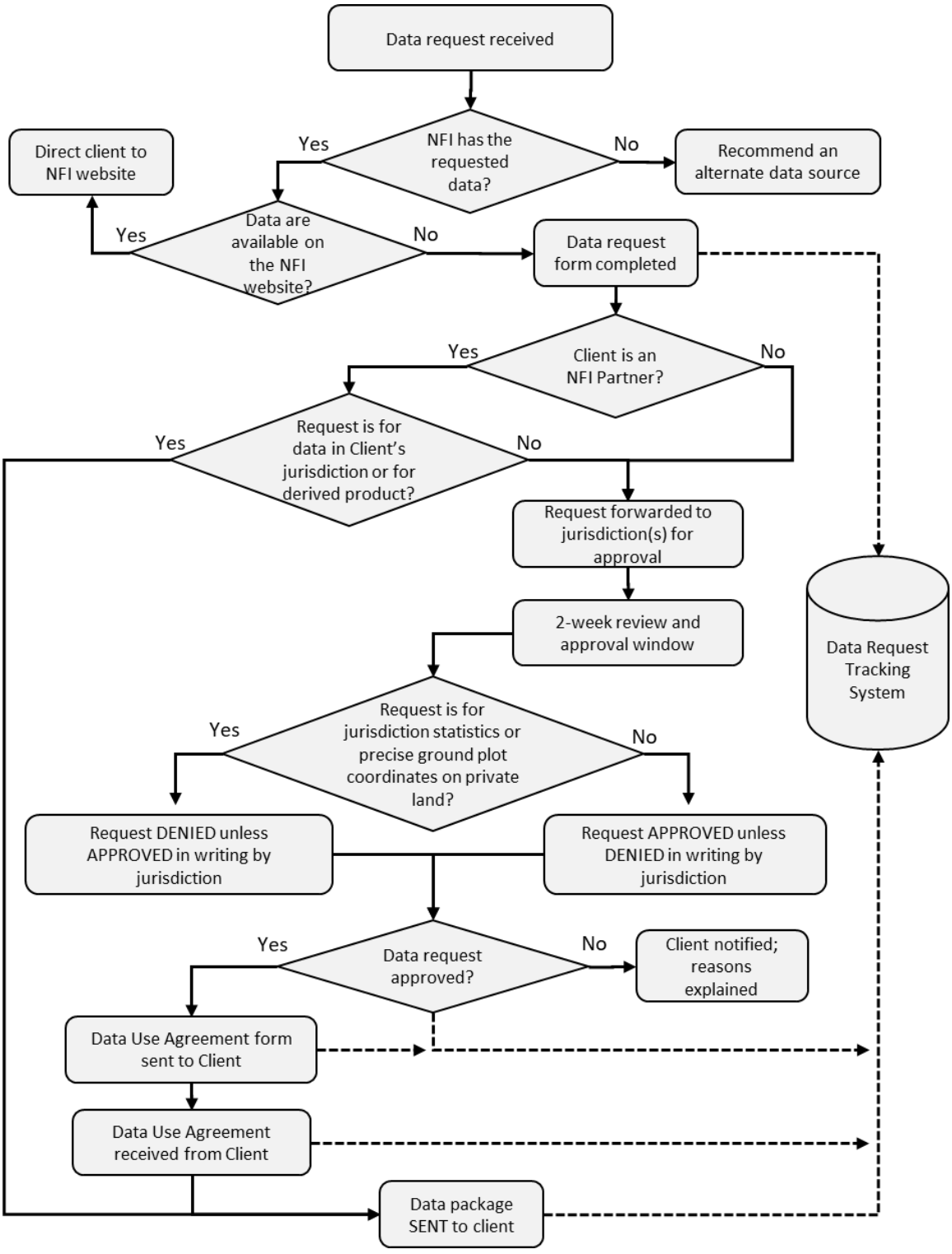

FIGURE 16: NFI BUSINESS PROCESS 14 - DATA REQUEST SERVICES