VCS MODULE VMD0018

METHODS TO DETERMINE STRATIFICATION

Version 1.0

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Sectoral Scope 14

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1 SOURCES

None

2 SUMMARY DESCRIPTION OF THE MODULE

The module provides the methods to be used to divide the project area or other areas into discrete strata, based on the delineation of areas within which the value of a chosen variable *X* is reasonably homogenous. Depending on the nature of the variable, and the time span of interest, homogeneity may be stated in terms of current values of *X* only, or may include processes leading to changes in *X* over time.

3 DEFINITIONS

Project Area: The area or areas of land on which the project proponent will undertake the project activities.

Stratum (plural strata): An area of land within which the value of a variable, and the processes leading to change in that variable, are relatively homogenous.

4 APPLICABILITY CONDITIONS

The module is applicable for use in any methodology or module referencing stratification for a variable *X* which varies across the project area, reference region or other relevant land base.

5 PROCEDURES

Introduction

Stratification is the process of dividing an area up into strata, based on variations in a specific variable *X*. *X* is any variable whose value varies across the project area or another relevant area – for instance, *X* may be a variable such as soil texture, soil carbon density, or amount of woody biomass per unit area. Areas are often heterogeneous in terms of micro-climate, soil condition and vegetation cover and management history, leading to the requirement for stratification. Stratification can increase the accuracy of the measuring and monitoring in a cost-effective manner. Stratification of an area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit.

The project proponent should recognize that mistakes in stratification could lead to significant increases in the cost and complexity of preparing a project description, and/or undertaking sampling and monitoring. At the same time, over-stratification (breaking an area into too many strata based on very small differences in the value of the variable) could equally lead to increases in cost and project complexity. In general, while stratification usually draws on quantitative data, ultimately most stratification is based to some degree on qualitative and subjective judgments. For this reason, the project proponent must document the rationale for such judgments at each step of the process.

Stratification will often be undertaken both before and after sampling, with the first stratification ("pre-stratification") serving to increase the efficiency and effectiveness of the field sampling. After the sampling

is complete, the project proponent can choose to refine the stratification using the results from the sampling, providing a final stratification.

The required steps of stratification are as follows:

Step 1: Identification of the type of stratification variable *X*

Goal: To identify the type of stratification to be undertaken based on whether or not subsequent sampling will be required to determine values of *X* across the project area.

Output: Identification of the type of stratification to be undertaken, allowing the determination of the stratification methods to be used.

Method: Classify the type of variable for which stratification is being undertaken. Three types of variables can occur:

1) Variables for which the distribution of the variable across the area is known. For instance, existing surveys or remote sensing interpretation may have already quantified the variation in the population of trees across the area.

2) Variables for which stratification has previously been carried out within the area, but where changes in stratification are believed to have occurred, or are projected to occur, based on history or planning.

3) Variables for which the distribution of the variable across the area is not known. For instance there may be existing soil mapping, but the distribution of soil carbon across the site may not be known.

Step 2: Identification of the time span of the stratification, and the variation through time of the variable *X*

Goal: To identify the correct temporal context for the stratification of *X.*

Output: A clear definition of the temporal period of interest for *X.*

Method: Stratification may be purely for analysis of current conditions, or may also be designed to be applicable throughout a longer period of time, during which changes to the variable *X* may occur. The types of time spans which can occur are:

1) Single point in time – stratification is to be used for the analysis of data from a single point in time. Therefore, analysis of processes leading to changes in *X* need not be taken into consideration.

2) Historic time sequence – stratification is to be used for the analysis of a historic time sequence of data regarding the variable *X*. If so, stratification must take into account an analysis of the differences in processes leading to change in *X* at different locations, rather than the status at any given time.

3) Future processes – stratification is aimed at enhancing the feasibility or accuracy of projections of future conditions, and thus considers both current conditions, and projected changes in the dynamics of the processes influencing *X*.

Identify which one or more of these time spans *X* falls into. In cases where *X* falls into more than one, methods applicable to each of the time spans must be used, and it may be beneficial to stratify separately for each of the time span types.

Step 3: Selection of a stratification method

Goal: To identify the series of steps required to stratify for the variable *X.*

Output: Sequence of tasks to be undertaken to complete the stratification process.

Method: Select the series of steps to be undertaken to complete the stratification, based on the type and time span of the stratification for the variable X, as follows:

1) If the variable is of type 1 (the distribution of the variable across the area is known), and the time span of the stratification is either for a single point in time or for the variable over a historic period, complete the following sequence of steps:

   - Step 5: Pre-stratification
   - Step 7: Post-stratification

2) If the variable is of type 1 (the distribution of the variable across the area is known), but the stratification is to be undertaken for projection of future processes and states, complete the following sequence of steps:

   - Step 4: Identification of key factors
   - Step 5: Pre-stratification
   - Step 7: Post-stratification

3) If the variable is of type 2 (stratification has already been carried out, but conditions are thought to have changed), and the stratification is being undertaken for any temporal period, complete the following step:

   - Step 8: Re-stratification

4) If the variable is of type 3 (the distribution of the variable across the area is not known), and the stratification is being undertaken for any temporal period, complete the following sequence of steps:

   - Step 4: Identification of key factors
   - Step 5: Pre-stratification
   - Step 6: Qualitative truthing of stratification during sampling
   - Step 7: Post-stratification

Step 4: Identification of key factors influencing the variable *X*

Goal: To develop an understanding, based on available information, of the factors and processes which determine the value of *X* at a given location, and the change in *X* through time.

Output: A list of key factors influencing the variable *X*, identifying for each factor:

- The name of the factor
- The nature of the effect of that factor on *X*
- A relative ranking of the importance of that factor, compared with other identified factors

Method: Identify, for the variable *X*, the key factors. For any variable *X*, there will be a number of key factors within the area, either currently or in the future which tend to cause change in the variable, and where the amount of change caused by that factor is expected to vary across the area. For instance, if *X* is tree density, key factors might include fire frequency, seed distribution, seedling survival. In cases where management has or is expected to influence *X*, management activities may also be included. For instance, if *X* is tree populations, plans to clear the trees from a portion of the area would be key stratification criteria.

For the purposes of stratification, identification of a key factor influencing *X* needs to be specific enough to allow different parts of the area to be distinguished depending on the degree of influence of the factor. However, this identification is not intended to allow quantitative projection of the future magnitude of effect on *X*. Thus for instance, knowing that different fire regimes are likely to lead to different tree populations is sufficiently specific, without being able to predict the future population dynamics of the trees under the different fire regimes. The intention of identifying key factors is to identify influences, not effects.

Step 5: Pre-stratification

In cases where the data on which stratification will ultimately be based is not yet fully known, pre-stratification must be used to guide the data collection process.

Goal: Based on existing information and, if required, low intensity sampling, to divide the area into relatively homogenous sub-areas based on variation in the variable *X*. The pre-stratification will be used to guide the more intensive sampling process.

Output: A series of outputs to facilitate stratification:

- A map showing the area divided into discrete sub-areas based on variation in the current or historic values of the variable *X*, or the processes influencing *X*.
- A stratum definition for each stratum, giving the expected characteristics defining the stratum.
- A key factors definition for each stratum, identifying the key factors which are believed to be causing this stratum to be different from others.

Method:

Step 5a: Collection of information

Local information on key factors identified in Step 4 must be collected, such as:

- Local site classification maps and/or tables.
- The most updated land use/cover maps, satellite images and/or aerial photography.
- Soil types, parent rocks and preferably soil maps.
- Landform information and/or maps.
- Ecosystem maps.
- Fire regime maps or descriptions.
- Historical records of management.
- Management plans.
- Other information relevant to key factors identified above.

Data sources may include archives, records, statistics, study reports and publications of national, regional or local governments, institutes and/or agencies, literature and local knowledge.

For each data source collected assess the following:

- When was the work to derive the information undertaken?
- What specific work was undertaken to derive the data? For instance, if the data source is a soil map, was the map derived from actual sampling carried out within the area, or from extrapolation based on samples collected elsewhere?
- To what standards were the data collection and collation carried out? For instance, soil samples may have been analyzed in a lab, or may have been classified based on field texturing.

Based on these assessments, determine the overall quality of the data. This is particularly critical where the intention is to use existing data on the value of the variable as the majority of the basis for stratification.

Even where the data is of high quality, it is generally recommended that some truthing of the data, based on field reconnaissance, remote sensing data or other primary sources be undertaken to confirm the accuracy of the data.

Step 5b: Preliminary stratification

The preliminary stratification must be conducted in a hierarchical order that depends on the significance of key factors on variations in *X*, or the differences in the key factors across the project area. The hierarchy of the key factors must be determined based on the degree of influence that each factor has on the value of the variable.

In many cases it may be difficult to determine which factor has the most influence on the value of *X*. For instance, soil carbon may be influenced by soil texture, biotic community and management, and it may not be clear which of these is the most important. In such cases, it is recommended that the factor which is least changeable be designated the highest level factor. In the example given, soil texture is likely the least changeable, and would therefore be the highest level factor, while biotic community might be second, and management might be third. The project proponent must document the reasons for their choice and ranking of factors.

The factor with the most influence must be the first factor considered, then the factor with the next most influence, and so on. At each level in the hierarchy, stratification must be conducted within the strata already determined based on higher level factors. For example, if climatic differences across the area are the factor with the highest influence on the value of *X*, the stratification process must begin with stratification according to difference of the climate. If the second most important factor is soil type, then each stratum determined based on climatic differences must be further stratified based on differences of soil type.

Preliminary stratification is often most easily carried out on a Geographical Information System (GIS) platform, where information, maps collected, and field data can be overlaid. Whether or not the preliminary stratification is carried out using a GIS system, the project proponent must document the steps taken during the stratification process, and the reasons for each decision made.

Step 5c: Supplementary sampling survey

Where existing information leaves doubt as to the homogeneity within or differences between preliminary strata, the project proponent should carry out a supplementary sampling survey to allow estimation of the value of *X* in each preliminary stratum. For example, the following characteristics can be surveyed to allow estimation of the value *X* within the preliminary stratum:

- Vegetation cover can be assessed by measuring randomly selected plots, using the plot methodology contained in module *VMD0019 Methods to Project of Future Conditions*.
- Site and soil factors can be assessed based on soil type, soil texture, slope gradient, intensity of soil erosion, and shallow ground water level, and sampling soils for soil organic and inorganic matter determination.
- Human intervention such as prescribed burning, logging, grazing, fuel collecting and plant collection can be assessed, by background research or local interviews.

The survey must use the methods given for sampling the variable in question in this methodology. Since the goal of this sampling is more qualitative than quantitative, sampling at this stage need not meet any specific standards for statistical variance.

Step 5d: Strata homogeneity check

If pre-sampling was conducted, a further stratification must be completed based on supplementary information collected from Step 5c above, by checking whether or not each preliminary stratum is sufficiently homogenous, or whether the difference among preliminary strata is significant with regard to the variable *X*. The degree of homogeneity may vary from project to project and may be assessed based on stratum size in the context of the project, the degree of natural variability and the significance of the variability to the project and baseline scenarios. A stratum within which there is a significant variation in the value of the variable *X* must be considered for subdivision. On the other hand, two or more strata with similar features can be merged into one stratum. At the end of this step, strata should differ significantly from each other in terms of either current value or projected future values of *X*. For example, sites with different soil textures would usually form separate strata. Sites with a more intensive management (for instance tilled agriculture versus range) might also be a separate stratum. On the other hand, site and soil factors may not warrant a separate stratum as long as all lands have a similar trajectory with regard to future values of *X*.

Step 5e: Pre-stratification map

A pre-stratification map, stratum definitions, and key factors definitions must be created, as follows:

- For the total area being stratified, prepare a pre-stratification map, preferably using a GIS (documenting “where is it different?”).
- For each stratum, document the unique characteristics which are believed to make this stratum different from all the others (documenting “what is different?”).
- For each stratum, document the specific processes which are believed to make this stratum different (documenting “why is it different?).

Step 6: Qualitative truthing of stratification during sampling

Goal: To estimate the accuracy of the stratification through qualitative review of the stratification during field work.

Output: Sketch revision of the stratification maps, and draft revisions of the strata definitions and the key factors for each stratum, based on a qualitative review.

Method: In cases where stratification is part of a process including ground sampling, stratum types and boundaries established during the pre-stratification phase must be checked in the field during sampling. While the sampling itself will provide quantitative data which must be used during the post-stratification in Step 7, qualitative data must also be gathered during the sampling phase, and reviewed on an ongoing basis against the pre-stratification. Notes on observations, giving the location of the observation and what was observed, must be documented. Best practices for qualitative truthing include :

a) Line intersect notes. While establishing plots or other sampling points, and during other work during the sampling phase, the routes traveled between plots and other points should be tracked, and compared at that time with the proposed stratification. Notes on observations, giving the location of the observation and what was observed, must be taken. Field workers should observe and investigate the following questions:

   - Is there an observable difference in the field at the location proposed for the stratum boundary, in terms of the variable *X*, or factors which are believed to influence the variable *X*?
   - Does this observable difference instead, or additionally, occur at other places, which might serve to refine the stratum boundary?
   - Do the proposed strata appear different in the ways predicted during the pre-stratification, or are there in fact strata which could be amalgamated?
   - Does a proposed stratum appear to contain two or more different distinct subtypes, in terms of the variable *X*, which might justify creation of further strata?

b) Sketch mapping. Based on the line intersect notes, sketch mapping reflecting the observations made in the field should be prepared, noting any possible changes in stratification boundaries or strata definitions.

c) Stratum redefinition. Based on the field observations, proposed changes to the stratum definitions should be documented, including amalgamation or splitting of strata.

d) Stratum process redefinition. Based on the field observations, proposed changes to the documentation of the processes which are believed to be driving the status of the variable *X* within each stratum should be documented.

Step 7: Post-stratification

Goal: Finalization of the stratum definitions and stratum mapping.

Output: Documented stratum definitions, and final stratum maps.

Method: After the intensive sampling phase, undertaken using the techniques in the relevant modules, or based on the known distribution of the variable, post stratification must be undertaken to determine or refine the stratification based on the quantitative and qualitative data collected or already existing. Using the data collected in the field or the existing data:

- Refine the stratum definitions, including subdivision or amalgamation of strata where necessary.

- Refine the stratum mapping to produce final stratum maps. This remapping must be based both on any changes indicated by the data collected, as well as on the sketch mapping undertaken in Step 6.

Refining of both stratum definitions and stratum maps should strongly consider both the pre-stratification, if undertaken, and the qualitative data gathered in Step 6, or the existing data if the distribution of the variable is known. During the post-stratification phase there is often a tendency to trust the quantitative plot data despite qualitative or other evidence which suggests that the quantitative data may not be representative. During post-stratification, the limits of statistical reliability, particularly of single plots as an indicator of stratum boundaries, should be acknowledged, and considerable weight should be given to the qualitative observations of experienced field people.

Note that if the stratification is being determined for use in projecting future conditions, the key factors and processes influencing the variable, determined in Step 4, must be considered in determining the stratification. A stratum must not only be similar in the value of the variable *X* at the present, but the processes and key factors must also be similar, such that the future values of the variable within the stratum are expected to remain similar. If this is not the case, consideration must be given to breaking the stratum into two or more strata, based on groupings of key factors and processes driving the future value of the variable *X*.

Step 8: Re-stratification

Goal: To correct stratification to reflect changes in conditions.

Output: Documented revised stratum definitions, and stratum maps.

Method: Through time, changes in conditions or processes can lead to changes in stratification. This will be particularly the case when undertaking work on Task 4 of *VMD0020 Soil Carbon Quantification Methodology*. Implementation of treatments may ultimately take place using different methods, in different areas, and at different time than was forecast in the project plan. Also, natural events may substantially change the nature and processes of areas within or across previously established strata.

The project proponent must routinely re-examine project area conditions to determine where events or actions may have occurred that could cause changes in stratification. The project proponent must conduct such a review prior to each monitoring event. Where such events or actions have occurred, the project proponent must repeat any or all of Steps 4 through 7, as required, to determine if, when and where, stratum boundary revisions are required.

Where re-stratification is conducted, changes in permanent sample plots are required under the following circumstances:

- Where re-stratification results in the subdivision of existing strata, the project proponent must assess whether additional sample plots need to be added to meet statistical requirements for sampling of the variable in question. Where re-stratification results in combining two or more strata, permanent sample plots must not be dropped even if the total number of plots in the new stratum exceeds the number required to achieve required levels of statistical accuracy.

- Where re-stratification results in a permanent sample plot lying on the boundary between two strata, the plot must be dropped.

6 PARAMETERS

None

7 REFERENCES AND OTHER INFORMATION

None

DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 Nov 2012	Initial version released