A Handbook for Collecting Vegetation Plot Data in Minnesota:

The Relevé Method

Minnesota Department of Natural Resources

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Minnesota County Biological Survey
Minnesota Natural Heritage and Nongame Research Program
Ecological Land Classification Program
Minnesota Department of Natural Resources

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Preface

This handbook was produced by the Minnesota County Biological Survey, Minnesota Natural Heritage and Nongame Research Program, and the Ecological Land Classification Program of the Minnesota Department of Natural Resources (DNR) to aid in collection and use of relevés in Minnesota. The handbook is an update of the DNR's first handbook for collecting relevés, compiled by John Almendinger in 1987 (DNR 1987).

Relevé sampling is a flexible and powerful tool for collecting information on and detecting patterns in vegetation. Relevé sampling has been used extensively by vegetation scientists in the DNR for nearly two decades, primarily for describing and classifying native plant communities. To facilitate widespread vegetation study in Minnesota using relevés, the DNR has developed a database that currently contains electronic versions of more than 8,000 relevés and other very similar kinds of vegetation plot data from across Minnesota, as well as 670 vegetation plots from adjacent parts of Ontario. The largest percentage of the relevés in the database were collected by plant ecologists and botanists working for the DNR, but the relevé database also contains many relevés collected by researchers at universities, private organizations, and other government agencies. Approximately 980 of the plots in the DNR's relevé database have also been entered into the Ecological Society of America's national vegetation plot database (VegBank). It is hoped that more, if not all, of Minnesota's relevés will be supplied to the national database in the future, should resources for data transfer become available.

This handbook provides standards for collection in Minnesota of relevés that are used for description and classification of native plant communities. Much of the information, however, applies to relevé collection in general and should be useful to researchers working on other kinds of vegetation studies that require plot-based sampling. Researchers using methodology comparable to that of the DNR would be in position to enhance their datasets with samples from the DNR's relevé database. In turn, the relevés they contribute to the DNR's database may help improve description, classification, and understanding of Minnesota's native vegetation. Appendices A and B of this handbook provide information for contributing samples to and obtaining data from the DNR's relevé database.

Contents

1. Introduction

Definition

The word relevé (rel-ə-**vā**), of French origin, translates into “list,” “statement,” or “summary,” among the English meanings most relevant to its use in vegetation study. In the usage of this manual, a relevé is a list of the plants in a delimited plot of vegetation, with information on species cover and on substrate and other abiotic features in the plot. Typically the vegetation is stratified into height categories chosen to describe apparent vertical structure, and in each stratum each plant is assigned a cover value based on its representation in that stratum. Note that in this usage there is no specification of how the placement of the plot in the vegetation is to be determined or of how the plot samples, or is related to, the surrounding vegetation.[1]

History

Relevés are closely associated with a procedure for describing and classifying vegetation that has a long history of development and use among European plant ecologists engaged in phytosociological studies.[2] This procedure, documented in what is essentially its current form in the early 1900s by the Swiss biologist J. Braun-Blanquet (Poore 1955a), involves describing or characterizing recognizable units in the vegetation of a region by the description or characterization of the vegetation in a single representative standard plot—a relevé—within each unit. The relevés from many units are then analyzed to develop descriptions and classifications of the vegetation in the study region.

Although developed for use in conjunction with the above-described method of vegetation characterization, relevés have been increasingly used in other kinds of vegetation studies as a practical, relatively fast means of collecting information on vegetation. Relevés have been most widely used in Europe, particularly in studies involving vegetation classification, and the technique has also been employed in regions of Asia, Africa, South America, and, increasingly, North America (Benninghoff 1966, Westhoff and van der Maarel 1978, Mucina et al. 1993, Rodwell et al. 1995, Barbour et al. 1999, Box 1999, Jennings et al. 2004). The list of references at the end of this handbook includes examples of vegetation studies in North America that have used relevé data (see, for example, Klinka et al. 1996, Peinado et al. 1998, Emrick and Hill 1999, Rivas-Martinez et al. 1999, Mack et al. 2000, Stachurska-Swakon and Spribille 2002, Tomback et al. 2005).

Relevés were first used in vegetation study in Minnesota by researchers at the University of Minnesota in the early 1960s (Janssen 1967). Since then, numerous studies in Minnesota have used relevé sampling or very similar

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[1] There appears to be variation among plant ecologists in application of the term relevé. For some, relevé is applied to any kind of plot-based vegetation sample incorporating information on species presence and cover (see, for example, Knapp 1984c). For many if not most, however, relevé is applied to a vegetation plot linked to a specific approach to describing plant communities that involves 1) determination of the minimal plot area needed to capture most species in the community (see page 6) and 2) subjectively placing plots in sample plant community stands to most efficiently characterize the vegetation in a study area (see page 2).

[2] The field of phytosociology was first defined in the late 1800s as the study of the sociological relationships of plants (Barbour et al. 1999), and has more recently been defined as the study of vegetation, including floristic composition, structure, development, and distribution (see, for example, Poore 1955a, Becking 1957, or Mueller-Dombois and Ellenberg 1974).

sampling methods, with E. Cushing of the University of Minnesota especially influential in the adoption of the technique in the state. Most of the studies in Minnesota have been done to characterize, classify, or describe the range of variation in vegetation in the study project areas (see, for example, Janssen 1967, Glaser et al. 1981, Almendinger 1985, Mason 1994, Stai 1997, U.S. Geological Survey 2001). Other studies have been done to establish baseline data on vegetation in the vicinity of proposed industrial developments or mining projects (Glaser and Wheeler 1977, Sather 1980), for characterization of rare plant or rare animal species habitat (Johnson-Groh 1997, Lane 1999), and to develop indices of biotic integrity for selected vegetation types or habitats (Galatowitsch et al., Galatowitsch et al. 2000, Gernes and Helgen 2002). Relevé plots have also been established in Minnesota for use in plant or vegetation monitoring, and the data from accumulated relevé plots have been used to develop species lists for restoration of native plant communities (Lane and Texler, in press).

The Minnesota County Biological Survey (MCBS), Natural Heritage and Nongame Research Program (NHNRP), and Ecological Land Classification Program (ELCP) of the Minnesota Department of Natural Resources (DNR) have collected relevés mainly for development and refinement of a native plant community classification used in guiding native vegetation survey work and research (DNR 1993, 2003, 2005a, 2005b). In 1987, the NHNRP and MCBS established a database for relevés collected in Minnesota and have since assembled more than 8,000 relevés from many sources, going back to the first relevés done in Minnesota in the 1960s. Most of the relevés in the database have been done by surveyors with the MCBS, NHNRP, and ELCP in accordance with the methodology described in Chapter 2 of this handbook. This methodology follows that of Braun-Blanquet, with some modifications instituted by researchers at the University of Minnesota (especially E. Cushing) and at the DNR.

Use of Relevés

Using relevés for vegetation study involves two broad considerations. One is the method by which relevé plots are placed in the study area. The second is how the data on plant species cover are collected in the plot. Both of these considerations are influenced by the objectives and requirements of the study.

Methods of plot placement in relevé studies can be separated into two general categories, subjective and objective. In a typical relevé study involving subjective plot placement, the surveyor divides the study area into sample stands based on plant community units identified during fairly intensive reconnaissance done prior to sampling with relevé plots. A single relevé plot is then placed at a carefully chosen site within each sample stand so that the data from the plot represent the attributes of the stand as a whole. Subjective plot placement is used most commonly in studies whose goal is to describe or characterize vegetation—for example, in developing plant community classifications. In the hands of a field researcher familiar with the vegetation in a study area, subjective plot placement is argued to yield suitable classifications in less time and using fewer plots than studies using objective plot placement and therefore is presented as a more efficient alternative (see, for example, Moore et al. 1970 or Becking 1957). The data collected using subjective plot placement are not suitable for analysis using probability statistics, although they can be summarized or described using numerical techniques such as ordination and classification.

The utility of subjective plot placement is made evident by considering projects whose aim is to describe or classify native vegetation in fragmented landscapes; this has been a significant application of the technique in the DNR. In such studies, the purpose is to characterize as faithfully as possible undisturbed examples of the vegetation, which requires deliberately placing plots away from field edges, clearcuts, roadsides, and other anthropogenically disturbed areas that may influence species composition in nearby parts of the stand and cloud the results of analyses. Subjective plot placement also allows for adequate characterization of rare or minor plant community types in a study area, which tend to be undersampled in vegetation studies using objective plot placement (Barbour et al. 1999, Smartt 1978). In general, in relevé studies that utilize subjective plot placement, the quality and usefulness of the resulting descriptions or classifications of vegetation depend greatly on the surveyor's field skills and on identifying stands and placing samples so that they evenly capture the full range of variation in vegetation in a study area. The surveyor must remain open-minded about the initial division of the study area into sample stands and be prepared to adjust the initial sampling criteria and units if it becomes evident that certain recurring community types were not recognized during preliminary reconnaissance (Mueller-Dombois and Ellenberg 1974).

In studies using objective plot placement, sample plots are placed either randomly or at regular intervals (i.e., systematically) across the entire study area, or alternatively the study area is divided into general units according to broad vegetation types, groupings of dominant species, substrate types, management units, or other general criteria and plots are placed randomly or systematically within these units; the latter are examples of stratified random or stratified systematic sampling. In general, objective placement of plots is used in experimental (rather than descriptive) studies, where the goals of the study require that the data collected be treatable with probability statistics. Examples might include a vegetation monitoring study in which one is concerned with detecting statistically significant change over time within stands, a study in which one is looking for statistically significant differences across sample stands in a landscape, or a study using correlation or regression techniques to test the relationship of plant communities and environmental factors. A discussion of study design using objective plot placement is beyond the scope of this manual, but a starting point for general information might include Mueller-Dombois and Ellenberg (1974), Greig-Smith (1983), or Bonham (1989).

The second broad consideration in use of relevés concerns the determination of cover of plant species within a relevé plot: whether it is estimated by eye or by mechanical means. Choosing between ocular and mechanical estimation of cover is influenced by the requirements of a study, weighing the time and resources available to collect data versus issues such as repeatability of observation and resolution of the data collected. Estimates of cover by eye are typically done when time and resources for collection of data are limited (relative to the size of the study area and the range of vegetation to be sampled) and the data are to be used for descriptive purposes such as vegetation classification. Ocular estimates of cover are usually made using a scale with fairly broad cover classes such as the Braun-Blanquet scale, which has seven categories for estimating species abundance and cover. The relatively broad categories in the scale help to promote agreement among different observers when estimating cover. Broad, rather than narrow, categories may also be more appropriate for describing species that vary greatly in cover over the course of a growing season or from season to season; in this way one does not give a false sense of exactness to an ephemeral variable (Barbour et al. 1999, McCune and Grace 2002). Cover data collected by visual estimation using the Braun-Blanquet or similar scales can be analyzed mathematically and are considered semi-quantitative. The use of broad categories, however, can make the data collected unsuitable for statistical analyses if certain assumptions are not met (Bonham 1989). The data may also lack the resolution necessary to detect fine-scale variation in species cover over time (such as in monitoring studies) or along an environmental gradient (Pakarinen 1984).

In studies requiring collection of statistically rigorous data, species cover can be estimated in the plot using methods that incorporate mechanical measurements, such as point, line-intercept, or photographic methods. When data are estimated by mechanical means rather than strictly by eye, the surveyor also may reliably record percent cover along a finely divided scale (for example, in 1% increments of cover) and need not rely on the broad classes used when estimating cover by eye. Cover data collected using mechanical measurements are considered quantitative, as the measurements minimize subjective judgments made by the observer (Bonham 1989). In comparison with ocular estimation, mechanical estimation of species cover generally increases the time required to complete collection of data within an individual plot. For more information on collecting species cover data, see Kershaw (1973), Mueller-Dombois and Ellenberg (1974), or Bonham (1989).

For those interested in more context on the use of relevés, as a starting point Benninghoff (1966) has a short summary of the basic method from a North American perspective; Poore (1955a, 1955b, 1955c, 1956) has a longer description and philosophical analysis of the relevé method; and Westhoff and van der Maarel (1978) and Becking (1957) provide an overview of the history and general concepts of the Braun-Blanquet approach to vegetation description and classification using relevés, with Becking's discussion prompted by an interest in comparing the approach of European phytosociologists to vegetation study with that of American ecologists. Detailed discussions of relevé methods and use of relevés in specific kinds of vegetation sampling are presented by various authors in Knapp (1984). The discussion in Tomback et al. (2005) provides examples of the considerations weighed in determining whether and how to use relevés in a particular study. Jennings et al. (2004) place the Braun-Blanquet approach in context with other vegetation sampling and classification approaches used in North America and also have an overview of issues concerning sampling design, plot placement, and estimation of cover, among other aspects of sampling. Useful descriptions and discussions of vegetation sampling methods in general are available in Mueller-Dombois and Ellenberg (1974), Greig-Smith (1983), Bonham (1989), Kent and Coker (1992), and Barbour et al. (1999).

2. Methods

Relevé Plot Location

Surveyors with the Minnesota County Biological Survey, Natural Heritage and Nongame Research Program, and Ecological Land Classification Program of the DNR collect relevés primarily for use in characterizing or classifying native vegetation and follow the basic methods developed by Braun-Blanquet. Surveyors first divide the landscape into units, most often according to native plant communities.[1] These units are identified using aerial photo interpretation, field experience in the study area, and other information (such as soils or surficial geology maps), and are transcribed onto topographic maps. Surveyors then begin field assessments of the plant community units, using the information transcribed onto the maps as a guide. The suitability of any plant community occurrence (or sample stand) for siting a relevé plot is determined by the quality of the vegetation and the absence of signs of human-related disturbance. An attempt is also made to select community occurrences or sample stands such that one captures all of the possible variability of the plant community within a given landscape or geographic region. This is done by distributing relevés among occurrences of the community that vary in habitat characteristics such as substrate, slope position, soils, and so on. In some landscapes, some community types may have few high-quality occurrences and it may not be possible for the surveyor to find enough sample stands to capture the full range of natural variation of the community. For example, good-quality remnants of deciduous forest in the agricultural regions of Minnesota are often limited to steep, untillable slopes, while forests on level sites, which may have differed in plant species composition from those on slopes, may be absent or too disturbed to sample as native plant communities.

When a surveyor decides to do a relevé within a given stand, the criteria used in siting the plot are: 1) the site is representative of the stand as a whole; 2) the site is uniform in vegetation composition and structure as well as in habitat type (considering soil moisture, substrate, aspect, hydrology, and so on); 3) the vegetation in the plot area is ecologically intact and has not been visibly disturbed by human-related activity such as recent logging, heavy grazing, or invasion by non-native species; and 4) the plot is not close to any noticeable ecotone or boundary between different types of vegetation. If there is variation in the vegetation in the vicinity of the plot, the surveyor records on the relevé field form some impressions about the different vegetation types present and the nature of the boundaries between them (diffuse, sharp, etc.; see Figure 2 on page 9 for a sample copy of the DNR's relevé field form). The surveyor also hypothesizes which environmental factors may be causing the apparent vegetational pattern. In classification studies, the importance of placing relevé plots in areas uniform in vegetation and habitat cannot be overly emphasized. If a relevé plot does contain a small area that clearly differs from the vegetation of the rest of the plot—such as a small wet depression in an upland forest—the presence of the atypical area is noted on the field form.

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[1] The initial classifications of native plant communities used by the DNR in vegetation studies were based on review of available literature in Minnesota and adjacent regions and on field observations made by NHNRP and MCBS plant ecologists (Wendt 1984, DNR 1993). These classifications have since been supplanted by a classification based in large part on analysis of relevé data collected in plant communities across Minnesota (see DNR 2003, 2005a, or 2005b). For a general discussion of the process of dividing a landscape or study area into units to be sampled, see Mueller-Dombois and Ellenberg (1974).

On occasion, relevé plots are placed deliberately to include different vegetation types as, for example, when two distinct vegetation types are strongly associated with one-another and are repeated on the landscape in a predictable pattern. In these cases, it is usually indicated on the field form that the purpose of the relevé is to characterize this association of vegetation types. DNR surveyors also do relevés for purposes other than classification of native vegetation, such as characterizing the habitats of rare plants or describing ecotonal areas. In these cases, the sample stands or the plot sites may be determined by criteria different from those used for classification purposes—this is usually indicated by the surveyor on the relevé data sheet.

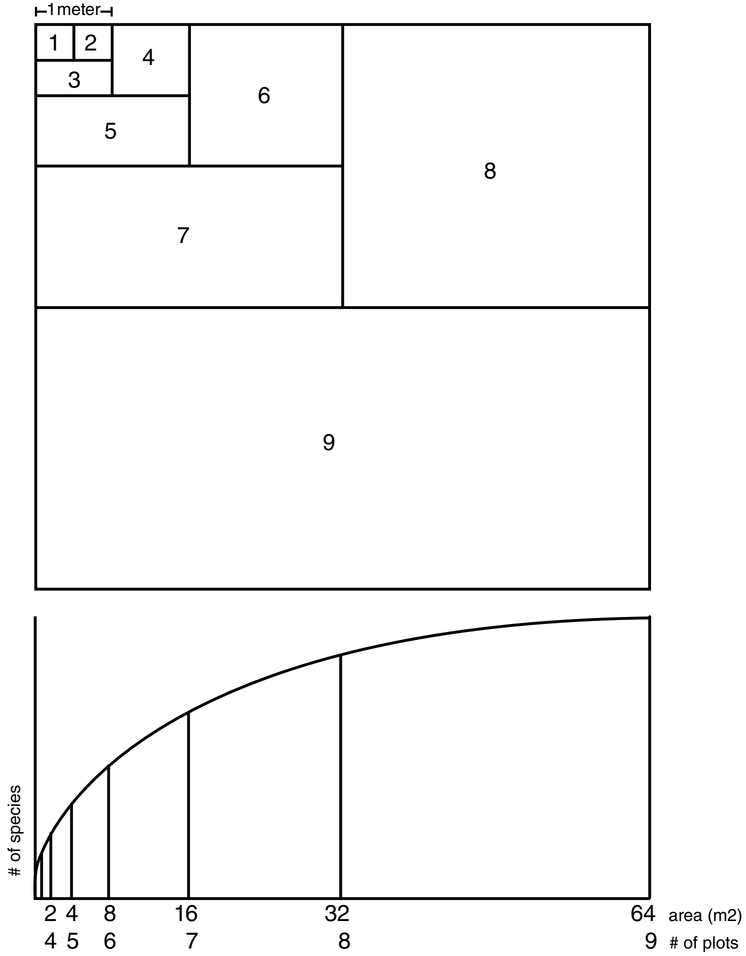
Relevé Plot Size and Shape

Each relevé plot should be large enough to include most species regularly distributed in the sample stand. The appropriate relevé plot size for a particular type of vegetation in theory can be determined by constructing a species-area curve. This is often done by sampling nested plots in a homogeneous area in a representative stand of the vegetation type and then graphing the number of species recorded against plot size (Fig. 1). For vegetation in temperate regions, the species-area curve tends to be steep initially and then levels in number of species as the plot size increases. The intersection of plot size with the point at which the curve appears to level yields the minimal sample area. Ideally, this process is repeated in several representative stands of the vegetation type, with the largest resulting minimal area then used as a guide for relevé plot size (Mueller-Dombois and Ellenberg 1974; see also Kershaw [1973] for a discussion of the subjectivity associated with assessing homogeneity of vegetation and establishing minimal sample area; and Greig-Smith [1983] for a critique of using nested rather than randomly placed plots for developing the species-area curve, as well as a critique of the minimal area concept itself).

In practice, the minimal sample area is generally correlated with the life-forms of plants and the structure of the vegetation, so it is not necessary to determine minimal relevé sizes for each new study. Guidelines for relevé size based on species-area curve investigations for different types of vegetation are given in Mueller-Dombois and Ellenberg (1974), Westhoff and van der Maarel (1978), and Knapp (1984c) (see Table 1). Chytry and Otypkova (2003) provide a review and discussion of plot sizes historically used in Europe. For Minnesota, a 400 square-meter plot in wooded vegetation and a 100 square-meter plot in treeless vegetation generally exceed the minimal sample area. Peet et al. (1998) present an approach to plot layout that incorporates an array of 10-meter by 10-meter modules and allows for flexibility in size and intensity of area sampled, depending on the requirements of the study.

DNR surveyors typically use square relevé plots—20 x 20 meters in upland forests, woodlands, savannas, and forested wetlands, and 10 x 10 meters in prairies, shrub swamps, and open wetlands. The shape of the plot and its orientation (if irregularly shaped) are important mainly in vegetation with regular or periodic patterns at scales finer than the plot size. For example, in the string bogs of Minnesota, which consist of alternating peat ridges and flooded troughs, the ridges and troughs may be sufficiently narrow that a 10 x 10 meter relevé plot would always contain a portion of both a trough and a ridge. If the surveyor wanted to contrast the vegetation of these two features, it would be appropriate to use rectangular relevé plots, laying out each plot entirely on ei-

Figure 1. *System of nested plots for determining minimal relevé area and hypothetical species-area curve derived from a survey of nested plots. In general, a relevé plot is considered sufficiently large when doubling the sample area results in an increase of less than 10% in number of species (after Mueller-Dombois and Ellenberg [1974]).*



ther a ridge or in a trough. Alternatively, if the vegetation of the area as a whole was to be compared with some other type of bog vegetation, placing rectangular plots transversely across the ridges and troughs would be appropriate. Relevé shape might also be altered when sampling vegetation that varies in relation to slope or aspect. In general, the shape of the plot is dictated by the specific purpose of the vegetation study, although where feasible square plots are preferable to oblong or irregularly shaped plots because square plots have lower ratios of edge-to-plot area.

Table 1. *Minimal areas for selected vegetation types (compiled from Mueller-Dombois and Ellenberg [1974], Westoff and van der Maarel [1978], and Knapp [1984]).*

vegetation type	**example in Minnesota**	**area (sq. meters)**
temperate deciduous forest	southern mesic maple-basswood forest central dry-mesic oak-aspen forest	100 - 500
boreal coniferous forest	northern poor conifer swamp northern dry-sand pine woodland	100 - 500
shrub community	northern bedrock shrubland mesic brush-prairie	10 - 250
grassland	southern dry prairie	25 - 100

Recording the Relevé Location

After deciding on the location, size, and shape of the relevé plot, the plot location is determined using a GPS unit or, if the surveyor does not have a GPS unit, the location is recorded on the surveyor's field map (usually a 7.5 minute United States Geological Survey [USGS] topographic map). The location can also be recorded on an aerial photograph if aerial photos are being used for orientation in the field. Later, the GPS coordinates can be used to create a map showing the location of the plot, or photocopies of the surveyor's field map or aerial photograph can be attached to the field form, expediting entry of location information into the DNR's Natural Heritage Information System electronic relevé database and providing a clear record of the plot location. Often, it is helpful to provide a sketch showing the relation of the plot to unmapped features (such as trails, fencelines, buildings, clearcuts, or ponds) that might aid in relocating the plot. This sketch is usually attached to the original field form and archived in the DNR's manual relevé file.

Delineating the Relevé Plot

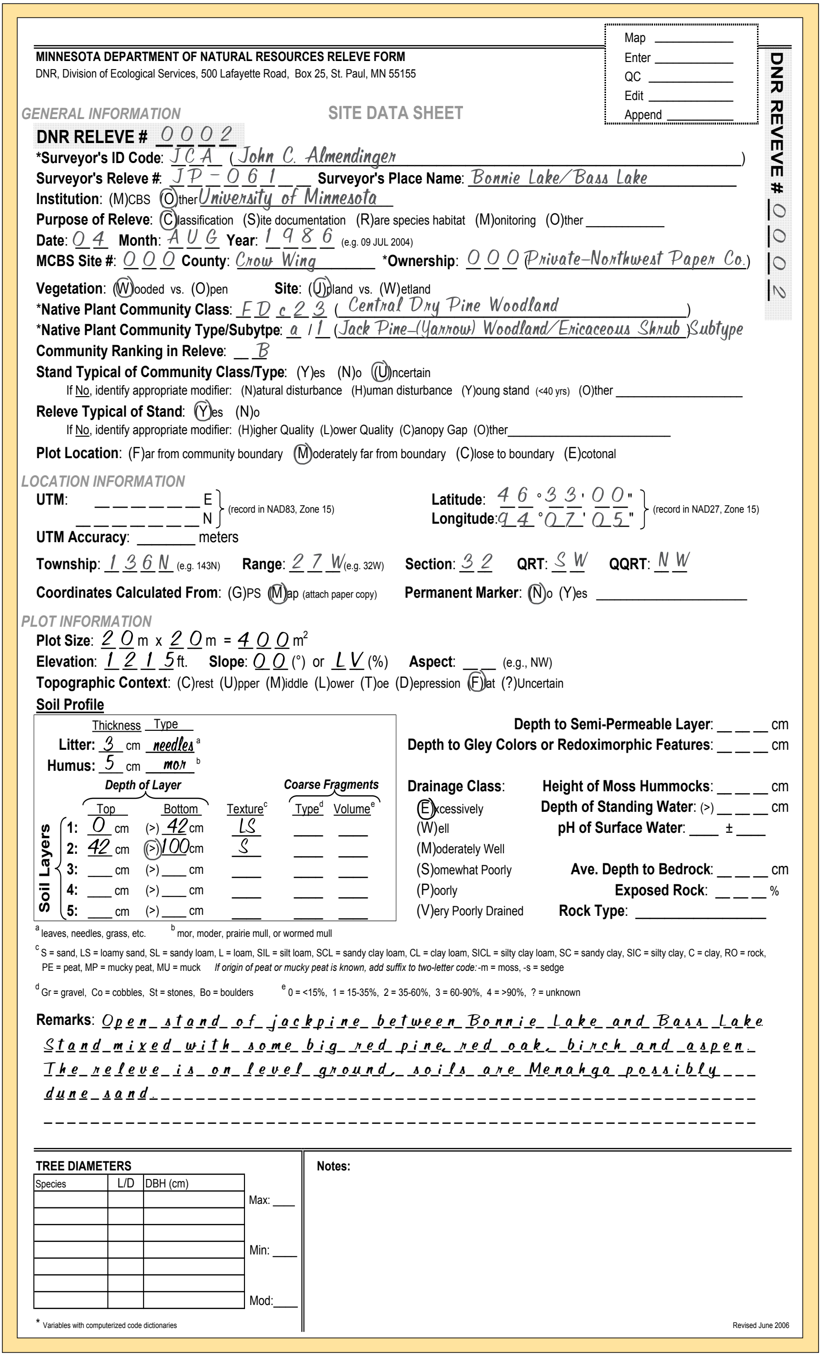
The final step before recording field data is delineating the relevé plot. For most work, the plot boundaries and corners can be established by measuring with a tape along the perimeter of the plot and turning 90° at each corner with the aid of a field compass. A 10 x 10 meter plot laid out in this way is generally within 3 square meters of 100 square meters in size. (More accurate techniques for delineating plots are described in Appendix C.) Plot corners are usually marked with flagging. In dense, brushy vegetation, it is often helpful to mark also the midpoint of each side and the center of the plot with flagging.

Recording Data

The relevé data form used by the DNR has site data fields on one side (Fig. 2) and lines and columns for recording species and plant physiognomic information on the other side (Fig. 6, page 25; see Appendix D for information on obtaining a printable copy of the DNR's relevé field form). Some of the site data are recorded in the field; other site data are transcribed from maps, lists, or tables in the office. The species data are always recorded in the field, with the exception of corrections for species that are collected for identification.

Several of the site data fields have a long space for writing out the name of the variable and an accompanying two- to five-character space for a code for that

Figure 2. *Sample relevé with site data. (Shown at reduced scale.)*



Map ____
Enter ____
QC ____
Edit ____
Append ____

MINNESOTA DEPARTMENT OF NATURAL RESOURCES RELEVE FORM
DNR, Division of Ecological Services, 500 Lafayette Road, Box 25, St. Paul, MN 55155

DNR REVEVE # 0 0 0 2

GENERAL INFORMATION

SITE DATA SHEET

DNR RELEVE # 0 0 0 2
***Surveyor's ID Code**: JCA (John C. Almendinger)
Surveyor's Releve #: JP-061 **Surveyor's Place Name**: Bonnie Lake/Bass Lake
Institution: (M)CBS [✓ (O)ther] University of Minnesota
Purpose of Releve: [✓ (C)lassification] (S)ite documentation (R)are species habitat (M)onitoring (O)ther ____
Date: 04 **Month**: AUG **Year**: 1986 (e.g. 09 JUL 2004)
MCBS Site #: 000 **County**: Crow Wing ***Ownership**: 000 (Private–Northwest Paper Co.)
Vegetation: [✓ (W)ooded] vs. (O)pen **Site**: [✓ (U)pland] vs. (W)etland
***Native Plant Community Class**: FDc23 (Central Dry Pine Woodland)
***Native Plant Community Type/Subtype**: a / 1 (Jack Pine–(Yarrow) Woodland/Ericaceous Shrub) Subtype
Community Ranking in Releve: B
Stand Typical of Community Class/Type: (Y)es (N)o [✓ (U)ncertain]
If No, identify appropriate modifier: (N)atural disturbance (H)uman disturbance (Y)oung stand (<40 yrs) (O)ther ____
Releve Typical of Stand: [✓ (Y)es] (N)o
If No, identify appropriate modifier: (H)igher Quality (L)ower Quality (C)anopy Gap (O)ther ____
Plot Location: (F)ar from community boundary [✓ (M)oderately far from boundary] (C)lose to boundary (E)cotonal

LOCATION INFORMATION

UTM: ____ E, ____ N (record in NAD83, Zone 15)
Latitude: 46°33'00" **Longitude**: 94°07'05" (record in NAD27, Zone 15)
UTM Accuracy: ____ meters
Township: 136N (e.g. 143N) **Range**: 27W (e.g. 32W) **Section**: 32 **QRT**: SW **QQRT**: NW
Coordinates Calculated From: (G)PS [✓ (M)ap] (attach paper copy) **Permanent Marker**: [✓ (N)o] (Y)es ____

PLOT INFORMATION

Plot Size: 20 m x 20 m = 400 m²
Elevation: 1215 ft. **Slope**: 00 (°) or LV (%) **Aspect**: ____ (e.g., NW)
Topographic Context: (C)rest (U)pper (M)iddle (L)ower (T)oe (D)epression [✓ (F)lat] (?)Uncertain

Soil Profile

	Thickness	Type
Litter:	3 cm	needles[a]
Humus:	5 cm	mor[b]

Soil Layers	Depth of Layer: Top	Depth of Layer: Bottom	Texture[c]	Coarse Fragments: Type[d]	Coarse Fragments: Volume[e]
1:	0 cm	(>) 42 cm	LS		
2:	42 cm	[✓ (>)] 100 cm	S		
3:	cm	(>) cm			
4:	cm	(>) cm			
5:	cm	(>) cm			

Depth to Semi-Permeable Layer: ____ cm
Depth to Gley Colors or Redoximorphic Features: ____ cm

Drainage Class:
[✓ (E)xcessively]
(W)ell
(M)oderately Well
(S)omewhat Poorly
(P)oorly
(V)ery Poorly Drained

Height of Moss Hummocks: ____ cm
Depth of Standing Water: (>) ____ cm
pH of Surface Water: ____ ± ____
Ave. Depth to Bedrock: ____ cm
Exposed Rock: ____ %
Rock Type: ____

[a] leaves, needles, grass, etc. [b] mor, moder, prairie mull, or wormed mull

[c] S = sand, LS = loamy sand, SL = sandy loam, L = loam, SIL = silt loam, SCL = sandy clay loam, CL = clay loam, SICL = silty clay loam, SC = sandy clay, SIC = silty clay, C = clay, RO = rock, PE = peat, MP = mucky peat, MU = muck *If origin of peat or mucky peat is known, add suffix to two-letter code:* -m = moss, -s = sedge

[d] Gr = gravel, Co = cobbles, St = stones, Bo = boulders [e] 0 = <15%, 1 = 15-35%, 2 = 35-60%, 3 = 60-90%, 4 = >90%, ? = unknown

Remarks: Open stand of jackpine between Bonnie Lake and Bass Lake. Stand mixed with some big red pine, red oak, birch and aspen. The releve is on level ground, soils are Menahga possibly dune sand.

TREE DIAMETERS

Species	L/D	DBH (cm)

Max: ____
Min: ____
Mod: ____

Notes:

* Variables with computerized code dictionaries

Revised June 2006

variable. The codes are used in the DNR's relevé database to make storage and retrieval of data more efficient. It is not necessary to fill in the codes if the surveyor does not know them; the codes can be transcribed from dictionaries when the relevé is entered into the DNR's relevé database.

Site Data Fields

DNR Relevé #: Each relevé is assigned a four-digit number when it is entered into the DNR's relevé database. This number is determined from the DNR relevé logbook by data management staff.

Surveyor's I.D. Code: This is a three-letter code, usually derived from the surveyor's initials. If the surveyor currently has an assigned i.d. code, he or she may either fill in that code or write his or her name in the longer space. If the surveyor does not have an assigned i.d. code, he or she can write his or her name in the longer space and data management staff will designate a unique i.d. code for them. If relevés are being done regularly by a team of the same two (or more) people, an i.d. code can be created for that team. If two or more people did the relevé but are unlikely to do more relevés together regularly, the principal surveyor's i.d. code is entered in the three-character space and the other surveyors' names are written in the longer space beside it.

Surveyor's Relevé #: (Optional) Because the DNR relevé number is not usually assigned until the relevé is entered into the database, this field is provided for the surveyor to assign a personal number or code to keep track of relevés during the field season. The surveyor's relevé number can be up to eight characters long and may contain a combination of numerals, letters, and other keyboard characters. Many surveyors begin the number with a year or a county-name abbreviation, followed by a hyphen and a number (for example, 06-01 or HN-01); some surveyors incorporate their initials (e.g., JKL06-01).

Surveyor's Place Name: (Optional) This field is provided to allow the surveyor to record a place name for keeping track of relevés, especially for places that are not within MCBS sites (see MCBS Site # below), or for large MCBS sites where labeling smaller units is helpful for tracking data collected at the site.

Institution: The institution or organization with which the surveyor is affiliated is indicated by circling the first letter of either "(M)CBS" or "(O)ther" and by writing the name in the space provided if the institution is other than MCBS (e.g., NHNRP, U of M–Ecology, U of M–Forest Resources, UMD–Natural Resources Research Institute, The Nature Conservancy, U.S. Forest Service, etc.).

Purpose of Relevé: The surveyor indicates here the purpose of the relevé by circling the first letter of the best of the listed choices; if none of the specific choices is applicable, the surveyor marks "(O)ther" and writes the purpose in the space provided. As mentioned above, the purpose of any vegetation study greatly influences the type of vegetation sampled and how relevé plots are placed. The DNR's relevé database contains relevés done for many different purposes (such as community classification, site documentation, rare plant habitat characterization, vegetation management impacts, etc.) and information about the purpose is often useful in determining whether a relevé should be included in the datasets of future studies or analyses. For example, a relevé may originally have been done to determine the impact of different logging techniques on forest understory vegetation and therefore one may not want to include it in the dataset of a study attempting to classify intact native plant communities.

Date: A two-digit number is entered in this field for the day (e.g., "02" or "14").

Month: The first three letters of the month are entered in this field (e.g., "APR").

Year: The full four-digit year is entered in this field (e.g., "2006").

MCBS Site #: If the relevé is within an MCBS site, the one- to three-digit site number is entered here. MCBS sites are numbered sequentially within each county and have been designated only in counties in which MCBS has completed or initiated biological surveys. If the surveyor is uncertain of the site number or whether the relevé is in an MCBS site, the site number can be determined by data management staff. If the surveyor knows that the relevé is in an MCBS site, they should make certain that the site number is entered, either by recording it themselves or alerting data management staff to look it up when the relevé is entered in the relevé database.

County: (Optional) This space is provided to allow the surveyor to track relevés by county during the field season. (The information provided in this space is not used to enter the county in the DNR's relevé database; rather, the county is determined electronically from the relevé plot coordinates provided by the surveyor.)

Ownership: This field is for the general ownership of the site (e.g., *private, state park, county forest,* etc.). The surveyor can write the ownership type in the space provided and the appropriate code will be entered by data management staff.

Wooded vs. **Open:** Indicate whether the vegetation being sampled is wooded or open. By convention, the dividing point between wooded and open plant communities is set at greater than or less than 25% tree canopy cover (canopy trees are defined as trees > 33 feet [10 meters] tall). This a rough starting point. The most important feature will be the kinds of ground-layer plants that are abundant in the community, especially whether they are sunlight-requiring or shade-tolerant species. It is especially important to pay attention to ground-layer species on sites where canopy cover has been reduced by recent disturbances such as timber harvesting, windstorms, or fire. The same is true for sites that were savanna in the recent past but where fire suppression has resulted in an increase in tree canopy cover. Although these sites may have > 25% tree canopy cover, they are still considered open plant communities based on abundant presence of sunlight-requiring prairie species.

<u>Upland</u> vs. **<u>Wetland</u>:** Indicate whether the relevé is on an upland or wetland site. Upland sites include all sites where soils are saturated only briefly in the spring or following heavy rains. They very rarely have standing water. Wetland sites have persistently saturated soils because of high water tables, have standing water present through the growing season or for long periods in the spring and following heavy rains, or are flooded annually by streams or rivers.

<u>Native Plant Community Class</u>: This is the native plant community class in which the relevé plot occurs based on Version 2.0 of the DNR's native plant community classification (DNR 2003, 2005a, 2005b). There is less chance for error if the surveyor writes the full community name in the space provided; the corresponding five-letter code can then be entered by data management staff. If the surveyor is not certain which community class to assign to the relevé, they should provide a list of possible classes with their best guess listed first.

<u>Native Plant Community Type/Subtype</u>: (Optional) This field is provided for surveyors who wish to identify the plant community, where applicable, to the level of native plant community type or subtype based on Version 2.0 of the DNR's native plant community classification. Again, if the surveyor is not certain which community type (or subtype) to assign to the relevé, they should provide a list of possibilities with their best guess listed first.

<u>Note on Native Plant Community Names</u>: Although the DNR has recently updated its native plant community classification (DNR 2003, 2005a, 2005b) the DNR's relevé database currently allows only the entry of community names from the previous version (Version 1.5) of the classification (DNR 1993). At present, it is helpful to record the appropriate plant community type name from Version 1.5 (and where applicable geographic section or subtype name) in the margin to the right of the Version 2.0 name; this enables entry of a temporary community name in the DNR's relevé database, which is often useful in screening relevés for analysis. Version 1.5 of the DNR's plant community classification is available in electronic format on the DNR's website at http://files.dnr.state.mn.us/ecological_services/nhnrp/nckey.pdf.

<u>Community Ranking in Relevé</u>: This is the one- or two-letter quality ranking assigned to native plant community occurrences by DNR ecologists. The ranks are indicative of community quality and range from "A" for high-quality, relatively undisturbed occurrences, to "D" for highly disturbed occurrences. *The community rank applies to the vegetation in the area of the relevé plot rather than to the stand as a whole. If the quality of the stand as a whole is different, this is recorded in the <u>Relevé Typical of Stand</u> field and also in either the <u>Remarks</u> or <u>Notes</u> field.* This ranking is a very useful guide for selecting relevés for analysis. The NHNRP and MCBS have drafted guidelines for native plant community occurrence ranking in Minnesota, which are available by request.

<u>Stand Typical of Community Class/Type</u>: In some instances, it may be evident that the vegetation in the relevé is not representative of typical occurrences of the native plant community class or type. This may be because the vegetation has been affected recently by human-related or natural disturbance, or for some other reason. Information of this kind is very useful in screening relevés for analysis. Information about human-related disturbance should be recorded here only if it has greatly altered the composition or structure of the vegetation. Examples would include recent clear-cutting of a forest or past cultivation of a prairie. If the disturbance is minor or occurred long ago (for example, cutting of an occasional tree, clear-cutting in the early 1900s, or grazing in the 1930s) this information is recorded below in the Remarks field.

Relevé Typical of Stand: Record here whether the vegetation in the relevé area is typical of the stand as a whole or differs significantly in composition or structure from the rest of the stand. For example, a surveyor may sometimes place a relevé in an area that is of visibly higher quality than the rest of the stand, is of lower quality than the rest of the stand, contains a significant canopy gap, or differs in some other way from the rest of the stand. This field, like the previous field, serves to highlight relevés that may be in some way anomalous for their designated community class or type.

Plot Location: This field provides information on the location of the relevé plot in relation to boundaries between the sample stand and adjacent plant communities. The choices are:

> **(F)ar from any community boundary –** boundaries with adjacent communities are not visible from the relevé plot (i.e., boundaries are > ca. 50 meters from the plot). This situation is most common when the plot occurs in a community that forms large patches or is the matrix or predominant vegetation in the study area.
>
> **(M)oderately far from any community boundary –** boundaries with adjacent communities are not close to the relevé plot but are visible from the plot (i.e., boundaries are ca. 10–50 meters from the plot). This situation is most common when the plot occurs in a community that forms patches that are larger than the relevé plot but that is not the matrix community in the study area. This category can also be used to represent a localized habitat in a large occurrence of a community (e.g., a north slope in a mostly level site).
>
> **(C)lose to a community boundary –** this occurs when the community patch is just large enough (or wide enough in the case of linear communities) to contain the relevé plot, or when the plot is placed close to (i.e., within 0–10 meters of) a community boundary in a larger patch.
>
> **(E)cotonal –** the plot is in a visible ecotone or transition between two communities.

UTM: If the surveyor is using a GPS unit, the location of the plot is recorded here based on UTM coordinates in NAD83 and zone 15. To prevent mistakes, the surveyor should provide an ArcView printout of the relevé location with a USGS topographic map as a background layer. The map provides a means of confirming the accuracy of the location entered in the database and also serves as a quick reference for viewing the location of the plot.

UTM Accuracy: This space is for the accuracy of the GPS reading in meters, especially when the accuracy is less than typical.

Latitude and **Longitude:** If the surveyor or data entry staff are using a USGS topographic map to determine coordinates, the latitude and longitude of the plot are entered here in NAD27. (If the surveyor is using a GPS unit and provides UTM coordinates in NAD83, data entry staff still use this space to record latitude and longitude in NAD27 for entry into the DNR's relevé database, as UTM coordinates cannot be entered into the database at present.)

Township: This is the township in which the relevé is located; township numbers are printed in the margins of USGS topographic maps near the boundaries between townships.

Range: This is the range in which the relevé is located; range numbers are printed in the margins of USGS topographic maps near the boundaries between ranges.

Section: This is the number of the section in which the relevé is located; section numbers are printed near the center of each section on USGS topographic maps.

QRT: The quarter section is recorded using the codes NE, NW, SE, or SW. If the relevé is near a boundary and its quarter-section location is questionable, half sections may be indicated using the codes N_, S_, E_, or W_.

QQRT: The quarter-quarter section is recorded using the codes NE, NW, SE, or SW. If the relevé is near a boundary and its quarter-quarter-section location is questionable, half-quarter sections may be indicated using the codes N_, S_, E_, or W_.

Note on Township, Range, and Section: The township, range, and section of the plot are requested in order to provide information on location that is independent from UTM coordinates or latitude and longitude. The legal description is automatically compared for consistency with latitude and longitude in the DNR's relevé database to screen for errors in plot location.

Coordinates Calculated From: Indicate whether the geographic coordinates of the relevé plot were determined with a GPS unit or scaled from a map (typically a USGS topographic map). If the coordinates were scaled from a map, the surveyor should submit a photocopy of the map with the relevé form.

Permanent Marker: Record whether the relevé plot has been marked with a permanent marker. If the plot is marked, include the method by which it is marked (such as buried magnets, stakes, or flagging) in the space provided. Other information about the specific location of the plot can be written under Notes or sketched on a separate sheet that is then attached to the original relevé form.

Plot Size: The dimensions of the relevé plot are recorded in meters and the resulting plot size is given in square meters. DNR surveyors typically use 20-meter by 20-meter plots for forest, woodland, and savanna plant communities, and 10-meter by 10-meter plots for open communities such as prairies and wet meadows. If the plot is larger than 999 square meters, enter “999” and indicate the actual size of the plot in the Remarks field. If the plot is irregularly shaped, this should be recorded either in the Remarks field, or under Notes if there is not enough space in Remarks.

Elevation: The plot elevation in feet is usually estimated from USGS 7.5 minute series topographic maps, either to the nearest contour or to the midpoint between two contours.

Slope: The slope of the relevé plot is recorded either in degrees or in percent, using the appropriate space. Values of less than 10 degrees or 10 percent are prefixed by “0.” For example, a slope of eight degrees is recorded as “08.” Level sites are recorded as “00.” *Note: Slopes are entered in the relevé database in degrees. If provided as a percent, they will need to be converted by data management staff.*

Aspect: The slope aspect (i.e., the downslope direction of the plot) is recorded using the abbreviations NE, NW, SW, SE, N_, S_, E_, and W_. For level sites, use “LV.”

Topographic Context: Circle the choice that best characterizes the topographic context of the plot in relation to any slope or slopes (Fig. 3) that may be affecting the flow of runoff or groundwater to or from the plot. For example, a plot that is locally on a topographic high point will tend to receive little runoff or groundwater flow from above and moisture reaching the plot will drain readily. Conversely, a plot that is topographically low in relation to adjacent or surrounding slopes will receive runoff or shallow groundwater flow from the full length of any slope above and drainage away from the plot will be gradual. The definitions of topographic context in relation to slope are:[1]

(C)rest – the uppermost portion of a slope, typically without a distinct aspect.

(U)pper – the upper portion of a slope immediately below the crest, usually with a distinct aspect.

(M)iddle – the area of a slope between the upper slope and the lower slope, usually with a distinct aspect.

(L)ower – the lower portion of a slope immediately above the toe, usually with a distinct aspect.

(T)oe – the lowermost portion of a slope. The toe is immediately below the lower slope and grades rapidly to level with no distinct aspect.

(F)lat – any level area excluding the toe of a slope. There is no distinct aspect.

(D)epression – any area that is concave in all directions, usually at the toe of a slope or in level topography.

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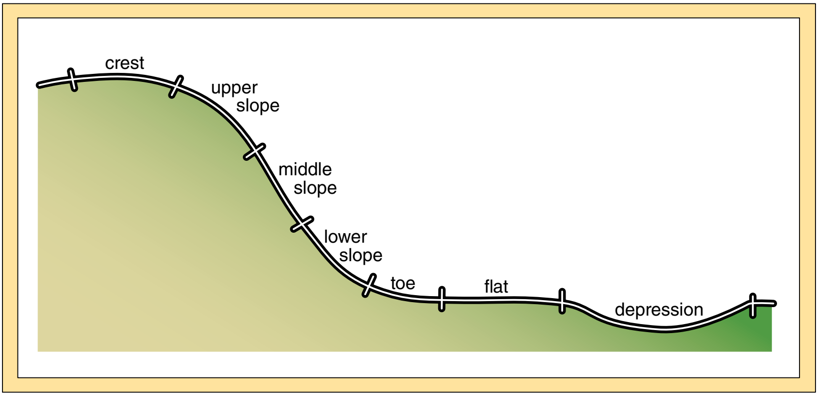
[1] From Ontario Institute of Pedology (1985).

Figure 3. *Diagram of slope position (modified from Ontario Institute of Pedology 1985).*



Soil Profile

To collect data on the soil profile in the relevé plot, it is suggested that the surveyor dig a soil pit, preferably at least 60 centimeters (24 inches) deep. If it is not feasible to dig a soil pit, the surveyor could use a soil probe, auger, or peat sampler to lay out a sample core of the soil in stratigraphic sequence. The data recorded includes information on litter, humus, and organic soil layers such as peat or muck, as well as any natural mineral-soil layers that differ from one-another in soil texture. At a minimum, the surveyor should record information on the litter, humus, and the texture of the surface soil layer.

Litter:[1] Litter consists mainly of leaves, needles, twigs, and other organic material in which the original structures are easily identifiable (compare with **Humus** below). Record the Thickness of the litter layer in centimeters. Also record the predominant component of the litter, such as oak leaves, pine needles, or grass, under Type.

Humus:[1] Humus consists of leaves, needles, twigs, and other organic material in which the original structures have been decomposed by soil organisms and are not readily identifiable. Record the Thickness of the humus layer in centimeters and the appropriate humus Type. The possible types are:

> **Mor –** derived from organic material that has been decomposed largely by fungi. Mor humus develops from litter composed predominantly of conifer needles and mosses and is little mixed with the underlying mineral soil. Mor humus has a brown fibrous structure throughout and leaves little or no residue on fingers when rubbed.
>
> **Moder –** derived from organic material that is being decomposed by soil fauna. Moder humus develops from litter composed predominantly of deciduous leaves and is partially incorporated into the underlying mineral soil by the activity of soil fauna. Moder humus is fibrous at the top and amorphous at the bottom; the amorphous portion leaves a fine, black silty residue when rubbed between fingers.

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[1] Ontario Institute of Pedology (1985).

Prairie Mull – develops in grasslands, in which plant roots decay in place to form a dark-colored, organic-rich surface horizon. Surface litter and humus are usually absent, with the exception of thatch that may have accumulated between fires.

Wormed Mull – present in deciduous forests that have been invaded by exotic earthworms. In wormed mull, worms transport litter and humus into the soil to form a dark-colored, organic-rich surface horizon. Worm castings are usually evident beneath the current year's leaf litter or at the surface if the litter has been consumed.

Soil Layers: Soil layers are denoted by recording changes in soil texture and the depth at which they occur. Appendix E provides a key with instructions for determining the texture of mineral soil layers. The texture of each mineral soil layer, as determined from the key, is recorded on the relevé form using the texture class codes in Table 2 below. If the soil pit or probe reaches bedrock, the bottom layer of the profile is recorded as rock (RO).

Table 2. *Soil texture class codes.*

S = sand
LS = loamy sand
SL = sandy loam
L = loam
SIL = silt loam
SCL= sandy clay loam
CL = clay loam
SICL = silty clay loam
SC = sandy clay
SIC = silty clay
C = clay
RO = rock

Appendix F provides information for identifying wetland organic soil layers. These soil layers are characterized by high organic carbon content (at least 12–18%) and form in settings where the soil surface remains saturated for long periods, leading to anaerobic conditions in which decomposition slows and plant material accumulates in the upper layers (U.S. Department of Agriculture 2006). The categories for describing organic soil layers are peat, mucky peat, and muck. For peat and mucky peat, the surveyor also indicates whether the peat has originated from mosses or sedges when this can be determined. The codes for recording organic soil layers are given in Table 3. Peat origin is recorded by adding a suffix to the code for peat or mucky peat (e.g., "MP-m" indicates mucky peat of moss origin).

Table 3. *Organic soil layer codes.*

PE = peat
MP = mucky peat
MU = muck
-m = moss origin
-s = sedge origin

The depth of each soil layer is measured in centimeters from the soil surface, which is set by convention as the top of the first layer capable of supporting plant growth (U.S. Department of Agriculture 2006). For mineral soil layers, depth is measured from the ground surface, starting below litter or humus, if present. For wetland organic soils, depth is measured from the muck or peat surface, excluding any layer of undecomposed plant material such as litter or thatch. In hummocky peatlands, depths are measured starting at the bases, rather than the tops, of hummocks. (In general, this means measuring depths starting at the muck or peat surface in hollows between hummocks.)

Measurements of depth are recorded for the top and bottom of each layer. (Note that the same number will be entered for the bottom of a given layer and the top of the layer immediately below it.) If the bottom of the lowest layer encountered is below the bottom of the soil pit or end of the soil probe, the surveyor should record the depth of the pit or length of the probe in the space for bottom depth and circle the "(>)" symbol before the space. For example, if the depth to the bottom of the lowest observed layer is greater than the length of a 100-centimeter soil probe, the entry for bottom depth for the layer would be " (>) 100 cm." Space is provided for recording information on up to five subsurface layers.

Surveyors should also record the type and estimated volume of rock fragments in any given layer. There are four categories of rock fragments, defined by fragment size (Table 4).

Table 4. *Rock fragment categories.*

GR = gravel = 2 to 76mm
CO = cobbles = 76 to 250mm
ST = stones = 250 to 600mm
BO = boulders = > 600mm

The percent volume of coarse fragments is estimated for each layer according to the categories presented in Table 5. For any layer that contains more than 90% rock fragments by volume, it is not customary to attempt to assign a mineral soil texture. One simply labels the layer as gravel, cobbles, stones, or boulders, depending on fragment size.

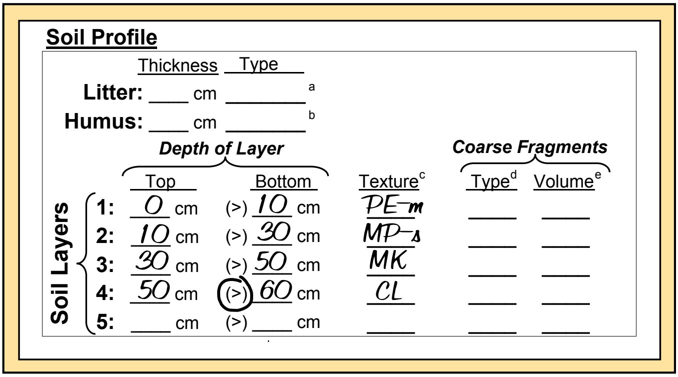
Table 5. *Categories for percent volume of coarse fragments.*

0 = < 15%
1 = 15 to 35%
2 = 35 to 60%
3 = 60 to 90%
4 = > 90%
? = unknown

An example of a completed soil profile for an upland site appears as part of Figure 2 (page 9). In this example, the profile has 3 centimeters of pine needle litter over 5 centimeters of mor humus, a layer of loamy sand at 0 to 42 centimeters, and a layer of sand at 42 to greater than 100 centimeters. Neither of the mineral soil layers contains rock fragments.

Figure 4 provides an example of a completed soil profile for a wetland site, in this case a poor fen community. The soil layers in the poor fen include a layer of peat of moss origin at 0 to 10 centimeters, a layer of mucky peat of sedge origin at 10 to 30 centimeters, a layer of muck at 30 to 50 centimeters, and a layer of clay at 50 to greater than 60 centimeters.

***Figure 4**. Example of soil profile from wetland site.*



Soil Profile

	Thickness	Type
Litter:	____ cm	________[a]
Humus:	____ cm	________[b]

Depth of Layer / ***Coarse Fragments***

Soil Layers	Top	Bottom	Texture[c]	Type[d]	Volume[e]
1:	0 cm	(>) 10 cm	PE-m	____	____
2:	10 cm	(>) 30 cm	MP-s	____	____
3:	30 cm	(>) 50 cm	MK	____	____
4:	50 cm	[✓ (>)] 60 cm	CL	____	____
5:	____ cm	(>) ____ cm	____	____	____

Drainage Class: Circle the choice that best describes the drainage class of the site. Soil drainage classes are an important but rough measure of how long soils are saturated or are able to hold water available for plants. Appendix G provides a key to soil drainage classes; the six possible drainage classes are defined in Table 6.

Depth to Semi-Permeable Layer: Information on the presence of a water-impeding horizon can help in interpreting the moisture or drainage regime for upland sites. Fine-textured (i.e., clay, silty clay, sandy clay, clay loam, silty clay loam, or sandy clay loam) soil layers greater than 13 centimeters (ca. 5 inches) thick will perch water, as will coarse-textured layers if these layers are cemented or compacted. Cemented or compacted layers are evident in the field by having peds, or structural units, that do not deform or disintegrate easily when squeezed. The depth recorded is the depth to the top of the semi-permeable layer.

Depth to Gray Colors or Redoximorphic Features: Soils that are saturated for long periods develop characteristic gray colors. Soils subjected to periodic saturation are characterized by redoximorphic features, which appear as pale gray zones and reddish or orangish mottles. Recording the presence of these features and the depth at which they occur provides information on the drainage regime or hydrology of the site.

Table 6. *Soil drainage classes.*

(E)xcessively and Somewhat Excessively Drained

Water drains very rapidly. These soils are commonly sandy, gravelly, on steep slopes, or shallow over bedrock, or have a combination of these conditions. Neither gray mottles nor a gray soil matrix are present within 150cm of the surface.

(W)ell Drained

Water drains quickly enough in the upper 100cm of soil to prevent the formation of gray mottles or a gray matrix.

(M)oderately Well Drained

Water drains slowly. Soils are saturated long enough to form gray mottles or a gray matrix within 50-100cm of the surface. Saturation is caused either by a semi-permeable layer that retards downward movement of water or by a high water table. A mixture of gray and orange or brown colors indicates fluctuation between saturated and unsaturated conditions during the growing season. A gray matrix indicates that saturation occurs for most of the growing season.

(S)omewhat Poorly Drained

Water drains slowly. Soils are saturated long enough to form gray mottles or a gray matrix within 25-50cm of the surface. Saturation is usually caused by a high water table but occasionally may be caused by a semi-permeable layer that retards downward movement of water. A mixture of gray and orange or brown colors indicates fluctuation between saturated and unsaturated conditions during the growing season. A gray matrix indicates that saturation occurs for most of the growing season.

(P)oorly Drained

Water drains very slowly. Soils are saturated long enough to form gray mottles or a gray matrix within 25cm of the surface. A mixture of gray and orange or brown colors indicates fluctuation between saturated and unsaturated conditions during the growing season. A gray matrix indicates that saturation occurs for most of the growing season. Muck and peat are absent from the surface or are <20cm thick if present.

(V)ery Poorly Drained

Water drains very slowly. Saturation occurs at the surface or immediately below the surface all year. Gray with a blue or green hue is the dominant color within 25cm of the surface. These soils usually have a high water table for most of the growing season. Muck or peat >20cm thick is present at the surface.

Gray soil colors caused by prolonged saturation can be brownish-gray, reddish-gray, bluish-gray, or greenish-gray in hue. They develop when iron and manganese in the soil are reduced in the low-oxygen environment caused by persistent soil saturation. For most soils in Minnesota, gray colors with values of 4 or greater and chromas of 2 or less on Munsell color charts (Munsell Color 1994) reliably indicate prolonged saturation. It is important to distinguish E layers, which are gray because of leaching in the upper soil layers, from gray soil colors caused by prolonged saturation. In the field, E layers are usually dry and become darker (i.e., have lower value) when wetted, whereas wetting soils that are gray because of saturation will not change their color much.

Redoximorphic features are zones of iron and manganese depletion and corresponding zones of iron and manganese oxide accumulation. They form when soils alternate between anaerobic and aerobic conditions, for example, in settings with fluctuating water tables where soils are saturated seasonally rather than permanently. When conditions are anaerobic, iron and manganese are reduced, become mobile in the soil solution, and can be depleted from saturated areas as water moves through the soil. These zones of depletion are recognized by their gray color, caused by lack of iron and manganese. If saturated soils dry enough to become aerobic, iron and manganese, where present, will precipitate as oxides and accumulate to form nodules, concretions, soft masses, or pore linings that are usually orange or red in color (Vepraskas 2001).

Average Height of Moss Hummocks: In peatland communities, the height of moss hummocks is often correlated with the degree of acidification of the peatland. The surveyor should record an average of the heights of hummocks in the plot.

Depth of Standing Water: This field is mainly for use in plant communities where standing water is a typical feature, such as aquatic or wetland communities. If water depth is greater than the measuring device used by the surveyor, the length of the device is entered in the space provided and the surveyor circles the “(>)” symbol.

pH of Surface Water: The pH of surface water is useful to record for all wetland communities, especially peatland communities. Important distinctions include how far the pH is from 5.6, which is the dividing point between acid and rich peatland communities, and also whether the pH is very high (>7.0). The pH is best recorded from an open pool. Compressing or digging holes in the peat mat to reach water can result in elevated readings, although in communities on floating mats or with a surface layer of loosely consolidated moss, the measuring device can be gently pressed into the mat or moss until contact with standing water. If possible, the surveyor should record the published accuracy of the measuring device in the space following the pH value. (If using pH paper, the accuracy is generally ± 0.5; properly calibrated pH meters typically have accuracies of ± 0.1 or better.)

Average Depth to Bedrock: This is the depth in centimeters of soil over bedrock and is recorded in areas of Minnesota where glacial deposits are thin and bedrock is close to the surface. One typically uses the average of several measurements from within the plot. Important distinctions made in northwestern Ontario forest ecosystem classification studies were soil depths greater than 100 centimeters or less than 20 centimeters (Sims et. al. 1997).

Exposed Rock: The percentage of the plot surface with exposed bedrock is often useful information in areas of Minnesota where glacial deposits are thin and bedrock outcrops are common.

Rock Type: The rock type is recorded when there is exposed bedrock in the plot.

Remarks: This field is for recording information on environmental factors that influence (or might influence) the vegetation in the relevé plot. The information recorded here is intended to aid in assessing the character and quality of the vegetation in the relevé and is very useful when creating datasets for analysis. The Remarks field is limited to 300 characters.[1]

In general, the Remarks field is for information that cannot be recorded elsewhere on the relevé form. Information concerning which plant species are present, the abundance of certain species, or the density of one of the vegetation layers can be determined from the species data and is redundant if entered here (although noting such things as dominant species, high abundance of disturbance species, or abnormally high abundance of forbs in a prairie is appropriate for the Remarks field). The location of the relevé plot also can be determined from information entered elsewhere (i.e., from the legal description, latitude, and longitude) and should not be described under Remarks. If a detailed record of the plot location is necessary, one can either describe the location under Notes on the relevé form (for example, *plot located 300m southeast of visitor station*) or attach a sketch to the relevé form showing the location of the plot relative to nearby landmarks. Neither of these records is entered in the relevé database, but they are archived in the DNR's manual relevé file in St. Paul. It is useful to record locational information in the Remarks field only when relating the relevé to a nearby feature (such as a road or a clearing) that may itself have some influence on the vegetation.

In analyses of relevés for vegetation classification in Minnesota, the most useful environmental information in the Remarks field has been:

- indication of vegetation quality (e.g., *old-growth forest, mature forest, young forest, overgrown savanna, high-diversity prairie*, etc.)

- the type, extent, and history (if known) of any disturbance (e.g., *recently heavily grazed, hayed annually in late summer, clearcut in 1930s, recently selectively cut, margins with broad zone of reed canary grass, burned in 1960s, soils eroded and compacted,* etc.). For forests in particular, it is helpful to note the presence of old stumps (especially old pine or cedar stumps in northern forests), the presence of a browse line, or potential evidence of earthworm activity (absence of duff over large patches, abundant worm casts). For prairies, noting the abundance of thatch or the abundance of forbs relative to graminoids is often useful. The absence of any evidence of disturbance is also useful to record.

- the growth form of trees (e.g., *open-grown, forest-grown, crooked, forked, multi-stemmed,* etc.) or the uniformity of tree crowns in a forest.

- the context of the relevé in the surrounding vegetation or landscape (e.g., *plot upslope from nearby stream, relevé in 5-acre strip of pine forest on slope within area of oak forest, plot in upland forest island in large peatland, relevé in 10-acre prairie surrounded by cropland*) or

---

[1] Although there is space for 300 characters in Remarks on the relevé field form, only 200 characters can be entered in the DNR's relevé database at present. Therefore, it is helpful to organize information so that the most important information is entered now, with the remaining information entered when the database is reprogrammed.

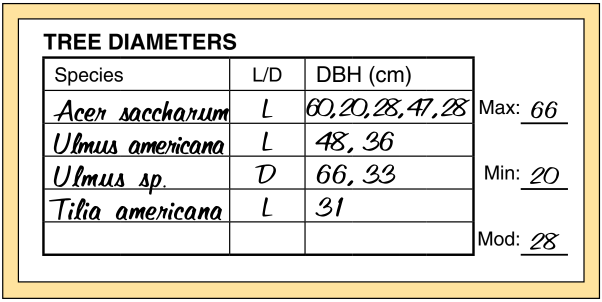
the presence of atypical or unusual landscape features nearby (e.g., *plot located near base of steep cliff)*. This kind of information may help either to explain or to highlight the presence of plants in the relevé that are unusual for the community type. For upland communities, information on the presence of nearby rivers, streams, lakes, or wetlands has been useful.

- indication of anomalous microhabitat conditions (such as a canopy gap, a wet depression in an upland site, or dry hummocks in a swamp forest) that may explain the presence or absence of some plant species.
- basic hydrological observations that provide information about how water may be affecting the plot. Examples include the presence of vernal pools, seeps, springs, flotsam, and plant growth-forms indicative of flooding such as tussocks, stools, and raised root systems. Also useful is information on the length of any slope above the plot.

Other useful kinds of information for the Remarks field are tree ages (when trees have been cored), presence of snags or downed logs, amount and decay-stage of coarse woody debris, presence of charcoal, or in general any information that might help to describe the structure or quality of the vegetation in the vicinity of the relevé plot. The Remarks field should also include information on relevé methodology when it deviates from standard procedures (e.g., *relevé plot larger than 400 square meters*). Because the Remarks field is limited to 300 characters, there is often not enough space to record all of the environmental information one might consider important. It is therefore common to write information under Notes when actually doing the relevé, and prioritize or condense the information afterward for entry into the Remarks field.

Tree Diameters: (Optional) Tree diameter measurements are optional but do provide additional information about stand structure. Diameters at breast height are recorded in centimeters for all canopy trees of each species in the plot. For each species, live trees (L) are recorded separately from standing dead trees (D) (Fig. 5). The maximum, minimum, and modal diameters for all canopy trees are recorded in the spaces to the right of the table for individual species.

Figure 5. *Sample tree diameter data.*



TREE DIAMETERS

Species	L/D	DBH (cm)
Acer saccharum	L	60,20,28,47,28
Ulmus americana	L	48, 36
Ulmus sp.	D	66, 33
Tilia americana	L	31

Max: 66

Min: 20

Mod: 28

Notes: (Optional) As mentioned above, this space is provided for the surveyor to record observations while doing the relevé. Information from these notes is later edited for entry into the Remarks field. The Notes space is also often used to record other kinds of information that are not necessarily entered into Remarks, such as information about the location of the plot in relation to nearby landmarks.

Vegetation Data

GENERAL OVERVIEW

The second side of the relevé data form (Fig. 6) has fields at the top for recording the surveyor's relevé number and surveyor's name, the county, township, range, and section, the date, and the surveyor's place name. These fields are repeated from the first side so that it is possible to determine which relevé the second page belongs to if the form is photo-copied onto two separate sheets and the pages become separated.

The rest of the second side of the relevé form is divided into lines and columns for entering information about the structure of the vegetation and the plant species present. The basic procedure for recording plant data in a relevé is to divide the vegetation into layers based on the life-forms and heights of the plant species and then record the cover or abundance of each species within each life-form and height-class group. For example, in a forest, the vegetation often is divided into a tree canopy layer, a tree subcanopy layer, a shrub and tree sapling layer, a forb layer, and a graminoid layer (Fig. 8, page 28), and the species in each layer are recorded on the datasheet along with their cover or abundance.

In accord with the division of the vegetation in a relevé into groups by life-form and height, the vegetation and plant species data are recorded on the relevé form in blocks of data lines that belong to separate life-form and height-class, or physiognomic,[1] groups. The first line of each group has a letter code designating the life-form of the plants, a number code or codes designating the height class range, and another letter code for the collective cover of the group. An example of a physiognomic group line is:

E 4–6 c

In this example, "E" is the life-form code for needleleaf evergreen plants, "4–6" is the range of height classes of the plants in the layer (which in this case is 2 meters to 20 meters), and "c" is a code for the estimated collective cover of the plants in the layer (which in this case is 75–100%). See below for complete lists and definitions of the codes for life-form, height class, and coverage class for physiognomic groups.

The individual species records are written immediately below the physiognomic group line. Each species data record consists of a code indicating the reliability of the identification of the species, a code for the cover or abundance of the species within the height class of the group, (sometimes) a code for the distribution of the species within the plot, the species name, and (sometimes) codes describing the vegetative state of the species. An example of a typical physiognomic group is given in Figure 7.

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[1] Physiognomy is defined as a combination of the external appearance of vegetation, its vertical structure, and the growth or life-forms of its dominant taxa (Barbour et al. 1999).

Figure 6. *Species data from sample relevé. (Shown at reduced scale.)*

VEGETATION DATA SHEET

DNR RELEVE # 0 0 0 2

Surveyor's Releve Number: JP-061

Surveyor's Name: John C. Almendinger

MN County: Crow Wing

Township, Range, Section: NW of SW of 32, T136N, R27W

Date: 04 Aug 1986

Surveyor's Place Name: None

ID	C.S	SPECIES NAME	REMARKS
	Ca	E 6 i	
	4.1	Pinus banksiana	
	r.1	Pinus resinosa	
	.		
		E 1 a	
	r.1	Abies balsamea	
	.		
	.	D 4 – 5 r	
	r.1	Quercus macrocarpa	
	r.1	Acer rubrum	OP
	+.2	Quercus rubra	
	r.1	Populus tremuloides	
	+.1	Salix humilis	
	r.1	Betula papyrifera	
3	+.2	Amelanchier intermedia Group	
	.		
	.	D 1 – 3 i	
	2.3	Corylus americana	
	2.1	Rhus radicans	
	+.2	Acer rubrum	
	+.1	Salix humilis	
	+.1	Populus tremuloides	
3	+.2	Amelanchier humilis Group	
	r.1	Prunus pensylvanica	
	+.2	Rubus strigosus	
	+.1	Prunus virginiana	
	+.1	Parthenocissus inserta	
3	+.1	Amelanchier intermedia Group	
	1.1	Vaccinium angustifolium	
	1.1	Quercus rubra	
0	+.1	Rosa acicularis ssp. Sayi	
	+.1	Quercus macrocarpa	
	r.1	Fraxinus pennsylvanica	
	.		
	.	C 1–2 b	
	+.2	Vitis riparia	
	.		
	.	G 1 – 2 i	
	3.4	Carex pensylvanica	
	2.3	Andropogon gerardii	
	.	G 1 - 2 i, continued	
	2.2	Schizachne purpurascens	
	+.2	Muhlenbergia glomerata	
	r.1	Muhlenbergia racemosa	
	+.1	Danthonia spicata	
	+.2	Agrostis scabra	
	1.1	Bromus ciliatus	
	+.1	Agropyron trachycaulum	
	+.2	Oryzopsis asperifolia	
	.		
	.	H 1 – 2 c	
	4.4	Pteridium aquilinum	
	2.1	Maianthemum canadense	
	+.2	Goodyera tesselata	
	r.1	Aster ciliolatus	
	r.3	Osmunda claytoniana	OP
6	+.1	cf. Heuchera	
4	r.1	Desmodium cf. glutinosum	#1
	r.1	Aster oolentangiensis	
4	+.1	Asclepias cf. ovalifolia	#2
	r.1	Campanula rotundifolia	
	r.1	Physalis virginiana	
	r.1	Monarda fistulosa	
	+.2	Achillea millefolium	
	+.1	Lathyrus ochroleucus	
	r.1	Lithospermum canescens	
	+.1	Smilacina stellata	
	r.1	Conyza canadensis	#3,OP
	+.2	Trientalis borealis	
	+.2	Aralia nudicaulis	
	+.2	Melampyrum lineare	
	+.2	Amphicarpaea bracteata	
	r.1	Smilax herbacea	
	1.1	Galium boreale	
	+.1	Lathyrus venosus	
	.		
	.	B 1 r	
	1.1	Gaultheria procumbens	
	1.2	Pyrola secunda	
0	+.1	Chimaphila umbellata var. cisatlantica	

Life Form
B = broadleaf evergreen
D = broadleaf deciduous
E = needleleaf evergreen
G = graminoids
H = forbs
L = lichens & mosses
C = climbers
K = stem succulents
X = epiphytes

Height Classes
8 >35m
7 = 20-35m
6 = 10-20m
5 = 5-10m
4 = 2-5m
3 = 0.5-2m
2 = 0.1- 0.5m
1 = 0-0.1m

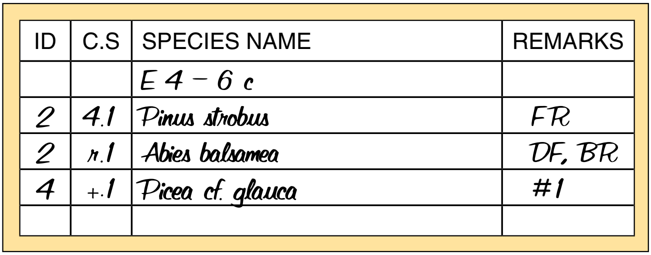
Cover/Abund.
c 5 75-100%
l 4 50-75%
p 3 25-50%
r 2 5-25%
b 1-5%
a <1%
1 <5%, many individuals
+<5%, few (2-20) individuals
r single

Sociability
5 = extensive mat
4 = small colonies, broken mat
3 = large group, many plants
2 = small dense clumps
1 = growing singly

Reliability Code
7 = Unknown
6 = cf. genus
5 = Genus certain
4 = cf. species
3 = species complex
2 = species certain
1 = cf. var./subsp.
0 = variety certain

Selected Remarks Code
DD = dead
DY = dying
GE = germinating
SD = seedling
SP = sprout (coppice)
FR = fruiting
OP = outside plot (<2m)
= specimen collection

***Figure 7.** Example of physiognomic group.*



ID	C.S	SPECIES NAME	REMARKS
		E 4 – 6 c	
2	4.1	Pinus strobus	FR
2	r.1	Abies balsamea	DF, BR
4	+.1	Picea cf. glauca	#1

The first line of data in this example ("E 4–6 c") gives the life-form, height classes, and cover of the group as a whole; subsequent lines are for the individual species within the group. As an example, within the physiognomic group, *Pinus strobus* has been reliably identified to the level of species (ID = 2), has a total canopy cover of 50–75% (C = 4), is growing singly throughout the plot (S = 1), and is in fruit (FR). See below for complete lists and definitions of the codes for reliability of identification of species, species cover and abundance, species distribution or sociability, and remarks about vegetative condition.

As illustrated above, the column headings on the relevé form refer only to the species data variables (reliability of i.d., cover, sociability, name, and remarks). The structural data codes (life-form, height classes, and physiognomic group cover) are entered in the "Species" column, and it is understood that these structural variables apply to all of the species in the rows immediately below that entry. Blank rows are used to separate the blocks of data lines for each physiognomic group. See Figure 6 (page 25) for examples of how physiognomic groups and species data are organized on the relevé form.

One potentially confusing aspect of doing relevés is determining the number of separate physiognomic groups within each relevé. The total number of groups is determined by both the number of life-forms represented in the plot and the number of distinct height layers for each life-form. For example, a forest relevé containing plants of four different life forms (e.g., broad-leaved deciduous plants, needle-leaved coniferous plants, forbs, and graminoids) and three distinct height layers (e.g., canopy, subcanopy, and ground layer) would have at least four physiognomic groups, because each life-form is recorded in a separate group (for example, broad-leaved deciduous species and needle-leaved coniferous species in the tree canopy layer are placed in separate tree canopy physiognomic groups). If each life-form in the above relevé was present in all three height layers, the relevé would have twelve physiognomic groups, although in reality the number will be between four and eight because forbs and graminoids do not occur in canopy or subcanopy layers.

In general, the number of life-forms in each relevé is determined by the plant species present and does not involve any interpretation by the surveyor. The number of height classes that are delineated in a relevé plot does involve interpretation of the structure of the vegetation by the surveyor and therefore is not necessarily a pre-determined number based on the species present.[1] Therefore, the number of physiognomic groups in any relevé is dependent, to some extent, on the surveyor's field interpretations.

Another sometimes confusing aspect of relevé species data is that it is common for a species to be recorded in several different physiognomic groups if that species occurs in different height layers or, for a few species in Minnesota, if it exhibits more than one life form. For example, relevés in which sugar maple is present often have three species records for sugar maple–one in the tree canopy height class, one in the subcanopy height class, and one in the shrub layer height class.

PHYSIOGNOMIC GROUP VARIABLES

Life-Form Codes: The life-form of each physiognomic group is represented by a one-letter code. This code is the first character of the physiognomic group line and is capitalized to distinguish it from the code for the physiognomic group coverage class (see Coverage Classes below). The definitions and codes for life-forms used by the DNR follow Küchler (1967). Appendix H provides a list of the life-forms for selected species in Minnesota whose life-forms are not obvious. *Note: The DNR is currently revising its list of life-form codes for all vascular plant species known to occur in Minnesota. When the revision is complete this list will be available on the DNR's website at* http://www.mndnr.gov/plants/index.html.

Woody Plants

B = Broadleaf Evergreen. This group of woody plants has broad leaves (as distinguished from needle-like leaves) that persist for two to several years. In Minnesota, this group is most often represented by members of the Ericaceae *(Andromeda*, *Arctostaphylos*, *Chamaedaphne*, *Epigaea*, *Gaultheria*, and the cranberry species of *Vaccinium)*. By convention, the DNR also includes suffruticose evergreen plants in this group (e.g., *Chimaphila*, and some of the above ericaceous genera).

D = Broadleaf Deciduous. This group of woody plants has broad leaves that are either shed annually or are dead (non-photosynthetic) during some part of the year. In Minnesota, this group encompasses many tree and shrub genera (e.g., *Acer*, *Betula*, *Corylus*, *Fraxinus*, *Quercus*, *Ulmus*, etc.).

E = Needleleaf Evergreen. This group of woody plants includes both needle-leaved and scale-leaved evergreens, which in Minnesota are all gymnosperms. The needle-leaved evergreen genera are *Abies, Picea, Pinus, Taxus*, and *Tsuga*; the scale-leaved genera are *Juniperus* and *Thuja*. By convention, *Larix*, the only needle-leaved deciduous genus in Minne-

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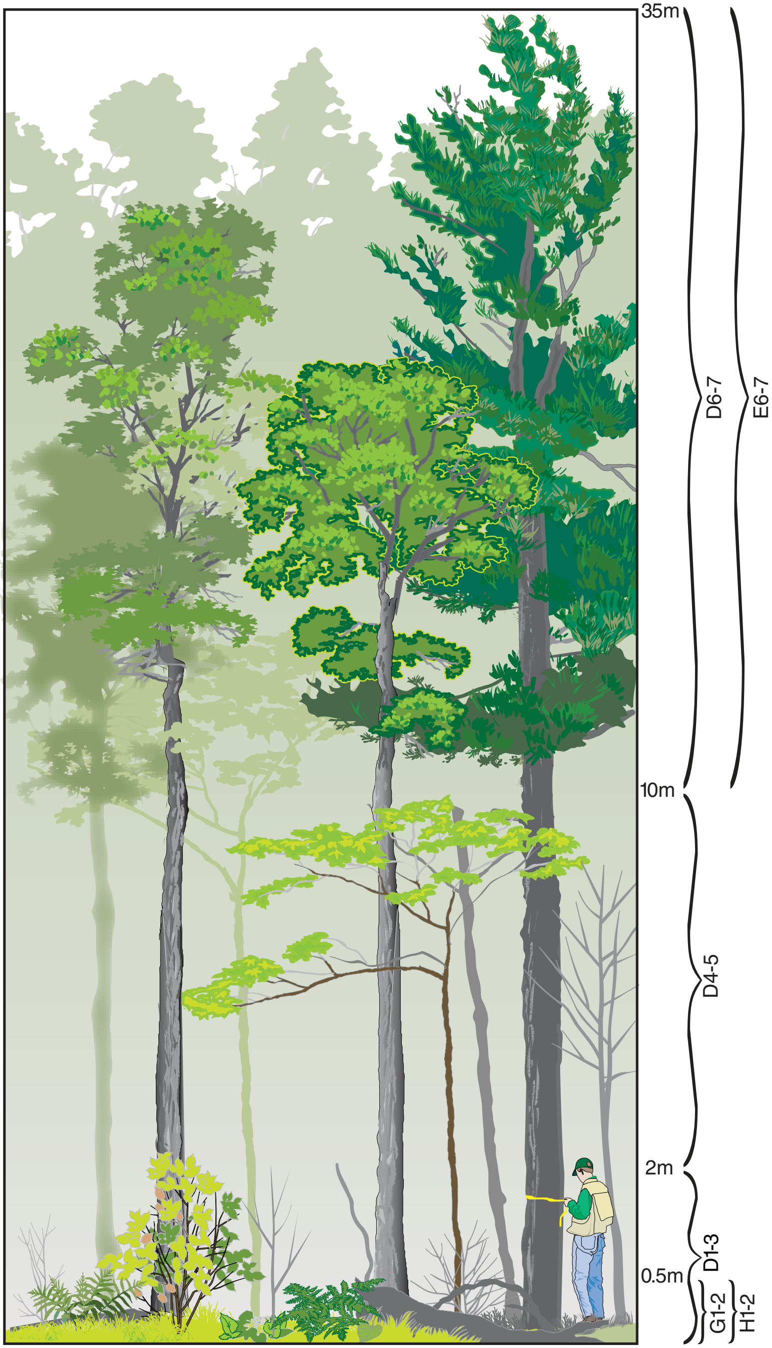
[1] Most decisions made in stratifying vegetation into height classes involve tree and shrub species. For forested vegetation, woody species are often separated by surveyors into a seedling/shrub layer (sometimes the seedling layer is separated from the shrub layer), a subcanopy layer, and a canopy layer, while for woodland and savanna vegetation, in which a distinct subcanopy is likely to be absent, trees are often stratified into a seedling/shrub layer and a canopy layer. The overall goal in stratifying vegetation into height classes is not to record every visibly distinguishable layer in the stand but to provide a general impression of stand structure, with information that might be useful in interpreting regeneration and succession.

Figure 8. *Delineation of height classes in forested relevé plot.*



sota, is currently placed in the needleleaf evergreen (E) group, although in the past it was separated into a needleleaf deciduous (N) group.

Herbaceous Plants

G = Graminoids. This group of herbaceous plants includes most plants that appear grass-like because of their long, linear leaves and unbranched form. In Minnesota, all members of the Cyperaceae, Gramineae, and Juncaceae are considered to be graminoids. *Note: Typha species, although grass-like in form, are considered forbs. See Appendix H for a listing of other forb species in Minnesota that are grass-like in form.*

H = Forbs. This group of herbaceous plants has broad leaves and is represented in Minnesota by many angiosperm families. By convention, ferns and fern allies are grouped with forbs. Also included are non-woody climbing species (such as *Clematis* spp.), evergreen forbs (such as *Coptis trifolia)*, and non-woody *Rubus* species *(R. acaulis* and *R. pubescens).*

L = Lichens and Mosses. This group includes all lichens and mosses that grow on the ground (either on soil or bare rock). In Minnesota the lichen genus *Cladonia* and the moss genera *Brachythecium, Hylocomnium, Mnium, Pleurozium, Polytrichum*, and *Ptilium* are examples of ground-covering taxa. Epiphytic mosses and lichens are included in the epiphyte special life-form (see below).

Special Life-Forms

C = Climbers. This group includes all woody plants that are rooted in the ground and climb objects or other plants. In Minnesota this group is most often represented by the genera *Rhus, Parthenocissus,* and *Vitis*. Herbaceous climbers, such as those in the genera *Convolvulus, Cuscuta, Dioscorea, Lathyrus*, and *Vicia*, are categorized as forbs.

K = Stem Succulents. In Minnesota this group includes only the native cacti genera, *Coryphantha* and *Opuntia*. Plants with fleshy leaves, such as species of *Sedum*, are categorized as forbs.

X = Epiphytes. Epiphytes include a wide variety of plants that are not necessarily similar in growth form or appearance. By convention, this group includes all plants that live on the above-ground parts of other plants. Among these are all epiphytic mosses and lichens, and higher plants such as *Archeuthobium pusillum*. Parasitic plants that are apparently rooted in the soil, such as species of *Monotropa* and *Orobanche*, are categorized as forbs.

S = Submerged or Floating-Leaved. This group consists of submerged and floating-leaved aquatic species, including submerged species that have flowering parts extending above the water surface, such as common bladderwort *(Utricularia vulgaris)*, large-leaved pondweed *(Potamogeton amplifolius),* and northern water milfoil *(Myriophyllum sibiricum)*.

Height Class Codes: The heights of the plants in each physiognomic group are represented by numbers ranging from one to eight. These numbers are written after the life-form code in the physiognomic group line. The codes and definitions for height classes follow Küchler (1967) (Table 7).

Table 7. *Height class codes.*

height class		meters
8	=	> 35
7	=	20 - 35
6	=	10 - 20
5	=	5 - 10
4	=	2 - 5
3	=	0.5 - 2
2	=	0.1 - 0.5
1	=	0 - 0.1

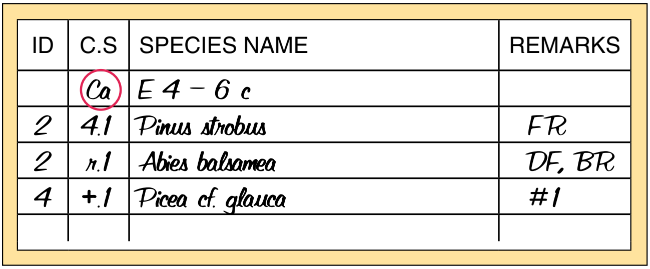
If all of the plants in a physiognomic group fall within one height class, a single height-class code is used. For example, if a forest has a continuous canopy of deciduous trees that is between 10 and 20 meters in height, the physiognomic group line would be "D 6–6 c." (In this example, the height class "6" is written twice as a reminder to data entry personnel that both allotted spaces for height class in a species record need to be filled in the DNR's relevé database to preserve the alignment of data columns; the line would have the same meaning if it was written "D 6 c.")

If the plants of a given life-form are not strongly stratified or occupy more than one height class, a range of contiguous height classes is entered. For example, if the tree canopy in the above forest ranged from 10 to greater than 35 meters, the physiognomic group line would be "D 6–8 c". When a range of height classes is given, it implies that the heights of the individual plants are evenly distributed between the lowest range value (in this case 10 meters) and the highest range value (in this case greater than 35 meters). If just a few of the trees in the above example were taller than 35 meters and the rest were between 10 and 35 meters, then it would be appropriate to record the trees in two physiognomic groups (i.e., D 8–8 and D 6–7).

One aspect of identifying height classes that merits closer attention is the method of delineating height classes for canopy trees in a forest relevé. Some surveyors delineate the canopy tree layer as ranging from the tops of the shortest canopy trees to the tops of the tallest canopy trees. This method tends to provide insight into stand history by emphasizing cohorts of trees and clearly separating trees in the canopy from younger trees in the understory. Other surveyors delineate the canopy as ranging from the lower parts of the crowns of the canopy trees to the tops of the canopy trees. This method tends to provide insight into vegetation structure and ecological function.

Tree Canopy Code: The physiognomic groups for canopy tree species in forest, woodland, or savanna communities are given an additional label ("Ca") to document that the group forms the tree canopy or part of the canopy. The application of tree canopy codes to physiognomic groups reduces ambiguity in assigning tree species to the canopy layers when analyzing relevé data. The tree canopy code is entered at the beginning of relevant physiognomic group lines (Fig. 9).

Figure 9. *Example of physiognomic group labeled as tree canopy.*



ID	C.S	SPECIES NAME	REMARKS
	Ca	E 4 – 6 c	
2	4.1	Pinus strobus	FR
2	r.1	Abies balsamea	DF, BR
4	+.1	Picea cf. glauca	#1

Coverage Class Codes: Coverage class codes are one-letter codes that represent the estimated cover of all of the plants in a given physiognomic group. Cover is defined as the percent of the relevé plot that would be covered by the downward vertical projection of the leaf surface area. Coverage class codes are recorded after the height class codes in the physiognomic group line and are written in lowercase letters to distinguish them from the life-form codes. The cover class codes and definitions follow Küchler (1967):

c = Continuous, with 75–100% cover. Continuous implies that the cover is distributed evenly across the relevé plot with plant canopies touching and total projected cover exceeding 75%. For some sparsely leaved species, such as needleleaf evergreens and graminoids, the plant canopies may touch, yet not have greater than 75% coverage—these still are designated as having continuous cover.

i = Interrupted, with 50–75% cover. This class is generally assigned to strata with a hole in otherwise continuous coverage, to strata in which the plant canopies do not touch, or to strongly clumped herbaceous or graminoid species where the canopies of the individual clumps do not touch.

p = Park-like or in patches, with 25–50% cover. This class is most often assigned to tree or shrub strata where the plants occur in patches, or to patchy colonies of herbaceous plants.

r = Rare, with 5–25% cover. This class applies to strata in which the plants are more widely scattered than in “p.” Often, the distinction between “p” and “r” is to separate strata composed primarily of plants with vegetatively reproducing colonies from strata composed of plants reproducing by long rhizomes or seeds.

b = Barren or barely present, with 1–5% cover. This is generally assigned to strata with plants that have fairly large leaf areas (such as bracken fern) but are widely scattered in the plot.

a = Almost absent, with <1% cover. This class is assigned to strata with plants that have small leaf areas (such as graminoids and conifer seedlings) and are widely scattered.

SPECIES OCCURRENCE DATA VARIABLES

Species Names: Species names are recorded on the relevé form in the lines below the associated physiognomic group line, using the Latin name for the species. The DNR currently uses *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Gleason and Cronquist 1991)—modified by *Trees and Shrubs of Minnesota* (Smith, in press) for woody species—as the authority for vascular plant names in Minnesota, but this is being changed to *Flora of North America* (Flora of North America Editorial Committee 1993–) as each volume in the series is published. The surveyor records as much of the species name on the relevé form as is warranted by his or her confidence in the identity of the plant (e.g., *Cornus* sp., *Cornus foemina, Cornus foemina* ssp. *racemosa*, etc.). It is good practice to write the full binomial name of a species on the relevé form whenever a plant has been reliably identified to species, even if there is only one species of the genus in Minnesota; if data entry personnel are not familiar with a particular species they are likely to enter the species record exactly as it appears on the relevé form. (For example, if a surveyor recorded only *"Amphicarpaea"* on the relevé form, it is possible that the plant would be entered in the DNR's relevé database only to the level of the genus, even though there is only one species of *Amphicarpaea* in Minnesota [i.e., *A. bracteata*].) It is conventional to record dead individuals of canopy tree species separately from live individuals of the same species. Species record lines for dead specimens are denoted by entering the code "DD" in the Remarks field (see Remark Codes below).

Species names are entered into the DNR's relevé database using eight-letter mnemonic codes assigned to the vascular plant species in Minnesota according to rules developed by the NHNRP and MCBS. It is not necessary for the surveyor to be familiar with these codes, but it is important for the surveyor to reference the variety or subspecies when known because the eight-letter codes for varieties or subspecies of a species are different from the eight-letter code for the species. The NHNRP and MCBS maintain a computer checklist of vascular plant species in Minnesota (MnTAXA), along with their eight-letter codes, authors, hybrid crosses, and other species-specific data. This checklist is currently under revision but will soon be available on the DNR's website at http://www.mndnr.gov/plants/index.html.

Reliability of Identification Codes: It is often not possible to identify with certainty all of the plant specimens in a relevé plot, because some of the plants in the plot will lack the taxonomic characters (such as flowers or mature fruit) that are needed to identify them. It is the surveyor's responsibility to indicate any uncertainty in the identification of plant specimens in the plot so that others can evaluate the work. To indicate uncertainty in identification of plants, the surveyor should use both the abbreviation "cf." (for the Latin *confer*, which has the meaning "appears to be" or "shows some likeness to" in this context) in the species written name, and a numerical code indicating reliability of identification. (The numerical codes for reliability of identification are necessary for entry of information into the DNR's relevé database. If the surveyor has recorded the numerical code, the use of "cf." in the written name is redundant but using "cf." in addition to the numerical code reduces the chance for confusion during entry of the species record into the relevé database.)

The numerical codes were developed by E. Cushing at the University of Minnesota (personal communication 1986) and are defined as follows:

0 = Identification of the plant is confident to the level of variety or subspecies.

Example

Baptisia bracteata var. *glabrescens*
Aster cordifolius spp. *sagittifolius*

1 = The species identification is confident but the variety or subspecies identification is in doubt.

Example

Baptisia bracteata cf. var. *glabrescens*

2 = The species identification is confident but the variety or subspecies is not distinguished, even though varieties or subspecies occur in Minnesota; or, varieties or subspecies are not recognized in collections in Minnesota.

Example

Baptisia bracteata

3 = Species identification is trivial because of hybridization among several recognized species but hybrid complexes are recognized within the group.

Example

Amelanchier interior complex

4 = The genus identification is confident but the species identification is in doubt.

Example

Baptisia cf. *bracteata*

5 = The genus identification is confident but the species is not distinguished.

Example

Baptisia sp.

6 = The genus identification is in doubt.

Example

cf. *Baptisia* sp.

7 = The plant is unknown but only one species is probably included. Plants recorded as "unknown" should be collected for later identification (unless the surveyor knows from experience that the specimen does not have the developed taxonomic characters necessary for identification) and the collection number entered in one of the remarks fields in the species data line.

In practice, the majority of species records on any given relevé are assigned a reliability of "2." Therefore, in order to save time when recording species data on the relevé data sheet, it is common practice for surveyors to record reliability of identification codes only when they differ from "2." If this is the convention used, the surveyor should indicate clearly that the code is "2" unless otherwise marked.

<u>Cover/Abundance Codes</u>: The DNR uses the Braun-Blanquet cover/abundance scale to designate the cover or abundance of each plant species within a given physiognomic group or layer. The categories in this scale are recorded on the relevé form using codes that include numbers (1 to 5) and characters ("+" and "r"). The numbers 2, 3, 4, and 5 designate cover classes for species with 5% to 100% cover in the physiognomic group. The convention for estimating species cover is to sum the "canopy cover" of each individual of the species in the layer. (Canopy cover is defined as the percentage of the ground covered by the downward projection of the outermost perimeter of the spread of foliage of each plant. This is in contrast to "foliar cover," which is defined as the percentage of the ground covered by the downward projection of stem and leaf area, exclusive of gaps between stems and leaves [Society for Range Management 1989; Jennings et al. 2004].) The codes 1, +, and r designate qualitative estimates of the abundance (number) of plants of a species with less than 5% cover in a physiognomic group. See Mueller-Dombois and Ellenberg (1974) or McCune and Grace (2002) for discussions of the Braun-Blanquet cover/abundance scale and similar scales.

The use of both cover and abundance classes is intended to enable the recording of meaningful data from one relatively large plot for both large, cover-forming plants and small plants that seldom cover much of the plot. For example, if one used a pure cover scale there are many species that would almost always be assigned the lowest cover value because even when numerous in a relevé plot they tend to cover very little of the plot area. This is true for many diminutive forb and graminoid species. On the other hand, if one used a scale with classes based only on abundance, the importance of canopy trees would be diminished relative to that of herbaceous species because canopy trees typically have few individuals within a plot, even when the leaf area of a species may effectively cover the entire plot. Other sampling methods overcome the need for a split cover/abundance scale by using large plots to sample larger, cover-forming plants (such as trees and shrubs), and small plots nested within the large plots for sampling herbaceous plants.

One convention used by the DNR is that whenever the cover of a plant is greater than 5% in the plot, cover takes precedence over abundance. For example, if there is a single individual of a tree species in the canopy in a relevé plot, but that individual has a leaf area that covers 30% of the plot, the species would be given a "3" for cover/abundance rather than an "r." If, however, there was a single individual with leaf area covering less than 5% of the plot, that species would be given an "r" for cover/abundance. The same holds for canopy trees whose stems fall outside the plot but whose leaf area covers a portion of the relevé plot. If the leaf area covers more than 5% of the plot, the species is given the appropriate cover value (i.e., 2, 3, 4, or 5). If the leaf area covers less than 5% of the plot, the species is given an abundance value of "r," and

"OP" is recorded in the Remarks column to indicate that the stem is outside the plot. It is useful for surveyors to keep in mind that when conducting visual estimates of species cover there is a tendency for observers to overestimate cover of large species, species in flower or clumped in distribution, and species that are known, and to underestimate cover of small species, species in vegetative state, species distributed evenly in the plot, and species not known to the observer (Kershaw 1973, Kent and Coker 1992).

The Braun-Blanquet cover/abundance scale (after Mueller-Dombois and Ellenberg 1974) is as follows:

5 = 75%–100%	(Cover code.) Assigned to a species within a particular physiognomic group when that species' cover is between 75% and 100% of the relevé plot area.
4 = 50%–75%	(Cover code.) Assigned to a species within a physiognomic group when that species' cover is between 50% and 75% of the relevé plot area.
3 = 25%–50%	(Cover code.) Assigned to a species within a physiognomic group when that species' cover is between 25% and 50% of the relevé plot area.
2 = 5%–25%	(Cover code.) Assigned to a species within a physiognomic group when that species' cover is between 5% and 25% of the relevé plot area.
1 = < 5%	(Abundance code.) Assigned to a species within a physiognomic group when there are numerous individuals of the species, but those individuals collectively cover less than 5% of the relevé plot area.
+ = < 5%	(Abundance code.) Assigned to a species within a physiognomic group when there are only a few (approximately 2–20) individuals of the species and those individuals collectively cover less than 5% of the relevé plot area.
r = < 5%	(Abundance code.) Assigned to a species within a physiognomic group when there is only a single individual of the species (a plant with two stems arising from the same root would be classified as a single individual). This code is also assigned to species that fall just outside the relevé plot (no matter how numerous they are outside the plot). For species that are assigned an abundance code of "r" because they fall outside the plot, the surveyor also enters "OP" in the Remarks column. The recording of species that are outside the plot is meant to alert others that these species are present in the stand, but happened not to fall in the relevé plot. The convention for species outside of the plot is to record only those species that are representative

of the stand (rather than of anomalous microhabitats within the stand) and that are within 2 meters of the plot boundary.

A useful approach for estimating species cover when applying the Braun-Blanquet scale is to decide first if the species covers more or less than 50% of the relevé plot. If it covers more than 50%, then the surveyor is left to determine if the coverage is 50–75% or 75–100%. If the cover is less than 50%, then the surveyor next determines whether the cover is 25–50% or less than 25%. If less than 25%, then the surveyor determines whether it is 5–25% or less than 5%. If less than 5%, the species is assigned one of the three abundance values. Note that the sum of the cover values for species in a physiognomic group should be consistent with the cover assigned to the physiognomic group as a whole. For example, if in a given relevé there are three tree species in the D 6–7 layer and each of the species is assigned a value of "+," with less than 5% cover, then the D 6–7 layer as a whole should not be assigned cover greater than "R" (= 5–25%).

Sociability Codes: (Optional) Sociability codes describe how a species is distributed within the relevé plot. They are only rarely recorded by DNR surveyors as they do not contribute useable information for classification analyses. When recorded, sociability codes refer only to the distribution of a species as it occurs in a particular physiognomic group. For example, it often happens that the distribution of a tree species is uniform within the tree stratum and clumped within the seedling stratum. The codes for sociability are (after Mueller-Dombois and Ellenberg 1974):

5 = Assigned to species where the plants are growing in a large, essentially monotypic stand that forms an extensive mat. This code typically is applied to non-woody plants (for example, moss or lichen carpets, graminoid sods, etc.).

4 = Assigned to species where the plants are growing in small colonies or broken mats. This code typically is applied to non-woody plants (for example, broken moss or lichen carpets and also colonies of herbaceous plants that have enlarged to the point where they are beginning to coalesce).

3 = Assigned to species where the plants are growing in small patches or in cushions. This code typically is applied to small isolated clones of herbaceous plants, patches of shrubs, and moss or lichen colonies.

2 = Assigned to species where the plants form small, often dense clumps. These small clumps may be rather evenly dispersed within the relevé. This code is often applied to woody or herbaceous plants where several aerial stems originate from the rootstock of a single genet.

1 = Assigned to species growing solitarily. This code is applied to both woody and herbaceous plants with single stems that appear to be evenly dispersed within the relevé plot.

Remark Codes: Remark codes are two-character codes that indicate some special attribute of the species as it occurs in a physiognomic group. Some remark codes refer to the species' viability (that is, they are qualitative estimates of the ability of the species to perpetuate itself). Other remark codes refer to the condition of the species as affected either by inherent factors (such as seasonal phenology or life-cycle) or external factors (such as herbivory, windthrow, or fire). When a vitality code is used, it is good practice to either enter an associated condition code that helps to explain the vitality of the species, or to include an explanatory note in the Remarks or Notes fields on the first side of the relevé form. For example, if the vitality code "00" (indicating poor vitality) is applied to a species record, then one would also apply a condition code to that species record to indicate why it had poor vitality (for example, it may have been defoliated by insects, in which case one would also enter the condition code "DF" for "defoliated" in the remark code column of that species record). The list of potential remark codes is not strictly limited, and miscellaneous remarks pertaining to features other than vitality or condition may be created to suit particular vegetation studies. Some commonly used, standard remark codes are listed in Table 8.

Table 8. *Standard codes for plant species remarks.*

Vitality

DD = dead
DY = dying
EX = being driven out
LU = luxurious growth
00 = poor vitality

Condition

BU = budding
BR = browsed
DF = defoliated
FL = flowering
FR = fruiting
FS = fire scarred
GE = germinating
GR = grazed
MS = multiple stemmed
MW = mowed
OG = open grown
PF = past fruiting
SE = present as seed
ST = sterile
SD = seedling
SP = sprout (coppice)

Miscellaneous

IN = introduced in Minnesota
RA = rare in Minnesota
OP = just outside plot (< 2 meters)
= specimen collection number

Appendix A. Contributing Samples to the DNR Relevé Database

Relevé samples can be contributed to the DNR's Relevé Database either by providing the DNR with paper copies of the relevés or by providing an electronic file of the relevé data. In general, paper copies are submitted for studies involving a small number of relevés (ca. 1–20); the relevés are then entered into the database manually by DNR personnel. Electronic files are typically submitted to the DNR when studies involve larger numbers (>20) of relevés. In these cases, the contributor should contact the DNR either to obtain software developed by the DNR for relevé entry or to determine the most suitable file format for submission. For further guidance on submitting relevés for entry into the DNR's Relevé Database, please contact:

Minnesota County Biological Survey
Minnesota Department of Natural Resources
500 Lafayette Road, Box 25
St. Paul, Minnesota 55155
(651) 259-5100

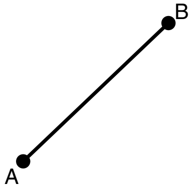
Appendix B. Obtaining Data from the DNR Relevé Database

Electronic datasets or paper copies of relevés housed in the DNR's Relevé Database are available to researchers interested in vegetation study. For information on obtaining relevé datasets or printouts, please contact:

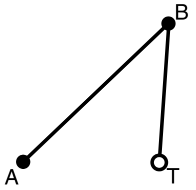
Minnesota County Biological Survey
Minnesota Department of Natural Resources
500 Lafayette Road, Box 25
St. Paul, Minnesota 55155
(651) 259-5100

Appendix C. Delineating a Square Relevé Plot

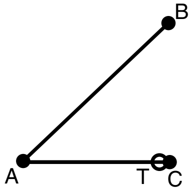
1. Using a tape scaled in meters, measure along a straight line the 14.14-meter diagonal of a 10 x 10 meter square plot (or 28.28 meters for a 20 x 20 meter square plot) and set chaining pins at each end (A and B). Leave the tape in place.



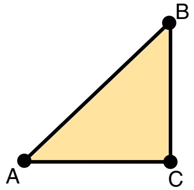
2. Using a second tape, measure 10 meters (or 20 meters for a 20 x 20 meter plot) from relevé corner B along a straight line that is approximately at a 45-degree angle from the diagonal tape on the ground (the angle is ca. 40 degrees in this example). Temporarily mark the relevé corner with a chaining pin (T), rewind the tape, and move to corner A of the diagonal.



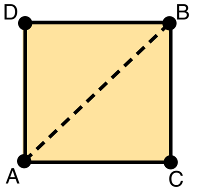
3. Measure 10 meters (or 20 meters for a 20 x 20 meter plot) along a straight line that passes over the temporary relevé corner T and set a surveyor's pin for the new relevé corner C. Remove the surveyor's pin at T. Leave the tape in place.



4. Measure between relevé corners C and B. This distance is almost always within 10 centimeters of 10 meters (or 20 centimeters of 20 meters), even with a poor setting of the temporary corner (the actual angle was 40 degrees). If the distance between B and C is not sufficiently accurate, consider relevé corner C as temporary and repeat step 3 by beginning at B rather than A. When satisfied, leave the tape in place to form a triangle on the ground.



5. Repeat steps 3 and 4 to establish relevé corner D and form a square relevé plot outlined by tapes. The diagonal tape may be removed, although leaving it in place to delineate a half-plot is often helpful when estimating the cover of a species that is approximately 50%.



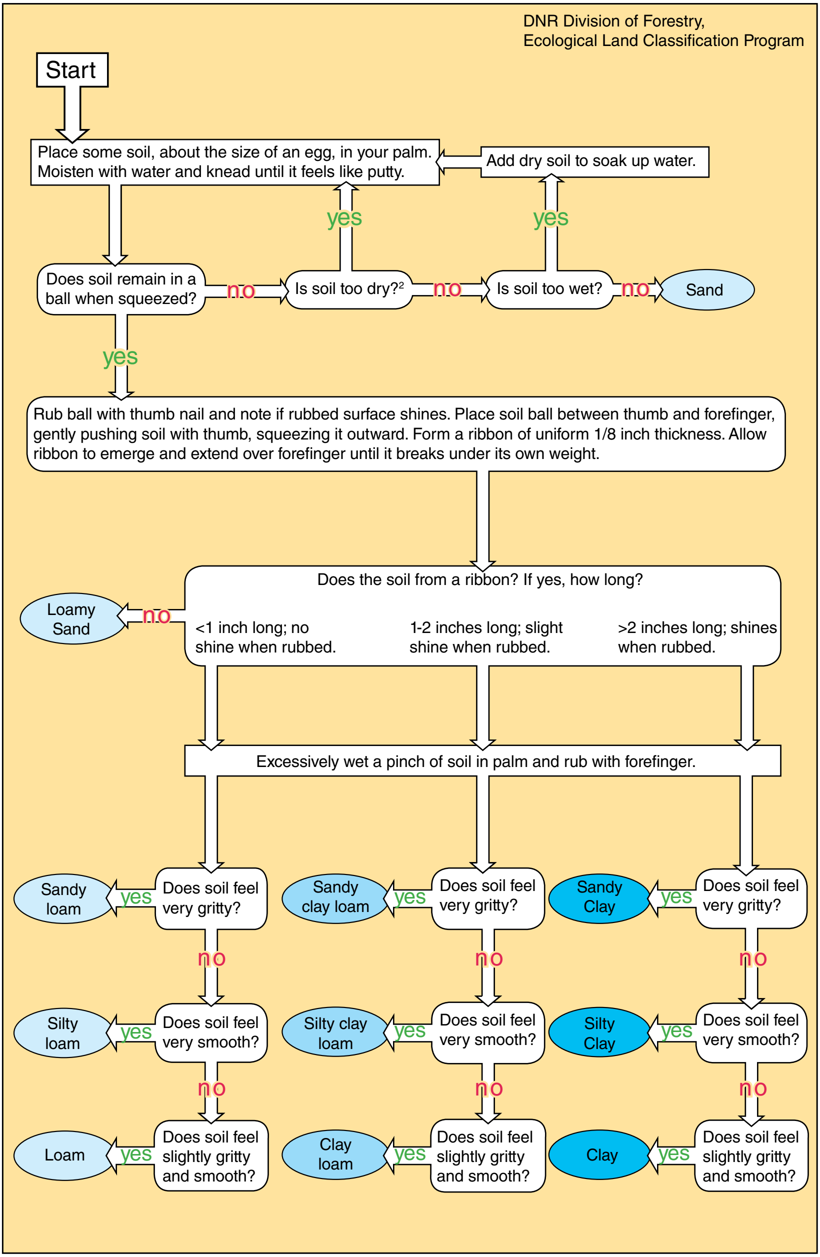
Appendix D. Obtaining a Copy of the DNR Relevé Field Form

A printable version of the DNR relevé field form is available on the DNR's website at http://www.mndnr.gov/eco/mcbs/vegetation_sampling.html.

A paper copy of the field form can be obtained by contacting:

Minnesota County Biological Survey
Minnesota Department of Natural Resources
500 Lafayette Road, Box 25
St. Paul, Minnesota 55155
(651) 259-5100

Appendix E. Key to Mineral Soil Texture[1]



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[1] Adapted from Richardson and Vepraskas (2000) and Thein (1979).

[2] If ball cracks along edges when squeezed, it is too dry.

Appendix F. Characteristics of Wetland Organic Soils

Texture Class	Peat	Mucky Peat	Muck
Value on Von Post peat decomposition scale[1]	H1 to H3	H4 to H6	H7 to H10
Color of organic material	Light yellowish brown or reddish brown.	Dark reddish brown to dark greyish brown.	Very dark grey to black.
Decomposition state of plant material	Composed of ***fibric*** organic material, in which plant remains are undecomposed or very slightly decomposed. Most plant remains are identifiable and no amorphous material is present.	Composed of ***hemic*** organic material, in which plant remains are slightly decomposed to moderately decomposed. Plant remains have lost some identifiable features and some mucky. amorphuous material is present.	Composed of ***sapric*** organic material, in which plant remains are very highly decomposed to completely decomposed. Plant remains are indescernible or reduced to residues such as roots and fibers.
Color of water released when material is squeezed	Clear to muddy brown.	Very muddy and dark.	Very dark, almost pasty (if any is released).
Amount of organic material that escapes between fingers when squeezed	None.	Up to one-third.	At least one-half.

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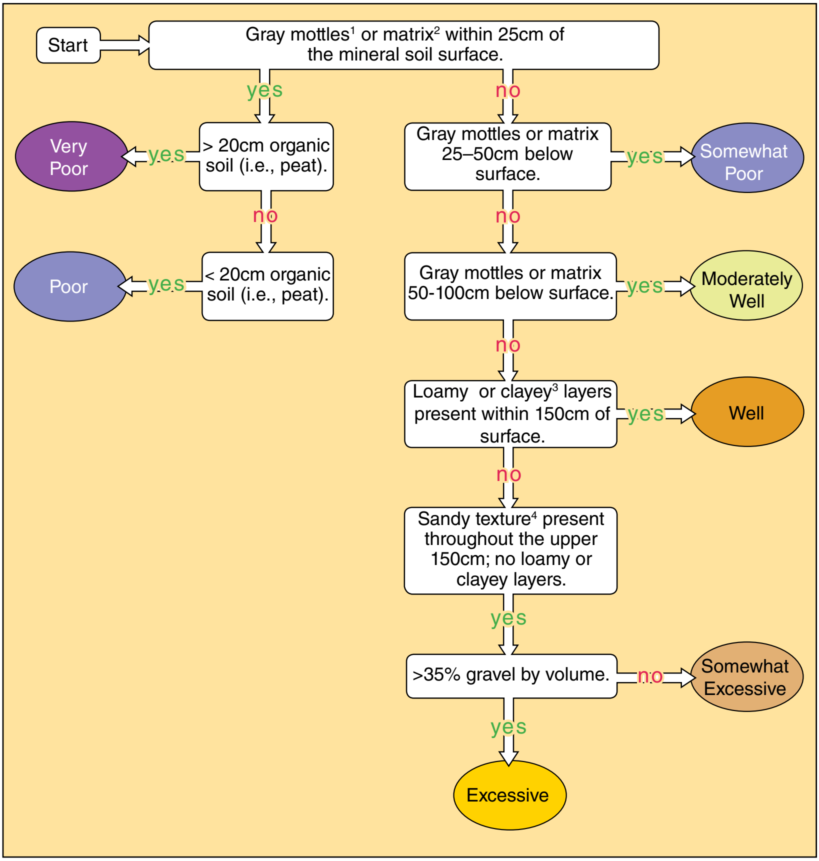
[1] An English-language version and brief explanation of the Von Post scale of peat decomposition is presented in Andriesse (1988).

Appendix G. Key to Soil Drainage Classes



Footnotes

[1] Exclude mottles that are faint or few in number

[2] Exclude gray "E" horizons

[3] Loamy textures: sandy loam, silty loam, loam, clay loam, sandy clay loam, silty clay loam, silty clay, and sandy clay

Clayey textures: clay, silt

[4] Sandy textures: sand, loamy sand

Appendix H. Plant Species Commonly Assigned Incorrect Life-form Codes (based on analysis of relevés in NHIS Relevé Database).

	correct code	incorrect code
Woody Broadleaf Evergreens*		
Bog rosemary *(Andromeda glaucophylla)*	B	D
Bearberry *(Arctostaphylos uva-ursi)*	B	D
Leatherleaf *(Chamaedaphne calyculata)*	B	D
Pipsissewa *(Chimaphila umbellata)*	B	D
Trailing arbutus *(Epigaea repens)*	B	D
Creeping snowberry *(Gaultheria hispidula)*	B	D
Wintergreen *(Gaultheria procumbens)*	B	D
Beach heather *(Hudsonia tomentosa)*	B	D
Bog laurel *(Kalmia polifolia)*	B	D
Labrador tea *(Ledum groenlandicum)*	B	D
Large cranberry *(Vaccinium macrocarpon)*	B	D
Small cranberry *(Vaccinium oxycoccos)*	B	D
Lingonberry *(Vaccinium vitis-idaea)*	B	D
Woody Climbing Plants*		
Climbing bittersweet *(Celastrus scandens)*	C	D
Wild honeysuckle *(Lonicera dioica)*	C	D
Grape honeysuckle *(Lonicera reticulata)*	C	D
Canada moonseed *(Menispermum canadense)*	C	D
Virginia creeper (*Parthenocissus* spp.)	C	D
Greenbrier *(Smilax tamnoides)*	C	D
Vitis spp.	C	D
Woody Broadleaf Deciduous Shrubs		
Sweet fern *(Comptonia peregrina)*	D	B
Fly honeysuckle *(Lonicera canadensis)*	D	C
Hairy honeysuckle *(Lonicera hirsuta)*	D	C
Rubus spp. (except *R. pubescens* and *R. acaulis)*	D	H
Woody Needeleaf Evergreens		
Tamarack *(Larix laricina)*	E	D
Graminoids		
Twig rush *(Cladium mariscoides)*	G	H
Evergreen Forbs		
Goldthread *(Coptis trifolia)*	H	B
Bunchberry *(Cornus canadensis)*	H	B
Twinflower *(Linnaea borealis)*	H	B
Partridgeberry *(Mitchella repens)*	H	B
Pyrola spp.	H	B
Climbing Forbs		
Clematis spp.	H	C
Dodder (*Cuscuta* spp.)	H	C
Common hops *(Humulus lupulus)*	H	C
Fringed false buckwheat *(Polygonum cilinode)*	H	C
Bur cucumber *(Sicyos angulatus)*	H	C
Smilax spp. (except *S. hispida)*	H	C
Graminoid-like Forbs		
Scheuchzeria *(Scheuchzeria palustris)*	H	G
Typha spp.	H	G
Moss-Like Forbs		
Lycopodium spp.	H	L
Rock spikemoss *(Selaginella rupestris)*	H	L
Non-Woody Rubus Species		
Arctic raspberry *(Rubus acaulis)*	H	D
Dwarf raspberry *(Rubus pubescens)*	H	D

*List includes all species with this life-form in Minnesota.

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