1. Background

Meeting the Challenge

The Ontario Ministry of Natural Resources (MNR) is responsible for the management and stewardship of Ontario's natural resources, comprising some 1.1 million square kilometers of land and water. More than ever, the successful management of this diverse geography is affected by MNR's understanding of the ecological features and processes that create natural resource values and influence the use of these resources. The composition, structure, and arrangement of these multi-scale ecosystems influence many business objectives including resource allocation, management, natural heritage protection, long-term sustainability, productivity, and conservation.

The MNR's core business and responsibility is driven primarily by four legislative acts, but particularly by the *Crown Forest Sustainability Act (CFSA)* and the Timber Environmental Assessment Terms and Conditions under the *Planning Act.* In addition, MNR has several national and international obligations for monitoring and reporting forest sustainability and environmental conditions. Sound forest management is not the only major priority. There are many important commitments captured in MNR's corporate mission of *Ecological Sustainability* in Parks and Natural Heritage area identification and management, wildlife management, water and aquatics systems management, and landscape management through sound ecological land-use planning. Numerous partnerships exist for delivery of MNR's mandate. These include related government agencies as well as non-government organizations. Private landowners, First Nations, industry, municipalities, conservation authorities, hunters, outfitters, and fishers as well as a wide range of environmental organizations share in the delivery of natural resource conservation and stewardship in Ontario.

The role of ELC over the past decade has therefore expanded considerably both in scope and in terms of the complexity of the information that it must handle. **Used appropriately, ELC provides a common language for research, training, communication, and negotiation. ELC-based products provide information that reduces management uncertainty and helps guide the implementation of regulatory policies and guidelines in support of, most importantly, MNR's mission of ecological sustainability.**

Ontario's classification program and products compare very favourably with all other jurisdictions pursuing similar initiatives. Despite this history, it is evident that integration of the various classifications needs to improve by rationalizing existing efforts across the province geographically and organizationally. A functional ELC framework is needed to synchronize the ELC business purpose more directly with the business functions of partners, clients, and stakeholders. This framework needs to be flexible, dynamic, and multi-scale.

Ontario Ecological Land Classification (OELC} Program Mission

> To provide the ecological information necessary to document the state of ecosystems or to predict ecosystem response to management or disturbance, at scales and levels of precision, homogeneity, and reliability appropriate to the predictive need.

In support of these goals, the following principles guide the implementation of a province-wide Ontario Ecological Land Classification (OELC) system.

> To reflect ecological processes such that the OELC system will support both the characterization of ecological conditions and the expected response of ecological systems to perturbation or change.
>
> To be procedure-based such that the creation, alteration, or abandonment of any categories, classes, attributes, or interpretations will be based on documented approaches, accepted procedures, and criteria.
>
> To be stable for specified periods. The OELC is an evolutionary product and will undergo change through time as data and knowledge accumulate. However, these changes must occur in an ordered fashion. Modifications will be subject to change management procedures that conduct impact analysis and that validate the data and procedures used to support the proposed changes.

The classification is based on five environmental variables expected to influence ecological response:

- climate and geology: climate controls the energy and water balance of the ecosystems; geology is the underlying bedrock.
- landform and parent materials, which modify the energy budget through slope, aspect and elevation, and surficial geology.
- landscape configuration: fertility and hydrology.
- soil, which influences nutrient availability and moisture supply, and further modifies the water balance.
- vegetation response.

MNR Strategic Directions

Ecosystem Sustainability and Ecological Land-Use Planning are the new directions for planning agencies. They begin by recognizing that any local land-use decision must take into account other land-use plans and the cumulative effect on the broader landscape. Governments and partners now understand that resource management and planning cannot proceed in a localized, and presumed isolated, fashion. Instead, there is a growing movement towards more integrated resource management approaches across a variety of spatial scales. Comprehensive understanding of ecological composition, structure, patterns, and processes is fundamental to integrated, ecosystem-based planning and management.

International trends towards evaluations of ecosystem sustainability, green labeling, ecosystem monitoring, and reporting at continental scales have resulted in a pressing need for completion of a comprehensive, multi-scale ecosystem classification and inventory. Nationally, via the Canadian Biodiversity Strategy, Canada has legal obligations and moral responsibilities to its citizens and to other members of the United Nations Convention on Biological Diversity to develop "national strategies and action plans to conserve and use sustainably the biological diversity within its jurisdiction ' The National Ecological Framework has provided a national Ecozone classification for this purpose. Additional international agreements dealing with reduction of greenhouse gases, management and maintenance of economically important natural resources, soil and water conservation, and protection of natural areas and old growth forests all require the same comprehensive ecological information framework.

Within Ontario, a number of strategic documents throughout the 1990s have provided critical direction.

Direction '90 (1991):

To ensure the long-term health of ecosystems by protecting and conserving our valuable soil, aquatic resources, forests and wildlife resources as well as their biological foundations.

To ensure the continuing availability of natural resources for the long-term benefit of the people of Ontario; that is, to leave future generations a legacy of the natural wealth that we enjoy today.

To protect natural heritage and biological features of provincial significance.

The *Policy Framework for Sustainable Forests* (1994):

Ecosystem boundaries are defined by primary components.

Goals and measurable targets for ecosystem conditions are developed.

Management strategies are designed, implemented, and, as necessary, modified to achieve goals and targets.

Ecosystem conditions are monitored and compared with the goals and targets.

Healthy ecosystems are secured.

Moving Ahead '95 (1994), a follow-up to *Direction '90:*

Healthy populations and communities of terrestrial and aquatic life will be safeguarded over geographical areas and time.

The integrity of natural processes and the inherent productivity of the land and water base will be protected.

Renewable resources will be available on a continuing, long-term basis.

Significant natural heritage features and landscapes will be protected.

The restoration and rehabilitation of degraded environments is recognized as having an important role in securing healthy ecosystems.

MNR Corporate Policies

From an administrative, legal, and policy perspective, land-use planning and management in Ontario underwent a major evolution from 1994 to 2000. The most important changes have been a result of:

- the Class Environmental Assessment (EA) (1994)
- the Provincial Policy Statement (Province of Ontario 1997)
- Lands for Life *(Ontario's Living Legacy* 1999).

From a legal perspective, the Class Environmental Assessment (EA) final board decision (1994) specifically directed MNR to develop a multi-scale ecosystem classification - in effect creating a legal requirement for an ecosystem-based approach to management.

Furthermore, as a result of the Provincial Policy Statement (PPS), greater responsibility for land-use planning decisions is now placed at the local or municipal level. Policy 2.3 of the PPS provides for the protection of "natural heritage features and areas'; and it creates the need for municipalities to describe and evaluate them, in order to understand their ecological functions and their “significance': Municipalities and their partners, therefore, face challenges in synthesizing complex biotic and abiotic relationships into forms that are useful within a land-use planning context.

This is of critical importance in the southern portions of Ontario where the majority of the land base is under municipal jurisdiction or private ownership. Newer, related initiatives such as Lands for Life *(Ontario's Living Legacy* 1999) have also stressed the need for comprehensive ecosystem classification and inventory to serve as the basis for MNR decision support, planning, and monitoring. Provincially, defining the upper levels of the ELC hierarchy (Ecozones, Ecoregions, Ecodistricts) is nearly completed (Crins and Uhlig, 2000). This will provide the necessary spatial, ecological framework for the corporate natural resource information system (NRVIS).

ELC is used at different scales. It is currently being incorporated into the Ministry of Natural Resources' Natural Resources Values and Information System (NRVIS Version 2), which should facilitate linking it to geographic information systems (GIS) and other local and regional databases. Furthermore, ELC is the framework adopted by the Natural Heritage Information Centre (NHIC) for community ranking (Bakowsky 1996) and database management of community-related data. It provides decision- making information at several geographical, ecological, and administrative levels.

ELC is an effective tool to address these needs at regional, sub-regional, landscape, and site levels. It provides a uniform and consistent approach to ecosystem description and classification. It facilitates evaluation of communities, and it presents a framework for consistent data collection, assembly, and management across municipalities, regions, forest management units, and watersheds.

Applications

Forest Management

The single largest area of application of ecosystem classification products has been in the area of forest management. ELC has facilitated on-site, community-level evaluations of forest site conditions, silviculture planning, inventory, environmental impact assessment of forest operations, productivity evaluation, prescribed burning, wildfire management, and control of competitive vegetation. Current forest management planning must address the issue of diversity from the community and ecosystem level rather than the species-by-species approach (Harris 1984}. At the Ecosite and Vegetation Type levels, ELC facilitates an ecosystem-based approach to the management of standardized silvicultural units within ecological regions (Hills 1966; Grins et al. in prep) or Forest Regions (e.g., Great Lakes-St. Lawrence and Carolinian Forest Regions, Rowe 1972). Silvicultural guides are currently incorporating ELC units as an integral part of forest management (OMNR 2000).

ELC enables data collection for basal area calculations. In addition, information on vegetative structure and composition, and disturbance levels is gathered, using recommended ELC processes. Therefore, ELC provides a framework for the collection and analysis of traditional data sets required for silvicultural prescriptions. It also enables a more holistic, community-based analysis of the timber potential of a particular unit.

Wildlife Management

Numerous studies have examined wildlife species occurrence and abundance in the context of the habitat descriptions provided by ecosystem classifications. Habitat suitability and management guidelines have been developed for most boreal birds and mammals. The specific ecosystem-habitat relationships have been used to guide inventory evaluations for various species and are used to spatially assess wildlife habitat supply and impact of forest management practices. The ecosystem classifications are the basis of the EA-mandated Wildlife Habitat Environmental Guidelines.

Research

Our knowledge of community composition and function, and species-habitat relationships continue to increase through research conducted by universities, resource management agencies, and other individuals and groups. ELC provides a common language of communication among researchers for stratifying ecosystem conditions for study and sharing their findings. In addition, ELC provides a basis for gap analysis. The lack of information on vegetation and environmental characteristics for certain community types (e.g., wetland, non-forested, and cultural) should provide a focus for future research efforts.

Private and Public Land Stewardship

Consistent ecological information is required for sound planning for Sustainable Forest License areas, private Freehold lands, municipal and county forests of southern Ontario, conservation authorities, and small, private woodlots. There is a pressing need for a common language and inventory framework among industrial partners and small landholders regardless of ownership or jurisdiction. This is particularly the case in southern Ontario where more than 90% of the land base is privately owned (Riley and Mohr 1994), and where landowners play a significant role in the protection, management, and restoration of natural communities and wildlife habitat. A variety of stewardship programs has shown that landowners educated in the ecological values of their property increase conservation efforts (Hilts and Maull 1990). Application of ELC standards has provided landowners with a wealth of information on their lands and a sound scientific basis for inventory and management decisions. Standardized community descriptions facilitate communication between resource professionals and private landowners. Greater efficiencies are possible through stewardship guidelines or recommendations based on ELC.

Natural Heritage Planning and Protection

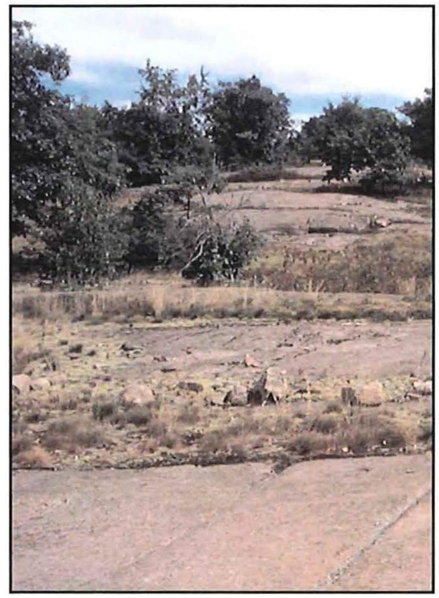
Protecting the ecological integrity of natural heritage areas should be the basis for most park or conservation area planning decisions (see Poser et al. 1993). If a park is created or managed for the protection of species, considerable focus must be placed on habitat. As Hummel (1995) indicated, "if we don't conserve the underlying ecological processes and larger natural systems upon which species depend, we will simply be fiddling”.

Current ecoregionalizations are based on the work of Angus Hills and more recent adjustments by Crins and Uhlig. They provide the basis for the evaluation of natural feature representation in the province and guide the identification and management of park areas and rare species. At finer scales, ecological classification can help ensure adequate representation of natural areas and habitats within a park system. It has also proven effective in identifying priority sites for conservation or acquisition (Jalava and Godschalk 1998).

Land base changes due to human impact have changed the face of Ontario. Many areas in southern Ontario have less than 5% woodland and less than 10 or 15% cover by any native ecosystems. In addition, more than 50 species of plants and animals are thought to be extirpated from southern Ontario since European colonization (Riley and Mohr 1994). Individuals, groups, and agencies are beginning to restore lost or degraded natural communities and species (Daigle and Havinga 1996; Waterfront Regeneration Trust 1995; Hough et al. 1994). ELC benefits the development and implementation of recovery plans for individual species by assisting agencies in locating existing suitable habitat types province-wide.

The recent development of Wetland Ecosystem Classification has also improved the Ontario Wetland Evaluation System (OWES) process using objective ecosystem classification and inventory methods. The NW and Southern ELCs increase reliability and objectivity in the identification and mapping of wetland conditions.

2. Ecological Land Classification



Plant Classification

Flower

- floral parts
- symmetry
- flower arrangement.

Leaves

- arrangement(alternate/opposite)
- shape
- margin

Ecosystem Classification

Geology

- bedrock, parent material type (carbonate, acidic, basic)

Physiography

- landform, modes of deposition
- topographic position (slope position, shape)

Soils

- depth, texture, nutrient status, moisture regime

Vegetation

- physiognomy (i.e., deciduous, conifer, mixed)
- species composition

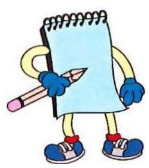
Figure 1
Classification of ecological communities uses environmental. And biological characteristics to distinguish them, just like the classification of plants uses floral and leaf characteristics to help distinguish species.

An Analogy

Just as a taxonomy and naming convention for species has facilitated. research and the accumulation of knowledge, ELC strives to, in a similar way, organize, categorize, and name ecosystems (Figure 1). Like the use of plant characteristics to distinguish species, ELC uses characteristics about ecosystems to distinguish separate communities. As plant classification enables communication at the species level, ELC provides the means to go up in scale to describe, identify, and map communities.

Ecological Land Classification

- moves up in scale -from species to community level classification.
- looks for community and landscape patterns and processes at different levels of scale.
- uses important ecological factors and distinguishing characteristics (e.g., soil texture, moisture, species composition) to identify community patterns.
- reduces continuous natural variation to a reasonable number of community units.
- is a uniform and consistent approach to describe, identify, classify, and map ecological land units.
- uses consistent methodology and data collection standards.
- uses common language to improve communication about ecosystems.
- moves towards ecological land-use planning and ecosystem management.
- has legal implications in some jurisdictions.
- is flexible and expandable.



The ELC Model

ELC establishes patterns among climate, geology, landform, soils, and vegetation, at different scales.

The study of Ecology looks at the interactions between organisms and their environment to try and explain their distributions and abundances. More specifically, ELC examines plant species distributions and assemblages and tries to understand them according to ecosystem patterns and processes - i.e., where does a particular species occur; what other species coincide with it in recurring assemblages; and what are the mechanisms that are responsible for community assembly? **ELC establishes patterns among climate, geology, landform, soils, and vegetation, at different scales.** The goal is to understand the underlying environmental mechanisms for screening and sorting species, at different scales, so we can understand and predict patterns in vegetation communities. These patterns are recurring assemblages of vascular plant species found under functionally similar suites of environmental variables.

- At a **very broad** scale, we see broad patterns in the types of vegetation that stretch across the country. It is primarily climate which affects large-scale distribution of vegetation. These broad bands generally follow lines of latitude and, therefore, reflect the influence of climate on where species can grow. At this scale, we see that treeless tundra areas occur in the extreme, coldest northern environments. Conifer trees are better able to tolerate extremes and make up much of the boreal forest that extends at mid-latitudes across the country. In contrast, deciduous trees are less tolerant of shorter growing seasons and extreme temperatures. They become prevalent in the warmer, more southern areas. These emergent patterns at the broad scale, shown in **Table 1,** have been interpreted, described, and mapped by various researchers, the most notable of which are Rowe (1972) and members of the Canadian Committee on Ecological Land Classification (Wickware and Rubec 1989; Canadian Committee on ELC 1989).

- At a **broad** scale, vegetation patterns are influenced by an interaction of the geology of bedrock, depth of surficial materials, and effects on climate by broad topographical features, such as moraines and drumlin fields. At this scale, differences among the erosion and fertility qualities of granitic Canadian Shield and Paleozoic rocks, for example, are reflected in broad vegetation patterns. Certain thresholds in climate, involving temperature, humidity, and precipitation, also appear to screen and select for species in floras. Thresholds in such variables appear coincident with species distribution boundaries. For example, the number of growing days, or frost-free days, in a year has been used to map patterns at this scale. Establishing these relationships allows us to delineate zones and regions to provide an ecological context to interpret vegetation patterns.

- At a **mid or meso** scale, the distribution and composition of vegetation are further screened by features in the landscape which determine relief and resource availability, such as topography, soil, and hydrology. As these environmental features vary across the landscape, they create a patchy mosaic of unique ecological conditions which support associations of vegetation communities.

- At a **fine** scale, variables in slope position, aspect, soil depth, soil texture, and moisture influence vegetation patterns across local gradients. At this scale, disturbance, and proximity to seed source also influence species distributions and assemblages. Patterns in species assemblages across these gradients are established using research plots. At the fine scale, other aspects of species' ecology determine specific species assemblages. Environmental tolerances, seed dispersal, germination requirements, and ability to compete for resources finally sorts out the composition and relative proportions of species in vegetation communities.

With information on which aspects of the environment, at a particular scale, influence the patterns in vegetation, we can develop a model for ecosystem organization and assembly. **Figure 2** uses a set of sieves as an analogy to demonstrate the screening of species at different scales. Once we have identified a region of relatively uniform climate, we observe a modal, or typical, response in the vegetation. If essential resources, such as water, nutrients, substrate, and light, are in adequate supply, and there is no disturbance, the modal community will dominate.

As we move out of the modal, or typical, community regime, fewer of the modal conditions are met. Ecological conditions change, becoming more extreme or limiting along gradients of slope, soil depth, soil texture, moisture, nutrients, and disturbance. Similarly, the competitive advantage among species changes. Other species better able to tolerate, or thrive in, marginal or peripheral conditions occupy these sites. The centrifugal organization model shown in **Figure 3** depicts this idea of a central, or modal, community response (Keddy and Maclellan 1990). At the centre of the figure, we find species that are the best competitors for resources under ideal, non-limiting conditions; in the forest example, Sugar Maple and Beech forests tend to occupy modal sites in southern Ontario. Axes moving out from the centre represent movement along environmental gradients, from least severe to most severe at the periphery. Using our example, moving from a Sugar Maple Forest to a White Pine-Oak Forest may represent the changes observed when moving from a relatively deep soil to a shallow or bedrock site. The coincident changes in rooting depth, available moisture, and nutrients shift the ecological balance from a modal community to a peripheral site.

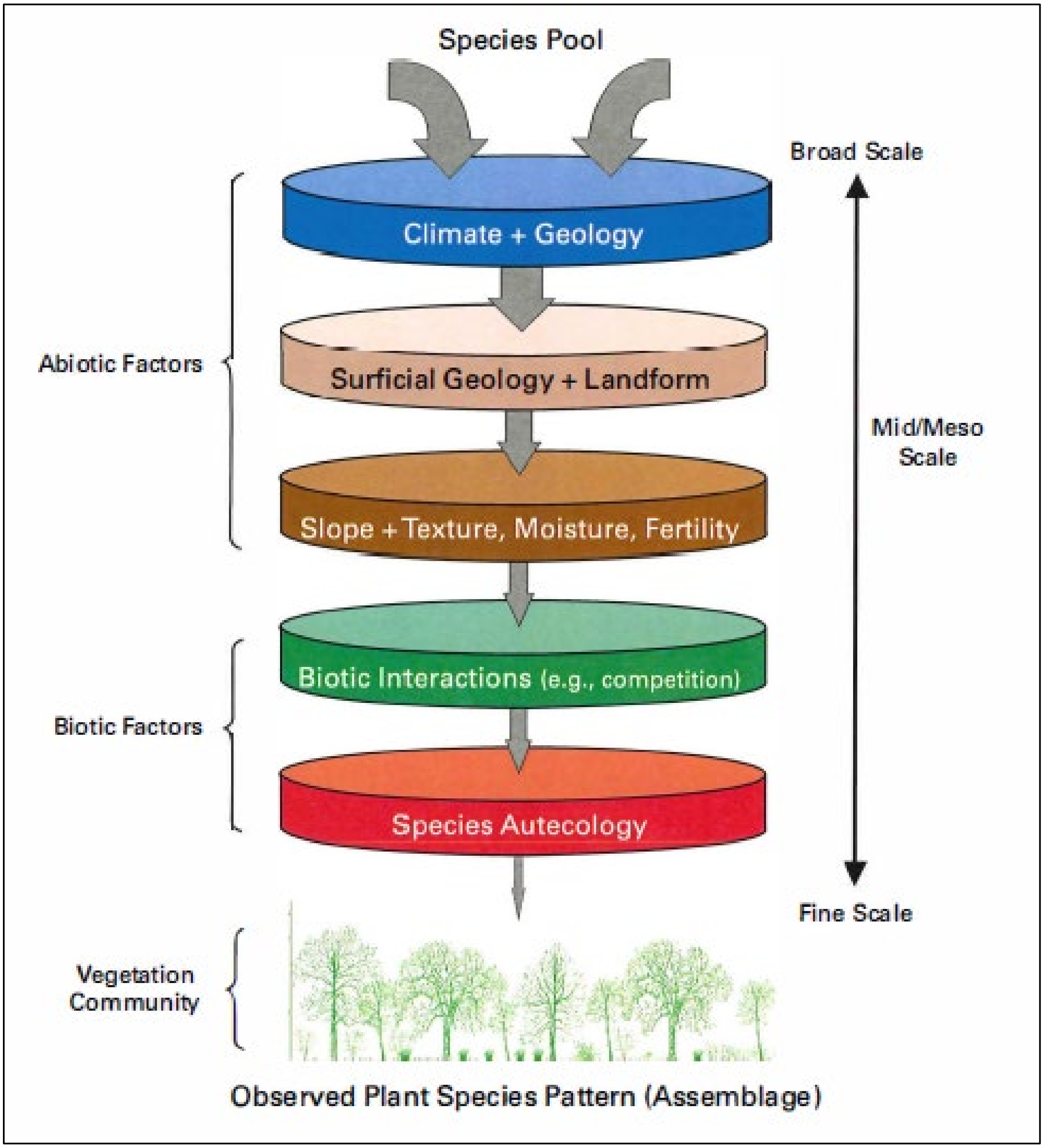
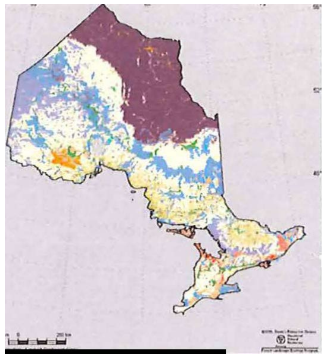
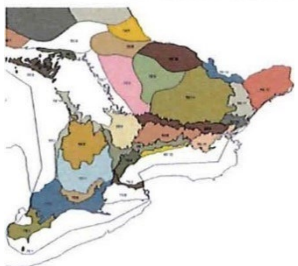
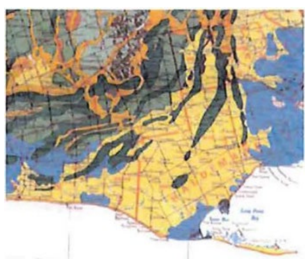
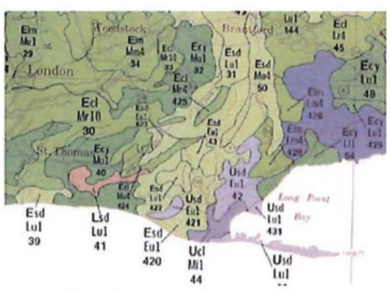


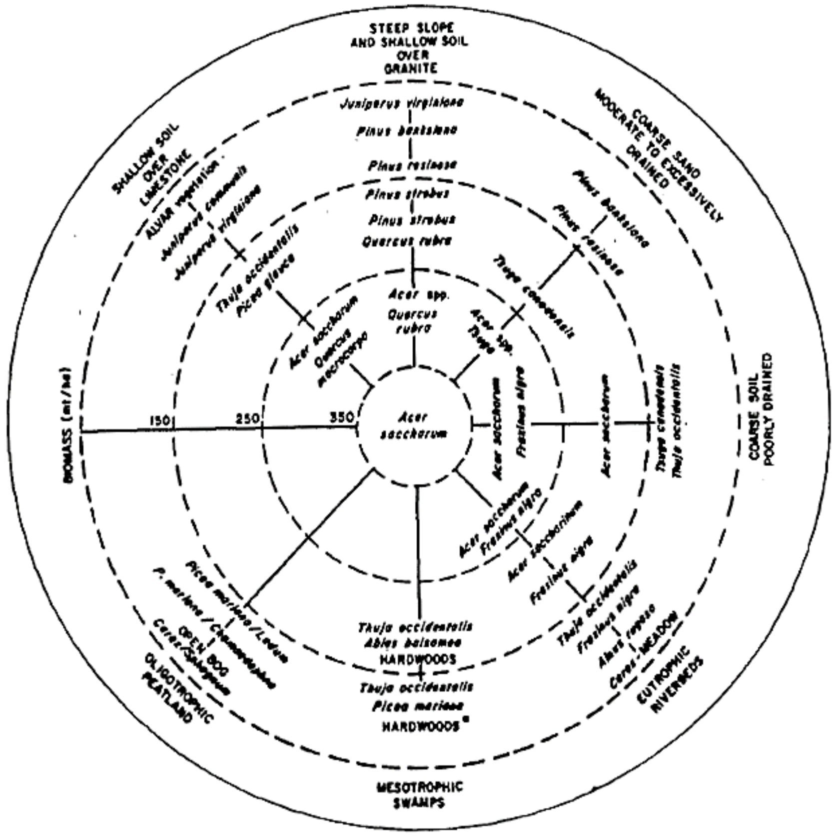
Figure 2

ELC model for community assembly: diagrammatic representation of how the abiotic environment and biotic factors act to screen and select for different vegetation and species characteristics, at different scales, to result in local observed plant species assemblages.

Table 1. Current imagery, data sources, and applications developed and used for different scales of planning and Ecosystem management.

	Data	Applications	Scale	Unit Name(s)
Ontario Ecoregions and Eco districts of Ontario  	• Satellite Imagery • Geology • Climate • Digital Elevation Model	• Natural Heritage Policy • Provincial Policy Statement • Crown Forest Sustainability Act - limber EA; Forest Management Planning • Provincial Analyses - roll-up • National State of the Environment; Sustainability Reporting	1:500,000-3,000,000	• Ecozone • Ecoregion; Site Region (Hills)
Southern Ontario 	• Satellite Imagery • Surficial Geology • Physiography • Climate	• Subregional Planning • Biodiversity assessment • Parks class targets • Life science representation • Wildlife management	1:250,000-500,000	• Eco region; Site Region (Hills) • Ecodistrict; Site District (Hills)
Landscape to Land Unit   	• Satellite Imagery • Air photos • Landform • Slope • Soils • Mesa-scale Climate • Drainage	• Official Plans • Watershed, Sub-watershed Plans • Wildlife management units • Comprehensive Environmental Impact Studies	1:50,000 - 250,000	• Eco district; Site District (Hills) • Eco section • Watershed • Landform (Chapman and Putnam 1984) • Soil Landscape • Soil Mapping • Canada Land Inventory • Ontario Land Inventory
Community 	• Air photos • Soils - texture, moisture, fertility • Vegetation	• Site-level Planning • Stewardship • Silviculture • Wetland Evaluation • Woodland Evaluation • Environmental Impact Studies • Environmental Assessments	1:2,000 - 20,000	• Ecosite • Vegetation Type • Soil Type • Cover Type • Stand

1. Forest



2. Marsh

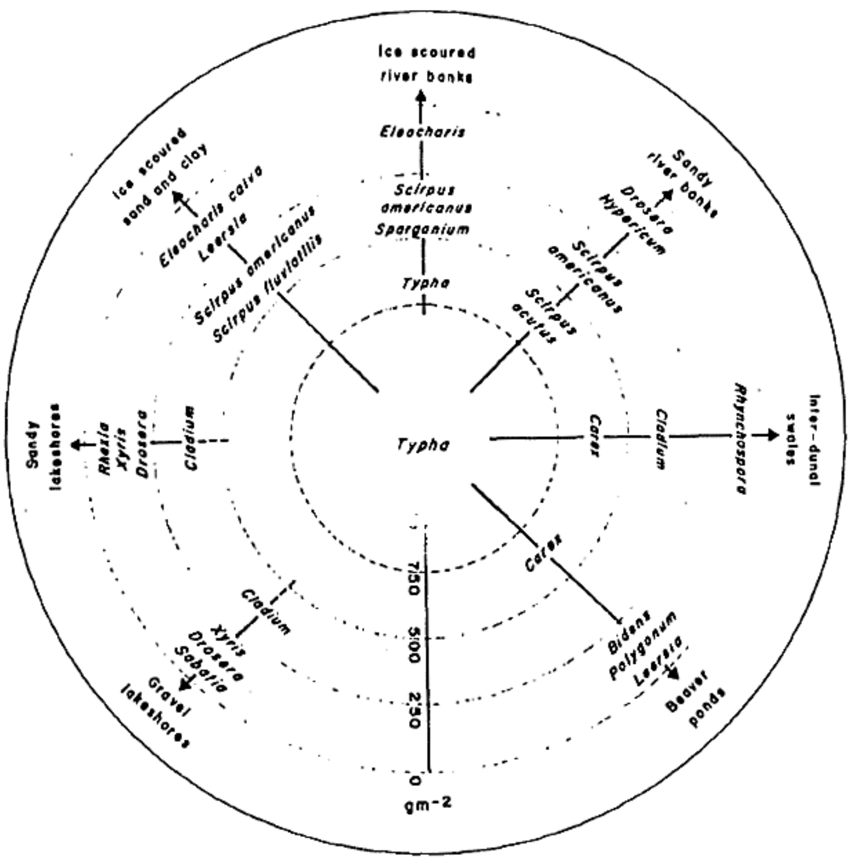


Figure 3

Centrifugal organization model.

These models are the basis for the development of an Ecological Land Classification. Understanding the principles of scale and their associated mechanisms for ecosystem organization is key. This is especially important when considering the ongoing management of natural heritage resources, at different scales. **Table 1** shows the different levels of scale at which we have gathered information and managed our resources. **Table 1** also shows how ELC units, at different scales, coincide with management applications, from provincial natural heritage policies to local site-level planning.

See references for further background reading on ecology and ecological land classification.

ELC in Canada

Since the early 1950s, there has been considerable work done across Canada to develop integrated, ecological approaches to land-unit description and classification (see Bailey et al. 1978; Sims and Uhlig 1992; Uhlig and Baker 1994 for useful reviews). The goal of such classification schemes is to identify recurring ecological patterns on the landscape in order to reduce complex natural variation to a reasonable number of meaningful ecosystem units (Bailey et al. 1978).

The pioneering work of Hills (1952, 1958) in Ontario, Krajina (1965) in British Columbia, and, at the national level, Rowe (1962, 1971, 1972; Rowe and Sheard 1981) has provided much of the conceptual basis for developing Ecological Land Classifications in Canada. Hills and other authors have defined ELC in terms of spatial hierarchies (Hills 1958; Bailey 1983, 1987; Bailey et al. 1978; Wickware and Rubec 1989a). Hills defined functionally and spatially related units; from large to small scale, they are Site Region, Site District, Landscape Unit, Site Type and Site Phase. Hills's hierarchical framework was capable of integrating resource inventories at various scales and it has been used for a variety of purposes by the Ministry of Natural Resources to guide planning and management. The reader is encouraged to consult Sims (1992) and Sims and Uhlig (1992) for histories of this pioneering work.

Hills's work is a benchmark, a basis upon which to build quantitatively based ecological units at the site-level scale. The Canada Committee on Ecological Land Classification (CCELC) generated uniform terminology and descriptions for the hierarchical levels of the Canadian ecosystem classification. In its proposed spacial hierarchy of Ontario, the CCELC set six hierarchical levels: Ecozone, Ecoregion, Ecodistrict, Ecosection, Ecosite, and Ecoelement (Environmental Conservation Service Task Force 1981; Wiken 1986; see **Table 2).** Ecozones to Ecodistricts have been defined and mapped across Canada (Wickware and Rubec 1989b). The levels in this proposed hierarchy, along with their operating scale and their applications, are summarized in **Table 2.**

Many jurisdictions have developed ecological classification schemes, including British Columbia (Krajina 1965; Pojar et al. 1987; Klinka et al. 1991; Meidinger and Pojar 1991), Alberta (Corns and Annas 1986), Ontario (see Sims and Uhlig 1992 for review), Newfoundland (see Meades and Roberts 1992 for review) and many areas in the United States (e.g., Bailey 1976, 1980, 1987; Reschke 1990; Nelson 1987; Kotar et al. 1988).

Table 2. The proposed spatial hierarchy of Ecological Land Classification units for Ontario (modified from Racey et al. 1996; based on Environmental Conservation Service Task Force 1981 and Wiken 1986).

Classification Unit [1]	Appropriate Scale[2]	Recommended Tools[3]	Example of Management Applications
Ecozone	**1:500,000-3,000,000** 10,000-1,000,000 km^2	Wiken **(1986)**	Ecological context for Ontario; planning; policy
Ecoregion	**1:500,000** 1000-10,000 km^2	Hills's Site Regions of Ontario (Crins and Uhlig 2000; Hills 1961; Burger 1993)	Strategic planning at regional or sub-regional levels; policy
Ecodistrict	**1:250,000-1:500,000** 100-1000 km^2	Hills's Site Districts of Ontario (Crins and Uhlig 2000; Hills **1961)**	Strategic planning at sub- regional level, watershed plans; policy
Ecosection	1:50,000 - 1:250,000 1000-10,000 ha	Ontario Land Inventory (MNR 1977), Physiography of Southern Ontario (Chapman and Putnam 1984)	Major landform contributions for forest prime land, broad habitat trends, watershed and subwatershed plans
Ecosite	1:**10,000** - **1:20,000** 10-100 ha	Ecological Land Classification for Southern Ontario: First Approximation and Its Application	Ecosystem mapping; conservation; inventory; regional planning; evaluation; silvicultural ground rules; wildlife habitat; sub-watershed plans
Ecoelement	1:**2,000-1:10,000** 100-100,000 m^2	Vegetation Type in the Ecological Land Classification for Southern Ontario: First Approximation and Its Application	Site and stand level research; inventory; development proposal; environmental impact assessment; evaluation; conservation

Notes

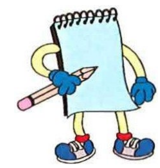
1. Units according to the Canada Committee on Ecological Land Classification (Environmental Conservation Service Task Force 1981; Wiken 1986).
2. Appropriate scales are identified, first in terms of appropriate cartographic scale, then in terms of typical size or resolution.
3. Not all levels of ELC are represented by products suited for use in southern Ontario. Recommended tools include existing maps, classifications, and publications available to land managers that represent ecological features at appropriate scales.

Ecological classification work in Ontario has built upon the CCELC hierarchy (Sims and Uhlig 1992; Uhlig and Baker 1994). Initially, studies done in northern and central Ontario in the 1980s and 90s resulted in the Forest Ecosystem Classifications (FEC). The FEC was developed using a baseline established by site studies (Jones et al.1983; Merchant et al. 1989; Sims et al. 1989; McCarthy et al. 1994; Chambers et al. 1997). These products were the first steps towards developing a quantitative ecological hierarchy in Ontario. The Southern ELC Field Guide was developed as a tool to accommodate the range of community types found across Ontario, and particularly to address land-use planning issues. The Southern ELC provides a comprehensive framework, accommodating the range of community types found in Ontario, including alvars, tallgrass prairies, bluffs and wetlands as well as forests.

With the development of the Southern ELC, we move closer to having a comprehensive mapping tool for Ontario.

ELC in Ontario

The goal of the provincial Ecological Land Classification (ELC) is to establish a comprehensive and consistent province-wide framework for ecosystem description, inventory, and interpretation. ELC facilitates key conservation, planning and ecosystem management objectives, at various scales of resolution (Uhlig and Baker 1994; Lee 1993).



The key focus of ELC is to improve our ability to manage both natural resources and the information about those resources. **Now, more than ever, we need a uniform and consistent way to identify, describe, name, map, manage, and conserve important landscape patterns and communities** (Riley and Mohr 1994). **To accomplish this, all resource management partners need a common framework by which to collect, organize, analyze, and report on ecological information** (Brownell and Larson 1995; Riley and Mohr 1994).

Now, more than ever, we need a uniform and consistent way to identi-fy, describe, name, map, manage, and conserve important landscape pat- terns and communities. To accomplish this, all resource management partners need a common framework by which to collect, organize, analyze, and report on ecological information.

The first approximation of ELC represents a synthesis and organization of over 4,000 community descriptions. However, as we learn more about the ecology of southern Ontario through field sampling, reviews of this product, and additional community descriptions from others, ELC will be further refined.

Mapping and inventory are important components of ELC. To be useful, ecological units must be mappable. ELC must provide, at the minimum, the demonstration of operational mapping technologies at a variety of scales. Protocols for air photo interpretation and mapping of ELC units have been developed in northwestern Ontario (Arnup and Racey 1996). We are currently refining these approaches for application to southern Ontario.

Identification of Ecosites and vegetation types in the field is another important component of ELC. ELC forms the basis for ongoing research by providing objective stratification and sampling of ecological conditions. This is especially important for major applications such as growth and yield studies, vegetation management studies, long -term ecological research, forest and wetland management plans, wildlife habitat analysis, life science inventories, park planning, private land stewardship, restoration, and land -use planning.

Regional Context

This manual and the ELC for southern Ontario apply to land and water units found within the 1995 southern Ontario administrative region of the Ontario Ministry of Natural Resources. This area is represented by Hills's Ecoregions 6E and 7E (Crins and Uhlig 2000). The manual and ELC, therefore, apply to the area roughly enclosed by the Ontario-Quebec border, along the north shores of Lake Ontario and Lake Erie, up the east shoreline of Lake Huron to the tip of the Bruce Peninsula, around. Georgian Bay to Midland, and eastward through Orillia, Marmara, and over to Arnprior **(Figure 4).** This area does not include Manitoulin Island.

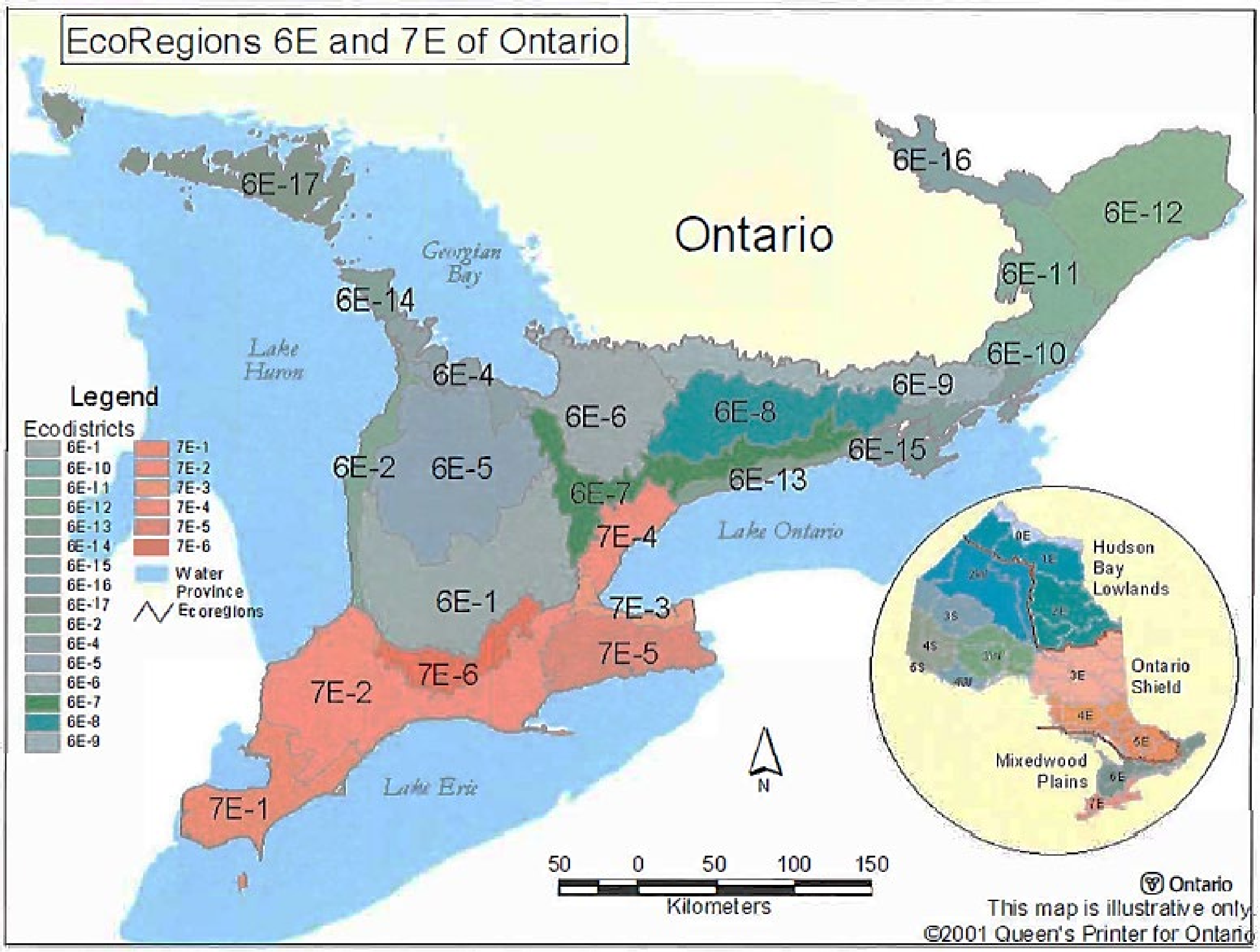


Figure 4

The Ecoregion and Ecodistrict lines for Ontario: this manual is applicable to Site Regions 6E and 7E of southern Ontario.

3. ELC Organizational Framework

The southern Ontario ELC has built further organizational levels into the proposed spacial hierarchy for Ontario outlined in **Table 2.** The southern ELC model is then made up of six nested levels. From the largest to the smallest scale, they are:

- Ecoregion (Site Region)
  - System
    - Community Class
      - Community Series
        - Ecosite
          - Ecoelement (Vegetation Type)

These six nested levels of ELC represent an organizational framework used in ELC application. The framework incorporates three levels that allow a community to be placed spatially within the proposed hierarchy for Ontario **(Table 2).** That is, an Ecosite designation is meaningful within a specific Ecoregion (Site Region).

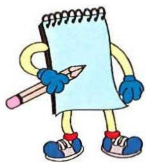
This framework also incorporates three other levels that allow us to understand better a community's ecological organization. That is, there are community patterns across our landscape, based on recurring suites of ecological conditions. Within ELC, these patterns acquire the terms System, Community Class, and Community Series - terms that have been well established in the fields of natural science and ecology. Terms such as fen, swamp, or alvar summarize suites of ecological conditions that are not confined to any particular geographic location.

Therefore, ELC in southern Ontario blends the ability to put landscape units into a spatial context (the provincial hierarchy: i.e., "you are here...") with the ability to understand their community-related organization (e.g., "it is a bog").

Definitions of ELC Levels

Ecoregion (Site Region)

Ecoregion or Site Region represents the highest level (coarsest resolution) of ELC applied within Ontario. Site Region was developed by Hills (1952, 1958, 1960, 1976) and his co-workers (Pierpoint 1964; Burger 1972, 1976, 1993; Burger and Pierpoint 1990) to provide forest and land managers with a province-wide ecological framework (Burger 1993). Hills's Site Regions, as modified by Jalava et al. (1997), are being used for the Ecoregion level in the ELC hierarchy (see **Table 2).**



Ecoregions are areas of land within which the response of vegetation to the features of landform follow a consistent pattern.

In developing the 13 Site Regions of Ontario, Hills and his colleagues stressed the dependence of forest cover on climate, soil moisture, soil nutrients, and disturbance. They defined site regions as **"areas of land within which the response of vegetation to the features of landform follows a consistent pattern" (**Hills 1966). Southern Ontario is composed of two of Hills's Site Regions: 6E and 7E **(Figure 4).**

Ecoregion 6E, the Lakes Simcoe-Rideau Site Region, occupies the northern portion of southern Ontario in what Rowe (1972) called the Great Lakes-St. Lawrence Forest Region. This area is characterized by mixed forests of White Pine (Pinus strobus) and Red Pine *(Pinus resinosa),* Eastern Hemlock (Tsuga *canadensis),* Sugar Maple *(Acer saccharum),* Red Maple *(Acer rubrum),* Yellow Birch *(Betula alleghaniensis),* Red Oak *(Ouercus rubra),* Basswood *(Tilia americana)* and White Elm *(Ulmus americana).* Other wide-ranging species include Eastern White Cedar *(Thuja occidentalis),* Largetooth Aspen *(Populus grandidentata),* Beech *(Fagus grandifolia),* White Oak *(Ouercus alba),* Butternut *(Jug/ans cinerea),* and White Ash *(Fraxinus americana)* (Hills 1959; Rowe 1972).

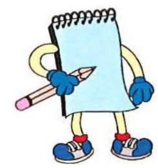
In contrast, Ecoregion 7E, the Lakes Erie-Ontario Site Region, occupies the southern-most portion of southern Ontario in what Rowe (1972) called the Deciduous Forest Region, or Carolinian Zone. This region is dominated by deciduous tree species, such as Sugar Maple, White Elm, Beech, Black Cherry *(Prunus serotina),* White Ash, Red Oak, White Oak, Red Ash *(Fraxinus pennsylvanica)* and Butternut (Hills 1959; Maycock 1963; Rowe 1972). Other, less common yet distinctive tree species include Tulip-Tree *(Liriodendron tulipifera),* Paw -Paw *(Asimina triloba),* Cucumber-Tree *(Magnolia acuminata),* Kentucky Coffee Tree *(Gymnocladus dioicus),* Black Gum *(Nyssa sylvatica),* Blue Ash *(Fraxinus quadrangulata),* Sassafras *(Sassafras albidum),* Black Walnut *(Jug/ans nigra),* Sycamore *(Plantanus occidentalis),* Swamp White Oak *(Quercus bicolor),* Big Shellbark Hickory *(Carya laciniosa)* and Pignut Hickory *(Carya glabra),* Black Oak *(Ouercus velutina),* and Pin Oak *(Ouercus palustris).*

System

System is an organizational level in ELC but does not appear in the CCELC proposed spacial hierarchy for Ontario **(Table 2).** The System level helps reduce a complex natural landscape into a small number of community- based units. It serves as a generalized organizational level that summarizes important ecological patterns and processes.

System has been frequently used as an organizational level by those responsible for categorizing and classifying natural communities (e.g., Reschke 1990; Kavanagh 1990). Similarly, many other community- oriented classification systems have used comparable units for organizing communities. Various names, such as Community Types (e.g., Nelson 1987) or Formation Types (e.g., Jeglum et al. 1974), may have been used in the past as analogous organizational levels in other classification schemes.

The differences among larger scale Systems is mainly the relation between the substrate surface and the depth of the water table (Curtis 1959). Communities are differentiated by the response of the vegetation to differing ecological conditions along a water depth and soil moisture regime gradient. This classification follows the separation of communities into three Systems: Aquatic, Wetland, and Terrestrial Systems.

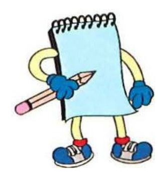


Communities are differentiated by the response of the vegetation to differing ecological conditions along a water depth and soil moisture regime gradient. This classification follows the separation of communities into three Systems: Aquatic, Wetland, and Terrestrial Systems.

The Aquatic System includes shallow or deep standing or flowing waters with little or no emergent vegetation. The depth of the water from the substrate surface, along with its influence on light penetration, represents the primary influence on such communities. Typically, aquatic communities are in water greater than 2 m deep. Within the Aquatic System, deep, open bodies of water are distinguished from those dominated by submerged and floating-leaved plant species.

The Wetland System includes those areas where water levels fluctuate and are less than 2 m in depth. It is the predominance of emergent hydrophytic herbaceous and woody vegetation that best distinguishes wetlands from aquatic communities. Further categorization of wetland communities is based on the extent and duration of flooding, combined with substrate type, disturbance (i.e., shoreline energy) and levels of available nutrients (Hutchinson 1975; Van der Valk 1981; Day et al. 1988; Keddy and Reznicek 1986; Zoltai and Vitt 1995).

The Terrestrial System includes all those upland areas where the water table is normally below the substrate surface. In many upland areas, unlike communities in the Aquatic and Wetland Systems, soil moisture is scarce at some point in the growing season. The distribution and abundance of plant species in upland areas are, therefore, affected by the availability of soil moisture, as well as by the nature of the parent material, physiography, soil depth and texture, drainage, disturbance, and the levels of available nutrients (Curtis 1959; Grime 1979).



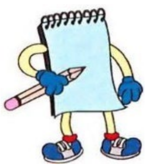
Community Class units range from units that have been very clearly defined (e.g., forest, marsh, cliff) to those that are broader or more vague (e.g., rock barren, savannah, sand barren).

Community Class

The Community Class level, like System, is a useful organizational level for ELC, but is not part of the proposed spatial hierarchy for Ontario **(Table 2).** Community Classes are useful for organizing communities into groups, based on some similar, yet generalized, ecological patterns and processes.

Many of the Community Class units will be familiar, having been part of the natural history and community ecology dialogue for many years. They range from units that have been very clearly defined (e.g., forest, marsh, cliff) to those that are broader or more vague (e.g., rock barren, savannah, sand barren). The objective here is not to reinvent any of these terms but to incorporate in the classification the most widely accepted definitions of these units to create a uniform and consistent classification format.

The criteria used to identify or discriminate among different community classes varies. Ultimately, the division of Community Classes is based on recurring patterns in plant species associations that have shared physiognomic characteristics, substrate type, geology, and meso- and microclimate, as well as other ecological factors. For example, a cliff is readily identified by a near-vertical exposure of consolidated rock. In contrast, to identify a tallgrass prairie, savannah, and woodland, the relative percent cover of trees along with the identification of a specific tallgrass assemblage of herbaceous species is necessary. The criteria used to identify each Community Class is found in the ELC Keys and Community Tables.

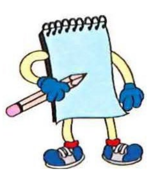


Community Series are distinguished based on the type of vegetation cover or the plant form that characterizes the community. For the most part, Community Series are identified based on whether the community has open, shrub, or treed vegetation cover, as well as whether the plant form is deciduous, coniferous, or mixed.

Community Series

Community Series also represents a useful organizational level for the classification yet is not part of the proposed spatial hierarchy for Ontario **(Table 2).** Community Series units break down Community Classes into units that are normally visible and consistently recognizable on-air photos or from a combination of maps, air photo interpretation and other remote sensing techniques. Community Series are the lowest level in ELC that can be identified without a site visit.

Community Series are distinguished based on the type of vegetation cover or the plant form that characterizes the community. For the most part, Community Series are identified based on whether the community has open, shrub, or treed vegetation cover, as well as whether the plant form is deciduous, coniferous, or mixed. These differences in vegetation cover typically reflect differences in disturbance levels, light levels, and various other environmental gradients.



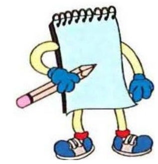
An Ecosite is a mappable landscape unit integrating a consistent set of environmental factors and vegetation characteristics. These characteristics represent the recurring plant species patterns selected for, and maintained, by varying ratios of different environmental factors.

Ecosite

Ecosite is defined as "a part of an Ecosection having relatively uniform parent material, soil and hydrology, and a chronosequence of vegetation", according to the proposed spacial hierarchy for Ontario (**Table 2).** That is, it is a mappable landscape unit integrating a consistent set of environmental factors and vegetation characteristics. These characteristics represent the recurring plant species patterns selected for, and maintained, by varying ratios of different environmental factors.

In northern and central Ontario, the Forest Ecosystem Classifications (FEC) (Jones et al. 1983; Merchant et al. 1989; Sims et al. 1989; McCarthy et al. 1994; Chambers et al. 1997) and the Northwestern Region Wetland

Classification (Harris et al. 1996) have been instrumental in refining the concept of Ecosites. These works have found that the principal elements used to define and identify Ecosites are:



Geology	Soils	Vegetation
bedrock type	depth	structure
	texture	species composition
	moisture regime	physiognomy
	nutrient regime	
	drainage	

Ecoelements are recurring patterns found in the plant species assemblages associated with a particular suite of soil types. Ecoelements are generated by grouping together plant communities that are most similar, based entirely on the plant species composition.

Ecoelement (Vegetation Type)

Ecoelements are recurring patterns found in the plant species assemblages associated with a particular suite of soil types. Ecoelements are generated by grouping together plant communities that are most similar, based entirely on the plant species composition. The goal is to distill the natural diversity and variability of plant communities to a small number of relatively uniform vegetation units. Classifying the Ecoelements normally includes the species that dominate the plant community, according to relative cover, and the soil types found.

4. How to Apply the ELC

The Process of Application

Whether the goal is planning (e.g., an official plan or a development proposal) or a life science inventory, the tools and techniques presented in this manual can be applied in a consistent manner. **Figure 5 shows** how these tools and techniques can be applied both at meso scales and at fine scales of resolution. **Table 3** gives further details on how to carry out the required tasks at the desired scale.

Meso Scale

Application at the meso scale (Ecodistrict to Ecosection; may also be referred to in other disciplines as the landscape scale), using only air photo or satellite imagery interpretation, is coarse. At this coarse scale of resolution, polygons can only be described, classified, and mapped to the Community Class and Community Series levels in ELC (e.g., Deciduous Swamp, Open Cliff or Coniferous Forest). This level of application gives a coarse-level ELC-based inventory on a regional, municipal, watershed, or sub-watershed scale, upon which official plans or watershed plans can be developed.

Fine Scale

Application at the fine (or Ecosite to Ecoelement) scale requires fieldwork. At this scale of resolution, it is necessary to collect the detailed site, soil, and vegetation data that are used to describe, classify, and map polygons to the Ecosite and Ecoelement levels in ELC (e.g., Bur Oak Deciduous Mineral Swamp Type, Cliffbrake-Lichen Carbonate Open Cliff Type, Fresh-Moist Hemlock Coniferous Forest Type). This detailed application level provides the information needed for site-level environmental impact assessments, evaluations, forest management, detailed life science inventories, restoration, land stewardship, and development proposals, to name a few. Furthermore, important management, disturbance, and wildlife information can be collected for other land-use purposes.

Combined Approach

The challenge is that most resource managers and planners need to operate across many scales. The tools and techniques presented here represent an integrated model approach for inventory and information.

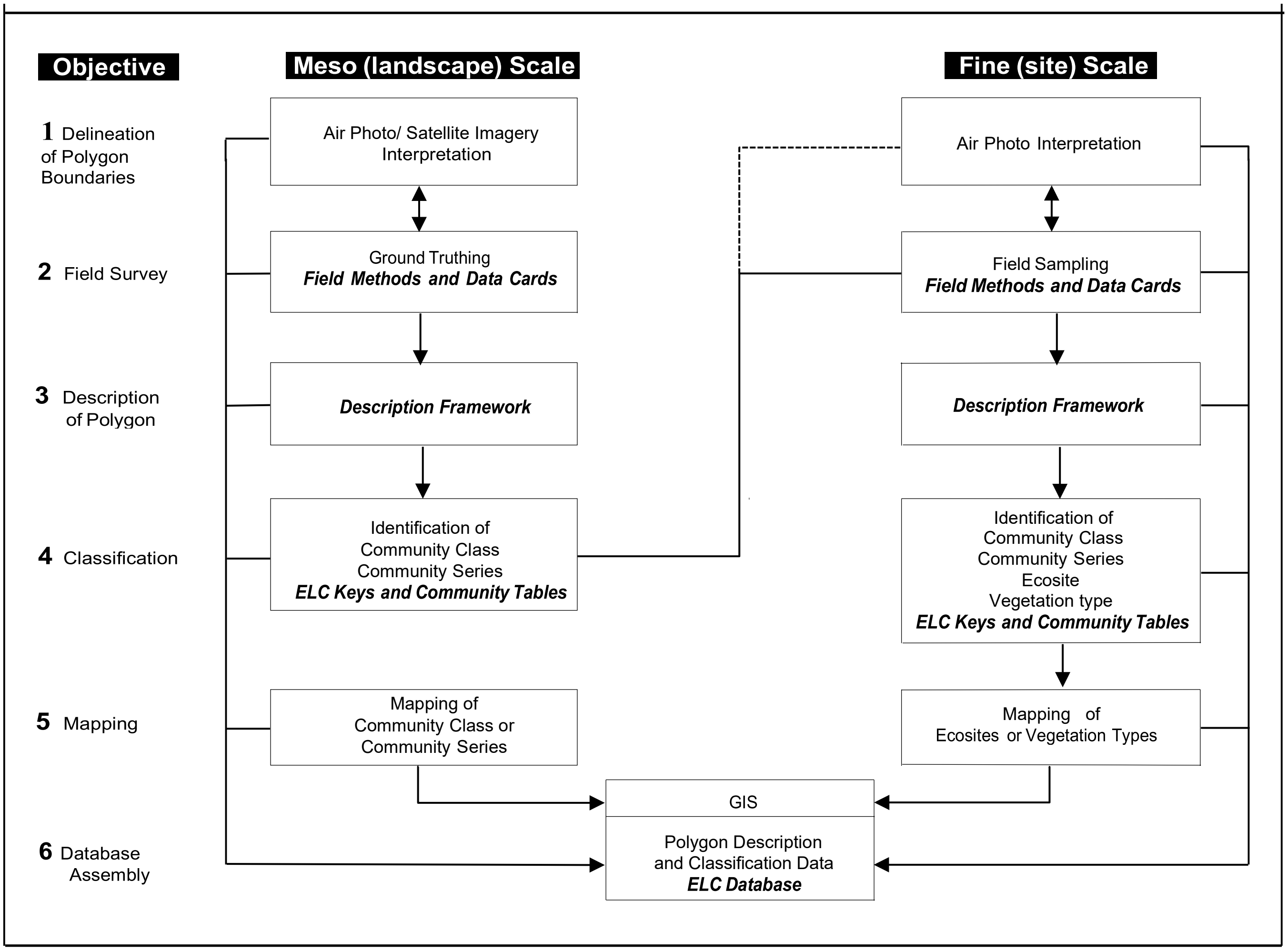


Figure 5

Schematic representation of how the tools and techniques in the ELC Field Guide and Training Manual are applied at different scales of resolution (refer to Table 3 for details).

management suitable for meeting these various scale and resolution needs.

In the short term, the mesa-scale level of application provides the necessary coarse-level products for resource management and planning. Application at this scale, using remote sensing, provides mapping across a jurisdiction, whether it be watershed, municipality, or conservation authority. The resulting coarse-level mapping would be at the Community Class and Community Series levels. This establishes a consistent framework by which more detailed Ecosite and Ecoelement-level information can be accumulated, as sites are visited over the long term.

In the ELC Database, detailed Ecosite and Ecoelement-level information simply appends the existing mesa-level records for any particular polygon. **Figure 5** shows how all the data and information collected are channeled into a centralized database. Consistent polygon descriptions and classifications for polygons, therefore, increase the search and query capabilities within the database.

Table 3. How to apply the tools and techniques in this manual to accomplish the *Objectives* in Figure 5.

	Objective	Meso (landscape) Scale	Fine (site) Scale
1	Delineation of Polygon Boundaries	• use landform, slope position, hydrological drainage patterns, and vegetation forms and cover to interpret and delineate polygon boundaries. • interpret and delineate polygon boundaries, at the meso scale of resolution, according to need: 1) interpret the more generalized Community Series-level boundaries; or 2) interpret and delineate all ecological boundaries for polygons that typically represent the more detailed Ecosite and Vegetation Type levels. • use additional information to help interpretation. • refer to the Case Studies section in the Field Guide and Arnup and Racey (1996) for further details on interpretation of air photos	• use landform, slope position, hydrological drainage pattern, and vegetation form and cover to interpret and delineate polygon boundaries. • interpret and delineate all ecological boundaries. If interpretation at the meso scale is only taken to the Community Series level, then go back to the air photos to re-interpret for the finest resolution of ecological land units (this will, more often than not, represent an Ecosite or Ecoelement) • use additional information to help interpretation
2	Field Survey	• select a small set of interpreted polygons, representing a range of site and vegetation conditions. • visit the polygon and use the ELC Field Sampling Methods and Data Cards to collect the necessary data to describe and classify the polygon according to ELC. • test and refine the interpretation of polygons done in **1.** • represents the Ecosite or Vegetation Type level	• conduct field surveys of polygons identified for planning purposes (e.g., a development proposal) or for more systematic purposes (e.g., inventory) • collect detailed site and vegetation data for each polygon using the ELC Field Sampling Methods and Data Cards
3	Description of Polygon	• use the eight fields in the ELC Description Framework to describe the environmental, historical, and vegetation conditions found within the polygon. • note that assigning conditions to History and Plant Form may not be possible at this scale of resolution. • use other information to help assign conditions for Site, Substrate, and Topographic Features	• use the eight fields in the ELC Description Framework to describe the environmental, historical, and vegetation conditions found within the polygon. • assign conditions to all eight fields; other sources of information may be necessary

4	Classification	• use the information and data documented in **1, 2,** and **3** to classify the polygon to the Community Class and Community Series levels. • use the ELC Keys and Community Tables to assign ELC units to the polygon. • note: only Community Class and Community Series level classifications can be achieved without a field visit and sampling of the polygon	• use the information about the polygon, documented in the field in **2** and **3,** to classify the polygon to the Community Class, Community Series, Ecosite, and Vegetation Type levels. • use the ELC Keys and Community Tables to assign ELC units to the polygon. • note: only by using field data can a polygon be classified according to all the levels
5	Mapping	• map polygon boundaries and their corresponding classifications: 1) manually transcribe the boundaries to hard-copy maps; or 2) enter data into Geographical Information Systems (GIS) for digital mapping. • note: mapping is to the Community Class or Community Series level	• map polygon boundaries and their corresponding classifications: 1) manually transcribe the boundaries to hard-copy maps; or 2) enter data into Geographical Information Systems (GIS) for digital mapping. • note: mapping can be done to the Community Class, Community Series, Ecosite or Vegetation Type level
6	Database Assembly and Data Management	• record the spatial relationships, boundaries, and unique identifiers for each polygon in a GIS database. • note: resolution is to the Community Class and Community Series levels.	• record the spatial relationships, boundaries, and unique identifiers for each polygon in a GIS database. • note: resolution is to the Community Class, Community Series, Ecosite, and Vegetation Type levels
		• enter the description and classification information into the ELC database for management. • note: the ELC Database has been designed to accommodate all the information documented for the polygon; coarse-level meso-scale information is stored and managed. • the database has search and query capabilities	• enter the description and classification information into ELC database for management. • the ELC Database has been designed to accommodate all the information documented for the polygon; detailed site-scale information is stored and managed. • the database has search and query capabilities

5. Bedrock and Surficial Geology

Bedrock Geology

To understand ecological patterns, it is first necessary to look at the bedrock materials which underlie them. Geologic materials form the fundamental precursor to soil.
Here, we refer to the underlying consolidated rock, which varies in type, nature, thickness, and chemical properties. It is, after all, this material which forms the foundation of our understanding, and which shapes the way ecological communities develop. Refer to the Reference Section for further reading on bedrock geology (particularly Chapman and Putnam, **1984).**

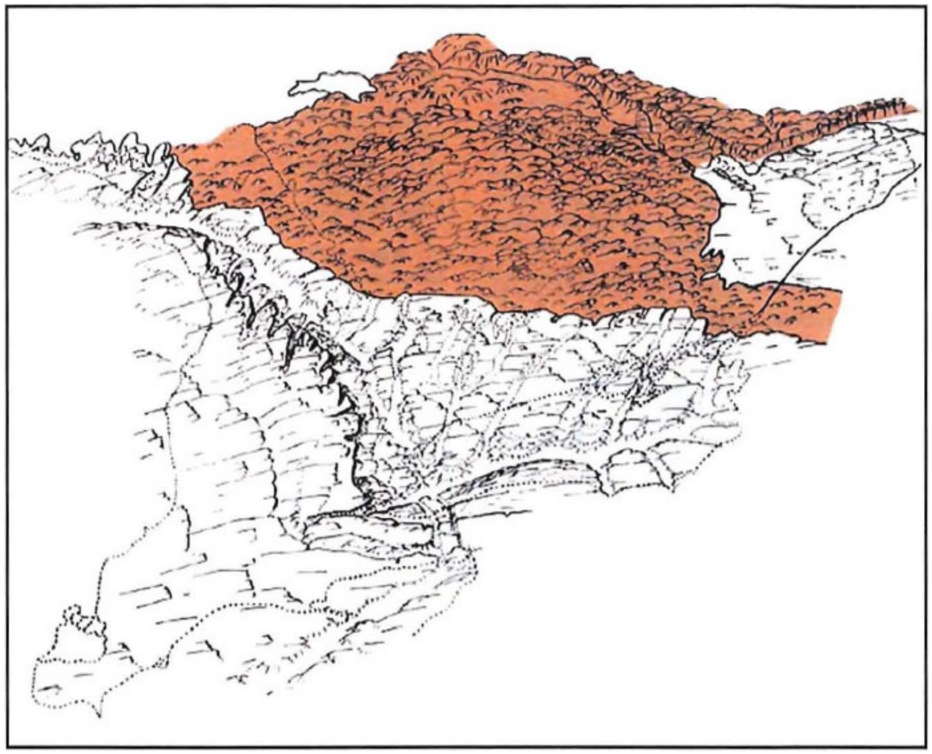


Figure 6

Bedrock topography of southern Ontario. Precambrian rock (Canadian Shield) is shaded; Paleozoic rock is unshaded; from Chapman and Putnam 1984.

In southern Ontario, there are two main types of bedrock materials **(Figure 6).** The north and east are characterized by Precambrian rock.
of the Canadian Shield. The Canadian Shield is made up of acidic metamorphic and igneous rocks which are hard and generally resistant to weathering. Most of this rock can be described as granite, with lesser instances of crystalline limestone, quartzite, and amphibolite (Chapman and Putnam 1984). South and west of the Canadian Shield, the ancient Precambrian rock was overlain by deposits of softer, sedimentary limestones, shales, and sandstones. These are Paleozoic rocks, formed through the deposition of marl, clay, silts, and sand in ancient water bodies. Long periods of weathering and deposition gave rise to great thicknesses of these mate rials, which cemented to form sedimentary rock. **Figure 6** shows the relative locations of the Precambrian Canadian Shield and the Paleozoic rocks. Furthermore, **Figure 7 shows** how the tilted layers of sedimentary rocks were ground down by the glaciers to reveal concentric bands of overlapping beds of limestones, shales, dolostones, and sandstones.

The very nature and properties of the bedrock, and the soil materials which arise from them, affect vegetation distribution. The Precambrian

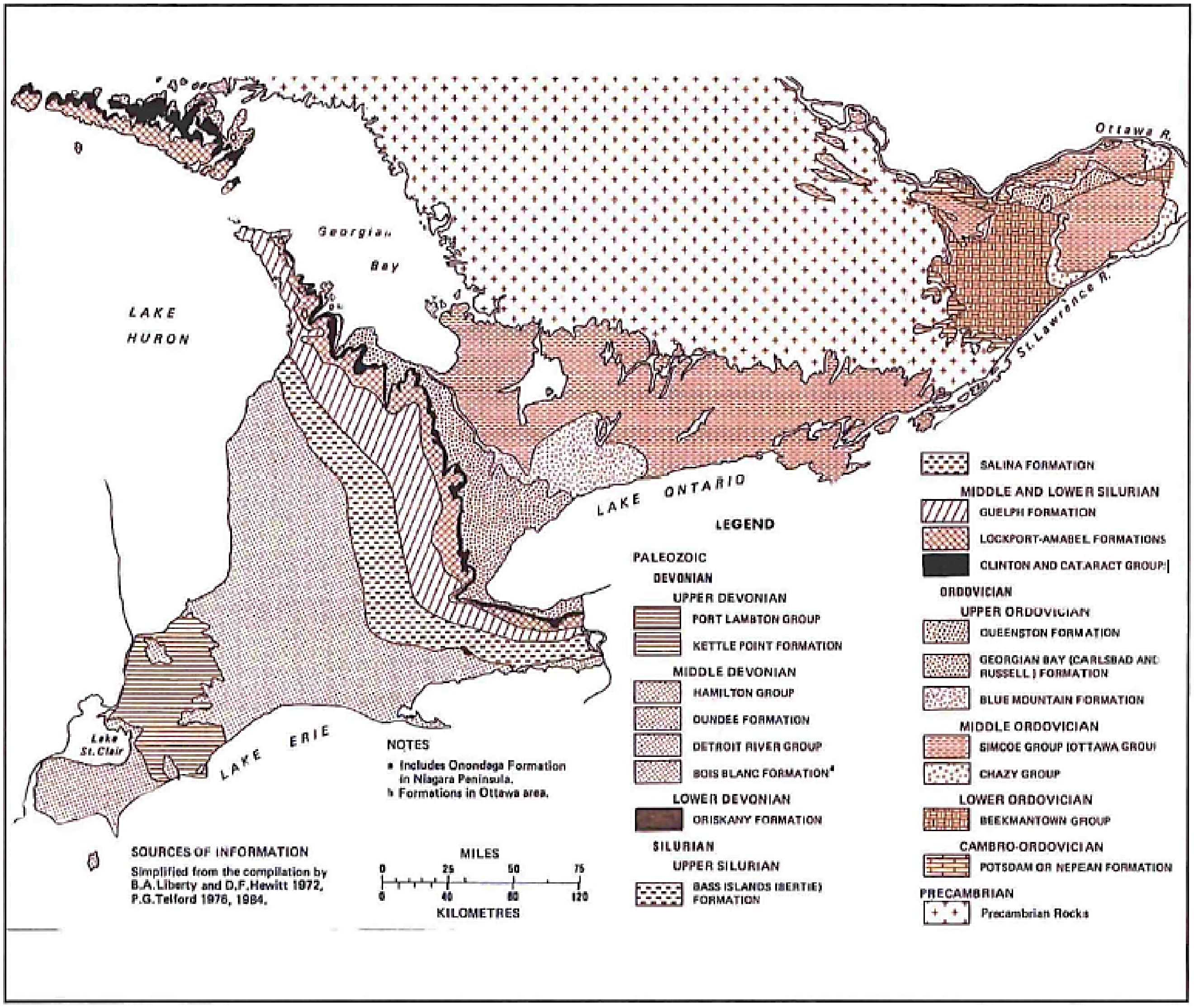


Figure 7
Bedrock geology of southern Ontario as presented by Chapman and Putnam 1984.

rocks of the Canadian Shield tend to be hard and not easily weathered. Erosion and soil formation processes are slow, making the accumulation of soil substrates shallow and patchy. The surface of these bedrock-controlled landscapes are typically complex, with rolling rock ridges, and knobs interspersed with troughs and hollows. On the other hand, Paleozoic, sedimentary rocks (i.e., southwestern Ontario) were created by sedimentation under large water bodies, making them relatively flat or gently rolling. These softer, more erodible materials were pulverized by the glaciers to produce large deposits of unconsolidated substrates (anything that is not solid bedrock), which were subsequently reworked by glacial processes into the landforms we see today. Furthermore, the chemical properties of Precambrian bedrock typically produce substrates that are circumneutral to acidic (pH 5.5 - 7.5) and have low fertility, yet Paleozoic rock is carbonate rich (high pH >7.5) and highly fertile. These factors, among other interacting bedrock-controlled factors, have a significant influence on vegetation patterns.

Table 4. The defining characteristics and examples of the three rock types used in ELC.

Rock Type	Defining Characteristics	Examples
Carbonate	sedimentary rocks made up largely of carbonate minerals; **rocks that fizz upon exposure to acid;** rocks that release carbon dioxide upon heating; high pH (pH >7.5); easily weathered	calcareous conglomerate, greywacke, sandstone, shale, limestone, dolostone, and marble
Circumneutral	igneous and metamorphic rocks containing 5- 66% silica; circumneutral pH (pH 5.5 - 7.5); intermediate weatherability	mafic to intermediate volcanic rocks, iron formation, diabase, gabbro, and anorthosite
Acidic	igneous and metamorphic rocks containing > 66% silica; low pH (pH < 5.5); not easily weathered	granite, granodiorite, quartz diorite, quartz monzonite, syenite and gneissic rocks, quartz sandstone, quartzite, and arkose

Note: Rock type can be determined usually by referring to other sources of resource information, e.g., Quaternary Geology series of reports and maps, physiography of southern Ontario (Chapman and Putnam 1984), or county soils reports.

Surficial Geology: Landform Origin and Development

By far the most important influence on the physical landscape of southern Ontario has been the last glaciation, and the subsequent legacy of water and drainage from the melting ice. Refer to the Reference Section for further reading on landform origin and development resulting from glaciation (particularly Chapman and Putnam 1984; Chapter 2, Glacial Geology).

There has been a series of glacial periods across Ontario, the last of which was the Wisconsin glaciation, approximately 14,000 years ago. At its peak, ice thickness in some areas exceeded 2 km. The tremendous forces of so much ice cause the glacier to flow, transforming it into a scraping and pulverizing river of ice. The underlying bedrock is eroded and incorporated into the ice, then deposited during stationary or hesitation periods of the ice front.

Huge amounts of unconsolidated material were left after the recession of the glaciers, up to 200 m at its deepest point (Chapman and Putnam 1984). Separate layers would have been deposited in episodic erosion and depositional events stretching back 23,000 years, including the last, Wisconsin, glacial period.

These layers of unconsolidated material consist mainly of (see **Figures 8 and 9):**

- sheets of heterogeneous material (till) laid down directly by ice.
- water-washed and sorted glacio-fluvial deposits of sands and gravels laid down in the beds of creeks and rivers.

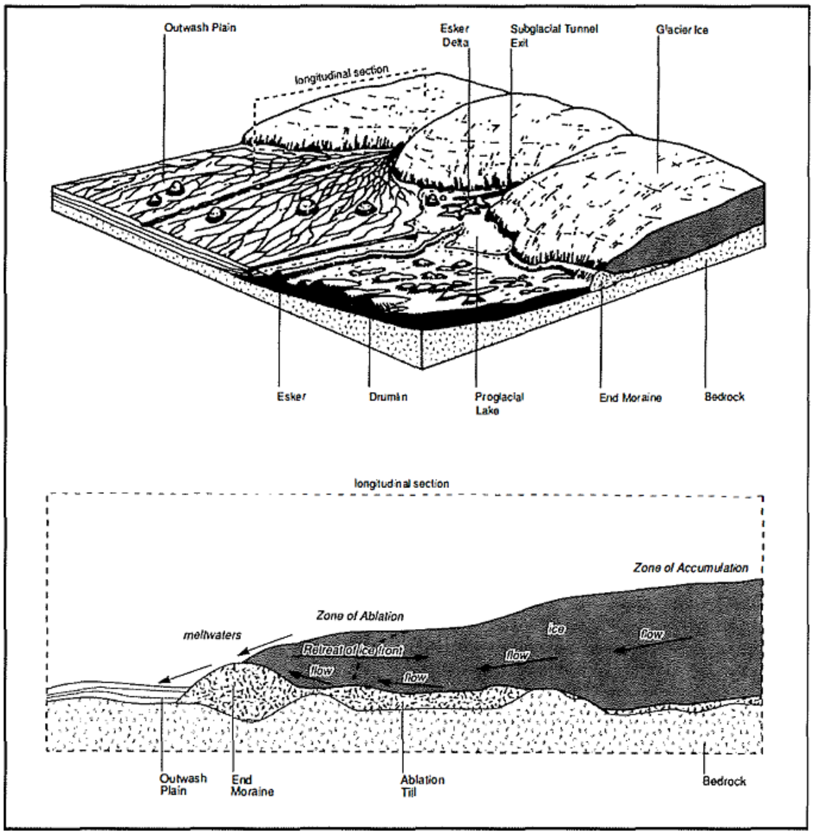


Figure 8
Glacial ice processes and corresponding landforms; from Sims and Baldwin 1991.

- sorted glacio-lacustrine deposits of clays, silts, and fine sands laid down in lake beds at this period (Chapman and Putnam 1984).

There are three principle forces which have shaped our landscape in southern Ontario: 1) ice, 2) water, and 3) wind. By the way they variably erode, transport, and deposit materials, they have played a major role in shaping the landscape and the landforms we find there.

Glacial Deposition Processes: Ice

The sheer volume of ice in glaciers creates huge forces which have influenced all of southern Ontario. Glacial ice is not static, but a flowing and dynamic river of ice and dirt. The active nature of glacial ice is the principle force giving rise to glacial erosion and deposition. The moving ice scrapes and pulverizes the materials, transports them, and deposits them. Ice deposition ranges from processes which smear and compact materials beneath the ice, to conveyor-like processes that loosely dump materials at the ice margins **(Figures 8 and 9).** These depositional forces create landforms of varying reliefs and shapes.

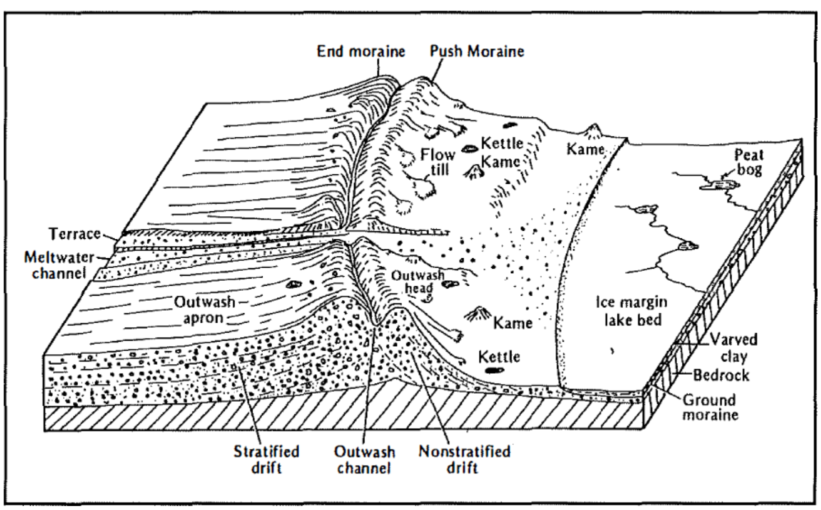


Figure 9
Ice-related landforms, along with landforms associated with post-glacial processes (i.e., water); from Sims and Baldwin 1991.

Glacial Tills

The materials deposited directly by the ice are called ***glacial tills.*** They consist of heterogeneous mixtures of debris, which vary in size from boulders, to gravels, sands, silts, and clays (Brady and Weil 1996). The mixed nature of glacial till deposits distinguishes them from other deposits, which tend to consist of materials sorted into consistent sizes. Glacial tills are deposited both beneath the active ice and as a result of down-wasting (deposition by ice stagnation and melting).

Formations Beneath Active Ice

The tremendous pressure exerted by the glacial ice melts the lower ice, releasing material that has accumulated on the bottom of the glacier.

Furthermore, friction and heat at the base of the glacier tend to plaster material onto the bedrock (Brady and Weil 1996). The materials smeared, through great pressure, onto the underlying bedrock are referred to as ***basal tills,*** or ***ground moraines.*** They are characteristically compact, unlayered (also called "unbedded") and ill- sorted materials ranging in size from fine clays to large boulders. Stones and other coarse fragments may show signs of abrasion from being dragged along under the glacier as it advances.

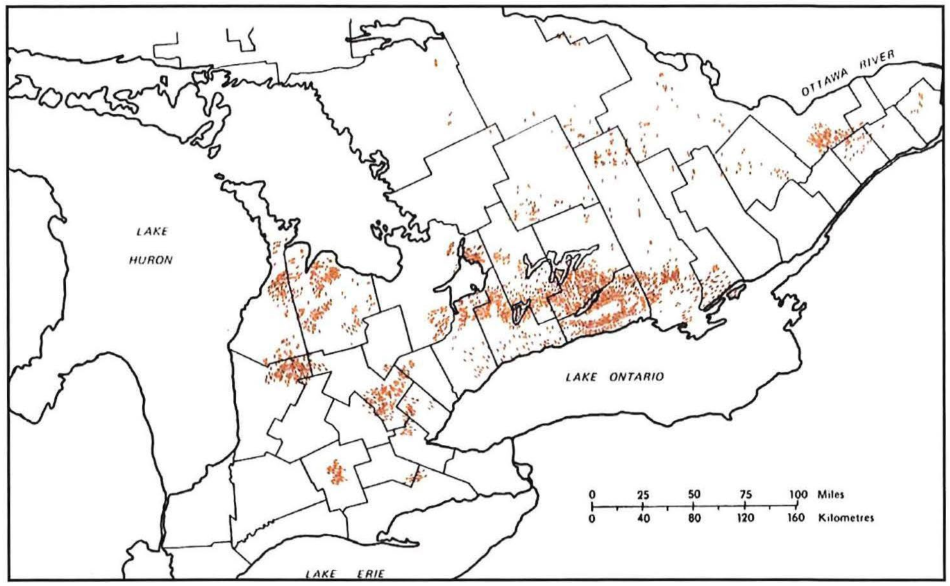


Figure 10
Location of drumlins and drumlin fields in southern Ontario; from Chapman and Putnam 1984.

Drumlins

The word drumlin is Celtic for little ***hill.*** Drumlins are smooth, elongated or whaleback-shaped hills with smooth, convex contours. Drumlins are typically 100 to 1,000 min length and are created by flowing glacial ice. The long axis and tapered end are oriented in the direction of glacial ice flow. Drumlins rarely occur singly, but rather in “swarms", where the ice would have fanned out on a lowland (Brady and Weil 1996). Drumlins are typically composed of unconsolidated glacial till material. The locations of significant drumlins and drumlin fields in southern Ontario are shown in **Figure 10.**

Formations from Down-wasting

Ablation Tills

Ablation tills, sometimes referred to as ablation moraines or melt-out tills, are made of loosely consolidated, unstratified materials (unsorted, not reworked by meltwater) that are deposited by a glacier receding at a relatively constant rate. These materials are generally deposited in place as the surface of the ice is removed by ablation (melting). Because the fragmented materials are generally not worked by water, they are characteristically angular in shape, not rounded.

Moraines

Moraine are mounds, ridges, or other distinct accumulations of generally unsorted, unstratified glacial till, deposited chiefly by the glacier ice. Moraines are deposited primarily during hesitations of the ice front or during recessional periods of glaciation. They consist of either tills - heterogeneous mixtures, deposited directly by the glacier - or of coarsely stratified gravel and sand deposited at the ice front by water issuing from the melting ice (Chapman and Putnam 1984).

Moraines typically have a rolling or knobby surface with undrained depressions (kettles) of irregular shape between the knobs. These kettles result when a buried block of glacial ice melts. Abandoned stream

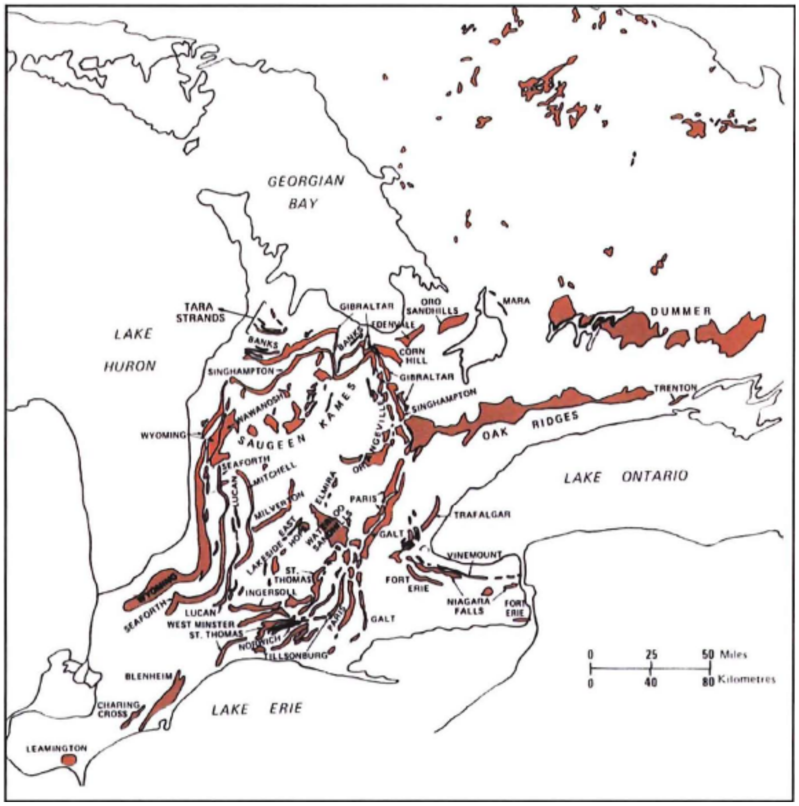


Figure 11 Moraines found in southern Ontario: from Chapman and Putnam 1984.

channels, formed by glacial drainage, either dissect or act as a boundaries for moraines (Chapman and Putnam 1984).

Various forms of moraines are deposited at the ice margin. This is a result of the flowing ice, acting like a conveyor belt, depositing materials at the edge, within holes, and between lobes of ice.

Forms of moraines:

The following definitions are examples of typical ice-created moraines. For a more in-depth review of moraines, refer to texts on glacial geology. The location of significant moraines in southern Ontario are shown in **Figure 11.**

End moraines and frontal moraines: These are moraines that are formed when materials have been deposited at the lower or outer end of a glacier. These Landforms are created down-wasting of materials during periods of ice-front hesitation (stadial) or when the glacier recedes.

Terminal moraines: A terminal moraine is an end moraine that marks the farthest advance of a glacier.

Push moraine: A push moraine is formed when the glacial ice front re-advances causing the ice to override previous depositions of material. When this occurs, the ice front pushes the till materials like a bulldozer, to form ridges.

Lateral moraine: A lateral moraine is a low, ridge-like moraine carried on, or deposited at or near, the side of a glacier.

interlobate moraine: This is a moraine that forms between two separately advancing ice sheets or lobes of a glacier. Unconsolidated materials are deposited as linear features running parallel to the direction of ice flow.

Kame moraine: A kame moraine is formed close to the ice front when a section or piece of the glacier breaks off the ice front and becomes a stagnant block of ice. The stagnant ice melts, dumping till material that is water-modified and poorly stratified.

Glacial Deposition Processes: Water

When we consider that the glacial ice was up to 2 km thick over much of Ontario, the amount of run-off water during the recession of the glaciers must have been staggering, especially during the warmer periods. Water, therefore, was a major factor in shaping and reworking the glacial landscape.

Recently deposited materials are eroded by glacial run-off water, which dissects the landscape by its drainage patterns. The sorting process characteristic of water deposition is governed by the speed and volume of the moving water. Running water acts as a material transport mechanism. In general, the faster the water, the coarser the deposits. Coarse fragments such as cobbles and gravel would be deposited in the swift- moving upper reaches, whereas the finest materials, silts and clays, would be carried long distances and deposited in standing water bodies.

Landforms created from material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice are generally called glacio-fluvial deposits. The deposits are characteristically stratified and may form outwash plains, deltas, kames, askers, and kame terraces. Coarse fragments generally show signs of moderate water working rounded edges and sorting into relatively uniform sizes and textures.

Deposits made in the standing or slow-moving waters of glacial lakes, formed by glacial ice or by meltwaters, are called glacio-lactustrine deposits.

Glacio-fluvial and Glacio-lacustrine Landforms

The following are examples of typical glacio-fluvial and glacio-lacustrine landform features. For a more in-depth review of these features, refer to texts on glacial geology.

Eskers

Eskers are linear to meandering ridges of sorted sand and gravel, deposited by water flowing beneath a glacier. They typically consist of various stratified layers of coarse, often gravelly, material. The locations of significant askers in southern Ontario are shown in **Figure 12.**

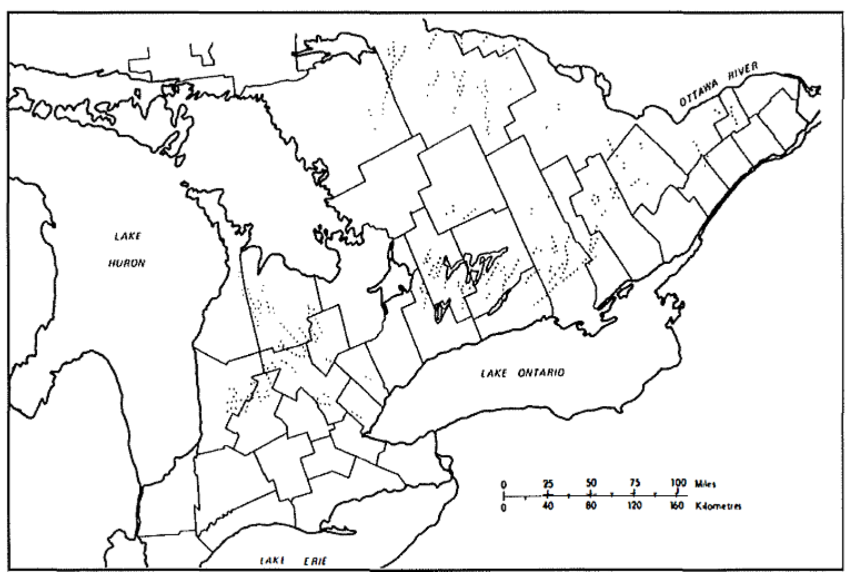


Figure 12

Location of eskers in southern Ontario; from Chapman and Putnam 1984.

Outwash Plains

An outwash plain is a flat surface.
of sand and gravel formed by braided river systems at the margins of retreating glacial ice. These rivers, shaped in stream terraces or broad fans, have a high degree of sand and gravel sediment which is laid down.

as stratified, sorted beds. The beds are pitted with depressions and have no surface drainage.

Deltas

A delta is a distinctive, sloping, sometimes terraced, fan-shaped deposit of sorted materials. Deltas occur at the point where water flows into a glacial lake.

Spillways

Spillways are the abandoned channels of glacial meltwater streams.

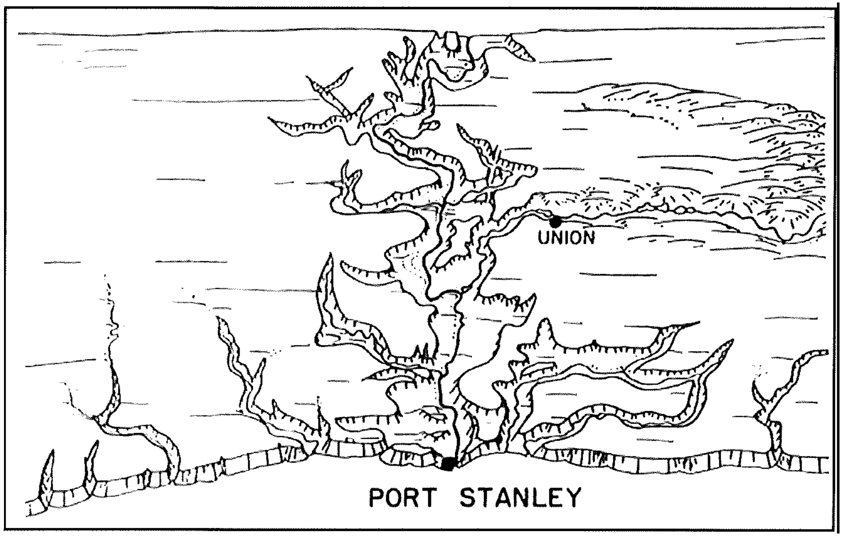


Figure 13
Kettle Creek, a relic glacial spillway; from Chapman and Putnam 1984.

Spillways are thought to have formed when meltwater, that is dammed by ice, breaches the dam. The result is massive flows of high-energy water, which incises deep, broad valleys in the glacial deposits ahead of the ice front. Spillways appear as valleys cut through the general glacial deposits of a region. **Figure 13 shows** the Kettle Creek glacial spillway.

Beaches

A beach is a deposit of unconsolidated, water-sorted debris representing the shore of a glacial lake. Old glacial beaches often form smooth, horizontal ridges of gravel and sand, and will occur at the boundary between level-lake plains below and rolling till plains above. The gravel is usually well-rounded, evenly graded and stratified.

Lake Plains

A lake plain is a relatively flat landscape of fine-textured mineral deposits. These formations represent old glacial lake bottoms. The slow-moving water in glacial lakes deposits fine sands, silts, and clays. Sometimes, distinctive layering or varving of deposits may be caused by weather that increases or decreases water movement and wave action.

Glacial Depositional Processes: Wind

As the climate warmed and the glacial ice began to retreat, great contrasts in humidity and temperatures existed between the expansive areas of ice and the bare land to the south. These contrasts led to tremendously strong winds, which blew across the barren landscape. Wind, at higher velocities, can lift, suspend, and transport finer materials. As the wind later drops, materials are laid down in *aeolian* (wind) deposits.

Wind, unlike water, is not well-suited for suspending material. As a result, aeolian deposits tend to be restricted in their range of particle sizes, from silt to medium sand. The particle size that is deposited depends on the force of the wind.

Aeolian Deposits

The following definitions are examples of typical wind origin landform features. For a more in-depth review of these features, refer to texts on glacial geology.

Sand Dunes

Sand dunes are low hills or ridges typically comprised of sand that has been sorted and deposited by wind action. Dunes occur singly or in groups.

Loess Deposits

Loess is the term used to describe wind-blown dust. A loess deposit - a layer of fine silts and sands - occurs when fine soil particles are transported and deposited by glacial winds. Loess deposits often appear as a layer of fine, evenly textured materials in the upper horizon of a soil profile. The loess deposit blankets other glacial deposits lower in the soil profile. When spread over broad areas, loess deposits are sometimes referred to as a loess cap.

Other Factors that Define Southern Ontario Landscapes

Bedrock-dominated Environments

Bedrock-dominated landscapes have either shallow depositions of till over the underlying bedrock, or the bedrock is bare. These landscapes form during glaciation when the forces of ice or water scrape or erode the bedrock free of till materials. In regions where the bedrock is very hard and not easily eroded, relatively little material is picked up, moved, and redeposited by the glacial ice. For this reason, the Canadian Shield areas of southern Ontario, the Frontenac axis, have only shallow deposits and are bedrock dominated. In these landscapes, the underlying bedrock material plays a more significant role in defining drainage patterns, general topography, and, ultimately, the ecological communities that inhabit these environments.

Modern, Post-Glacial Deposition

Although the scope of the glacial events and the resulting landform features dominate the landscape, surficial features are never static. The landscape is constantly evolving under the influence of ice, water, and wind. In modern times, these forces simply act on significantly smaller scales than during a major glacial event. In addition, with time, landscapes are changed by vegetation, as the primary deposits become organic in nature.

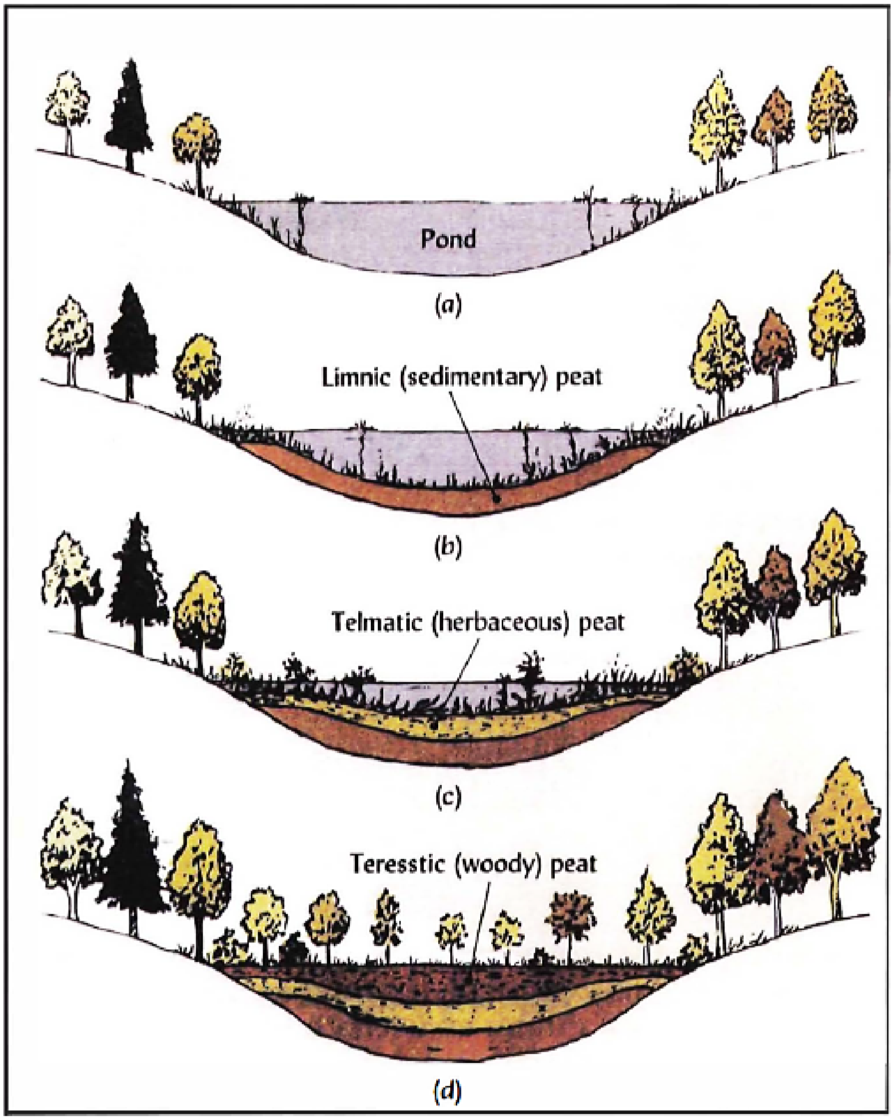


Figure 14
Stages in the development of a typical organic deposit:
- a) **nutrient run-off from the surrounding uplands encourages aquatic plant growth, especially around the pond edges.**
- b) **and c) cool temperatures inhibits decomposition, and accumulating organic debris fills in the bottom of the pond.**
- d) **as organic depth increases to above the water table, trees are able to grow.**
from Brady and Weil 1996.

Colluvial Deposits

Colluvial deposits are unconsolidated materials deposited by gravity, often at the base of a slope. Rock fragments and weathered, heterogenous mixtures of materials and debris, including soil, accumulate at the base of steep slopes as a result of gravity.

Pluvial Deposits

A fluvial deposit is material that accumulates as a result of rivers and streams. Flowing water and its associated erosion and deposition processes are the determining factors.

Organic Deposits

Organic deposits occur in low -lying, poorly drained or cooler portions of the landscape where decomposition of organic material is generally slower. Over time, as successive generations of plants live and die, thick layers of semi-decomposed organic material build up to form organic deposits **(Figure 14).** Landscapes dominated by thick organic deposits support their own set of distinct ecological communities. Although the underlying and surrounding soil materials still influence the ecology of these landscapes; it is the organic depositions that dominate and define the ecological communities that these landscapes support.

Human Influence on Landscapes

Successive generations of human habitation have brought land clearing, farming, road construction, and urban development to most areas of southern Ontario. These human activities have an impact on the current landscapes and have helped to shape the surficial deposits and landscape structures everywhere in southern Ontario.

Summary for Bedrock and Surficial Geology - Attributes Used When Applying ELC

Bedrock Geology

Paleozoic

Carbonate:

- Sedimentary rock
- easily weathered.
- high in carbonates-fizzes with acid
- high pH

Precambrian

Basic:

- igneous and metamorphic rock
- intermediate weatherability
- no carbonates-does not fizz with acid.
- circumneutral pH

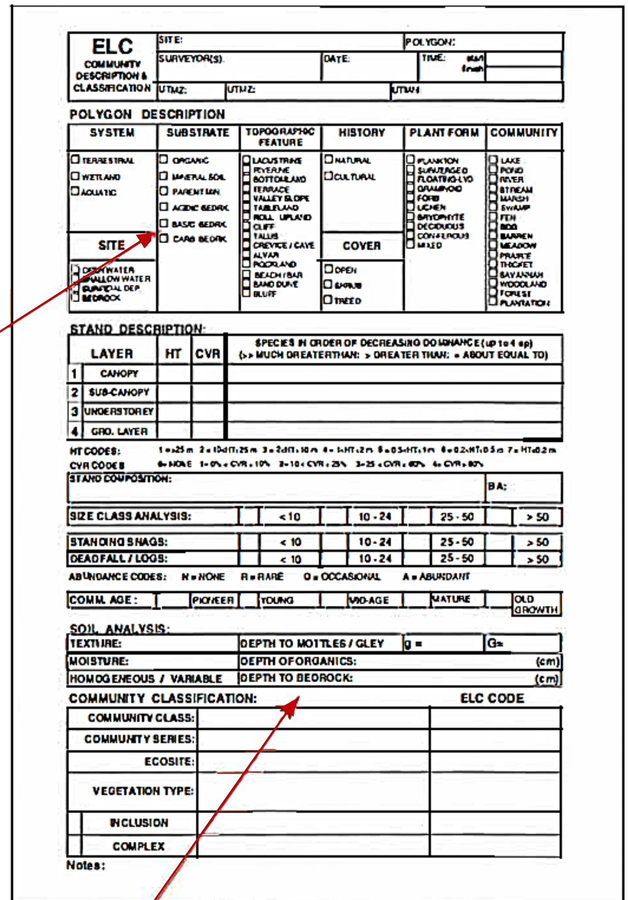
Acidic:

- igneous and metamorphic rock
- not easily weathered.
- no carbonates-does not fizz with acid.
- acidic (low) pH

Record the bedrock geology by assigning attributes within the Site and Substrate fields of the Polygon Description section of the Community Description and Classification data card.

Record Depth to Bedrock

- Record the prevailing depth of bedrock within the polygon, in the Soil Analysis section of the Community Description and Classification data card.
- Record the depth to bedrock, for each sample, on the Soils Ontario data card.



ELC COMMUNITY DESCRIPTION & CLASSIFICATION

SITE: | POLYGON: | SURVEYOR(S): | DATE: | TIME: | UTMZ: | UTME: | UTMN:

POLYGON DESCRIPTION

SYSTEM: TERRESTRIAL, WETLAND, AQUATIC

SUBSTRATE: ORGANIC, MINERAL SOIL, PARENT MIN., ACIDIC BEDRK., BASIC BEDRK., CARB. BEDRK.

TOPOGRAPHIC FEATURE: LACUSTRINE, RIVERINE, BOTTOMLAND, TERRACE, VALLEY SLOPE, TABLELAND, ROLL. UPLAND, CLIFF, TALUS, CREVICE / CAVE, ALVAR, ROCKLAND, BEACH / BAR, SAND DUNE, BLUFF

HISTORY: NATURAL, CULTURAL

PLANT FORM: PLANKTON, SUBMERGED, FLOATING-LVD., GRAMINOID, FORB, LICHEN, BRYOPHYTE, DECIDUOUS, CONIFEROUS, MIXED

COMMUNITY: LAKE, POND, RIVER, STREAM, MARSH, SWAMP, FEN, BOG, BARREN, MEADOW, PRAIRIE, THICKET, SAVANNAH, WOODLAND, FOREST, PLANTATION

SITE: OPEN WATER, SHALLOW WATER, SURFICIAL DEP., BEDROCK

COVER: OPEN, SHRUB, TREED

STAND DESCRIPTION: LAYER | HT | CVR | SPECIES IN ORDER OF DECREASING DOMINANCE — 1 CANOPY, 2 SUB-CANOPY, 3 UNDERSTOREY, 4 GRD. LAYER

STAND COMPOSITION: | BA:

SIZE CLASS ANALYSIS: <10 | 10-24 | 25-50 | >50

STANDING SNAGS: <10 | 10-24 | 25-50 | >50

DEADFALL / LOGS: <10 | 10-24 | 25-50 | >50

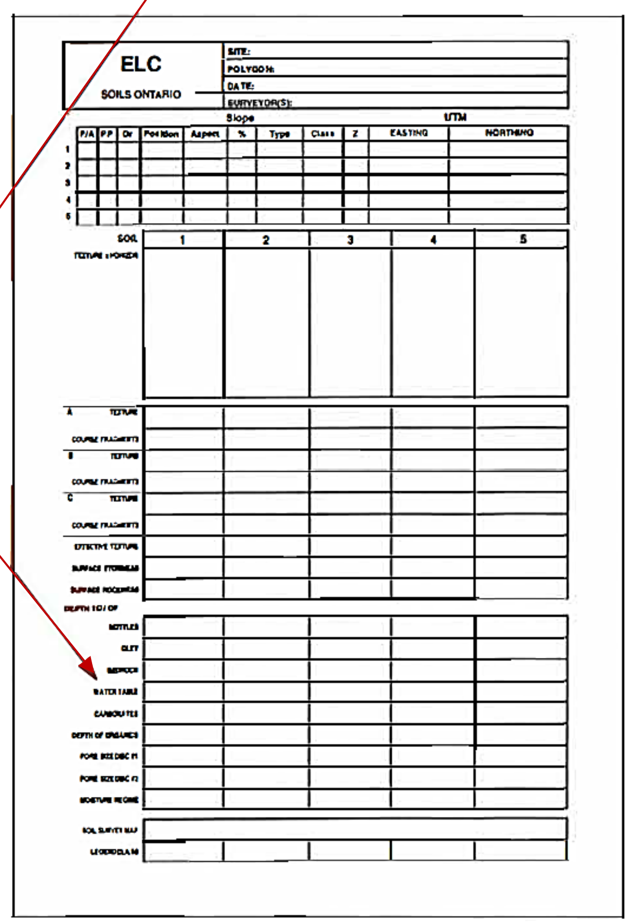
ABUNDANCE CODES: N = NONE R = RARE O = OCCASIONAL A = ABUNDANT

COMM. AGE: PIONEER | YOUNG | MID-AGE | MATURE | OLD GROWTH

SOIL ANALYSIS: TEXTURE: | DEPTH TO MOTTLES / GLEY | g = | G= | MOISTURE: | DEPTH OF ORGANICS: (cm) | HOMOGENEOUS / VARIABLE | DEPTH TO BEDROCK: (cm)

COMMUNITY CLASSIFICATION: | ELC CODE — COMMUNITY CLASS: | COMMUNITY SERIES: | ECOSITE: | VEGETATION TYPE: | INCLUSION | COMPLEX

Notes:



ELC SOILS ONTARIO

SITE: | POLYGON: | DATE: | SURVEYOR(S):

Slope | UTM | EASTING | NORTHING

SOIL 1 2 3 4 5

TEXTURE | COARSE FRAGMENTS | EFFECTIVE TEXTURE | SURFACE STONINESS | SURFACE ROCKINESS | DEPTH TO / OF: MOTTLES | GLEY | BEDROCK | WATER TABLE | CARBONATES | DEPTH OF ORGANICS | MOISTURE REGIME | SOIL SURVEY MAP

The following tables in the OIP manual are used to give further descriptions of bedrock attributes:

OIP, page 33
- guide to lithological modifiers.
- key to rock types.

OIP, page 34
- calcareous classes
- description of effervescence or fizzing with acid

Depth to Bedrock

As soils become shallow, decreasing depth to bedrock imposes restrictions on vegetation rooting depth and anchorage. When determining depth to bedrock, refer to the following tables and charts:

FG, page 29
- Key to Terrestrial Ecosites
- shallow, bedrock-controlled sites -average substrate depths less than 15 cm, over bedrock
- rock sites -average substrate depths less than 5 cm, over bedrock.

OIP, page 32
- Chart C - soil moisture regime for soils< 120 cm deep over bedrock.
- note differences between OIP and ELC in their treatment of shallow soils. Use OIP for site and soil descriptions; use FG, page 29, Key to Terrestrial Ecosites, i.e., "average substrate depths less than 15 cm, over bedrock", for ecological site determinations using ELC.

Surficial Geology: Landform Origin and Development

Parent Material

Ice-deposited materials.
- material not sorted.
- heterogeneous mixtures of various sizes of particles - boulders, stones, cobbles, gravels, sands, silts, and clays
- not, or only weakly, stratified.
- coarse fragments that are sharp and angular to slightly rounded

Water-deposited materials
- material well-sorted
- stratified layers of varying textures - consistent texture within layers
- coarse fragments that are well-rounded (tumbled)

Wind -deposited materials
- material well-sorted
- particle size restricted to silt to medium sand

Types of Substrates

Organic
- organic substrates have greater than 40 cm of organic material accumulated on top of mineral material.
- formed by inhibition of decay, typically through cool, wet conditions; promotes the accumulation of organic debris.
- materials in various states of decomposition

Colluvial
- by direct gravity-induced movement
- material often of mixed sizes in talus cones or rubbly colluvial blanket
- nutrient status and weatherability dependant on mineralogy of the rock source

Shallow soil and bedrock
- shallow soils have an average substrate depth of less than 15 cm, over consolidated bedrock.
- rock-dominated sites have an average substrate depth less than 5 cm.

Code	Parent Material	Mode of Deposition	Recognizable Features	Landform
M	Morainal (glacial)	by melting ice (e.g., drumlins)	heterogeneous mixture of stones, sand, silt, and clay; angular to rounded; not; sorted; not stratified	till plains; terminal or recessional moraines; drumlins
F	Fluvial and Glacio - fluvial	by and in running water (e.g., river deposits)	coarse textured; well - rounded; sorted and often stratified. crossbedding, cuts, and fill	alluvial fans; flood plains; outwash plains. spill ways; interlobate moraines; kames; eskers
L	Lacustrine and Glacio - lacustrine	by running water into standing water; in standing lake water (e.g. lake deposits)	fine to coarse textured; well- rounded; sorted and often varved or stratified; sand or gravelly beach deposits, or clayey deep-water deposits	deltas; lacustrine clay plains; beaches
w	Marine	in or by brackish sea	fine to coarse textured; well - rounded; moderately well - sorted; often stratified; often contains shells	marine plains
E	Eolian (also *Aeolian)*	by wind	silt to medium sand; very well-rounded; very well - sort ed; loose	dunes; loess blankets, ripples, and ridges; veneers

0	Organic	low temperature inhibition of decay; in cool and wet depressions	black, organic remains in various stages of decom - position	bogs, swamps, fens, marshes
C	Colluvial	by direct gravity - induced movements and erosion	often mixed; material type dependent on origin	talus slopes, rubbly colluvial blankets
B	Bedrock	by geological processes	consolidated rock	rock plains or out crops; rock knobs; escarpments or ridges

6. Physiography and the Concept of “site”

Physiography is the relationship among parent materials, topo - graphic features, and climate.

Physiography

Once we are oriented within the broader ecological context established by regional climate, bedrock, and surficial geology (i.e. Ecoregions, Ecodistricts), what factors further influence community assembly? At meso scales, it is the nature and variability of surface features which have the greatest influence. Across our landscape, we encounter a textured mosaic of surface features including deeply incised river valleys, bluffs, or cliffs with steep slopes; gently sloping moraines and drumlins; and flat sand and clay plains. Physiography, here, refers to the nature of different landforms and how they compose a variable surface, as well as the extent and degree to which these features create gradients in relief (i.e., elevation) and resource availability.

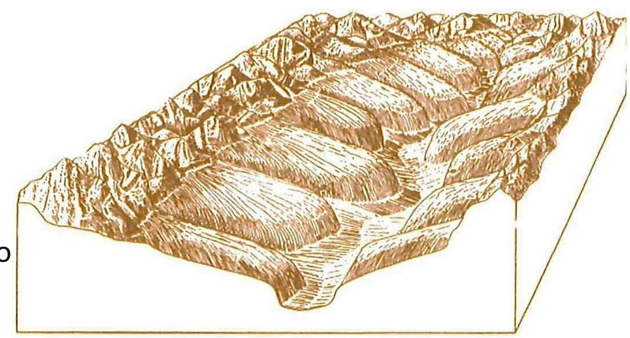


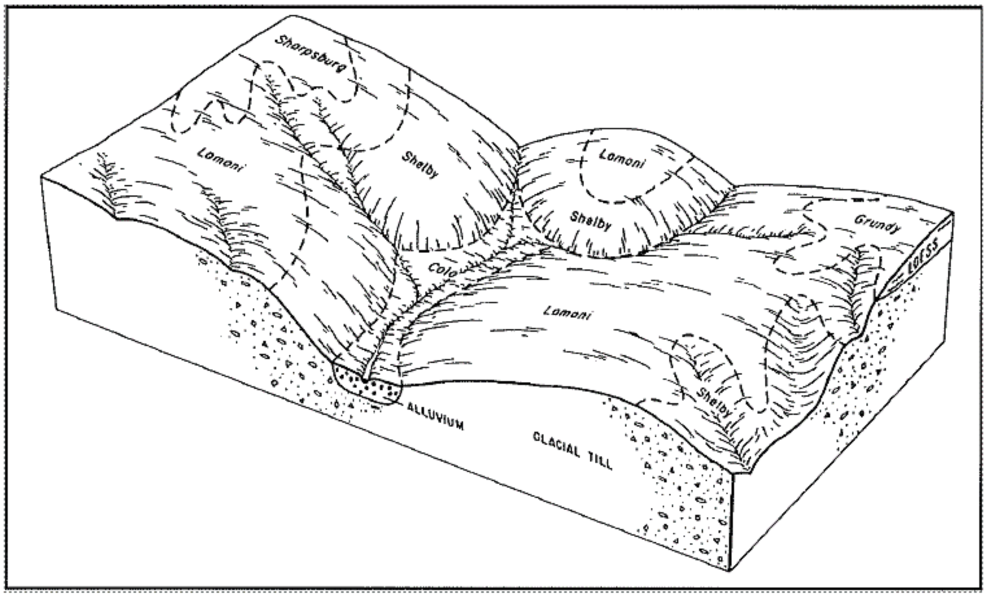
Figure 15
Meso-scale landscape pattern, showing erosional and depositional features, and their effect on slope; from Garner 1974.

Landforms were created across southern Ontario by four main processes: erosion, transport, deposition, and modification of mineral material. Glaciation was the most significant historical event, in which all these processes occurred. Refer to the geology section for descriptions of landforms. These surface features modify or control local climate, hydrology, productivity, and the movement of material across the landscape. Ultimately, it is the nature, including shape, of their parent material and the gradients they create in eco-climate, degrees of slope, and elevation that influence community patterns, structure, and composition (see **Figure 15** and **Figure 16).**

Hills (1966) recognized the influence of landform and climate and called these patterns " land- types”. Further resolution of these patterns leads to the development of Canada and Ontario Land Inventory Units. This represents the Ecosection level in the ELC hierarchy.

At finer scales, the abiotic patterns within a landform, or site, represent the finer ecological context to which plant species respond (see **Figure 17** and **Figure 18).** This means that the position within a particular landform or landform sequence further influences vegetation patterns. The site-specific nature of a slope's position, length, and degree (steepness) controls moisture and nutrient regimes. Aspect, steepness, and elevation of slope influence local growing conditions and climate. Climate at this scale includes features such as daily temperature regimes, snow melt, frost-free periods, affects of solar input and shading (e.g., north-facing slopes). Physiographic position "causes localized changes in moisture and temperature. When rain falls on a landscape, water begins to move.

Hills describes fine scale abiotic patterns as " physio- graphic site types" (1966).



downward by the force of gravity, either through soil or across the surface to a lower elevation. Even though the landscape has the same soil- forming factors of climate, organisms, parent material, and time, drier soils at higher elevations may be quite different from the wetter soils where water accumulates. Steepness, shape, and length of slope are important because they influence the rate at which water flows into or off the soils. Aspect affects soil temperature, where soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes" (Broderson 1994).

Figure 16
Finer scale slope patterns. Dotted lines depict areas of similar slope position, drainage, and soil texture; from Broderson 1994.

Physiography is an important component of ELC and its application at the Topographic Feature level (see **FG,** page 114). A knowledge of landform features in a local area can actually give shortcuts or indicators as to soil components and vegetation assemblages expected within an area. "When relationships between landform features and other ecological parameters are understood with are understood within a specific physiographic or geographic area, it is then possible to make accurate predictions about certain soil and vegetation characteristics based on the recognition of landforms" (Sims and Baldwin, 1991). Furthermore, application of ELC through air photo interpretation or satellite imagery depends on this relationship between emergent and visible physiography of an area and the overlying vegetation patterns.

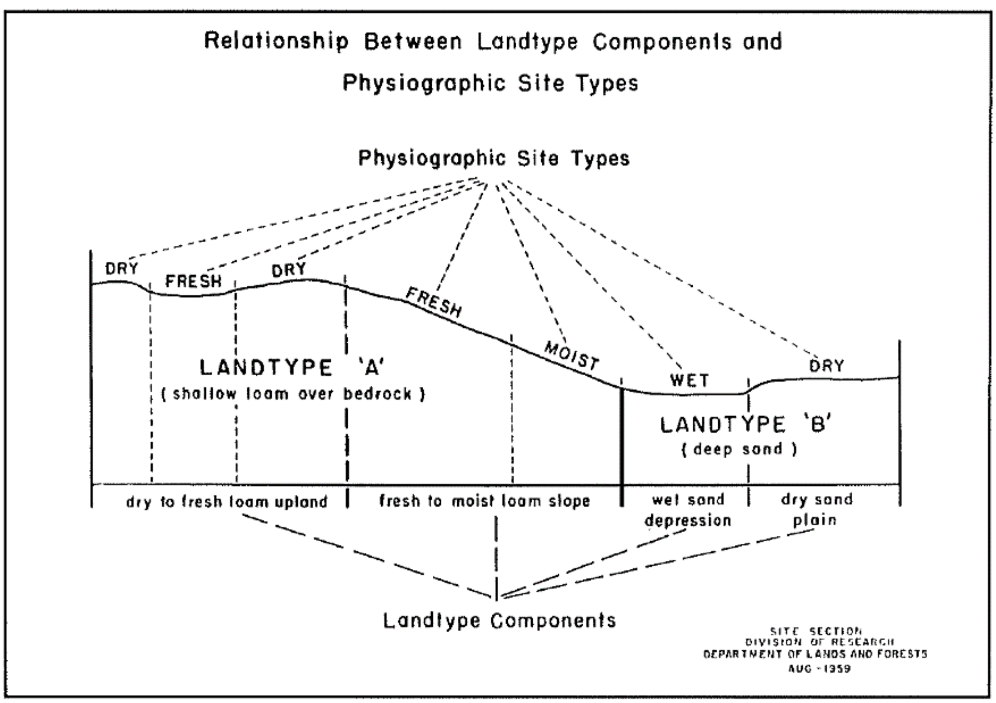


Figure 17
Influence of slope, drainage, and soil texture in creating zones of ecological conditions, called Physiographic Site Types by Hills; from Hills 1966.

At the finest scale, within a given sampling location (plot/prismsweep) there are often very finely scaled variations in the soil surface. This can be the result of fallen trees and the tip-up mounds they produce, fallen and buried logs, moss hummocks, grass tussocks, strings and flarks, hummocks and hollows, and smaller vernal pools, to name a few. These features, referred to as **microtopography,** do not change overall site productivity but do help to characterized local processes and help to define habitats for certain species.

Description of Physiography and Site

Whether a large area or a specific location is being described, it is important to describe physiographic and site characteristics. Describing these is important for understanding localized variations in community patterns, structure, and composition.

Broad Scale

Prior to interpreting and delineating polygons on air photos, determining sample locations, and applying ELC, a reconnaissance of the surrounding landscape is recommended. Use established sources of information to document and describe the area of interest. The following sources of information can be consulted to acquire this level of information:

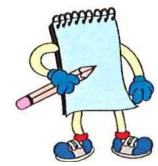
- Geological Survey Maps; Geological Survey of Canada; Ontario Ministry of Northern Development and Mines
- Physiography of Southern Ontario (Chapman and Putnam 1984)
- Canada Land Inventory
- Ontario Land Inventory
- Soil Landscapes of Canada: Energy, Mines, and Resources Canada
- County Soil Survey maps
- National Topographic Series maps (NTS)
- Ontario Base Map Series (OBM - 1:10,000)
- Digital Elevation Model/Digital Terrain Model (DEM/DTM)
- air photos

The goal here is to:
- describe landform and mode of deposition.
- determine prevailing or dominant parent material and soils.
- assess slope (elevation, relief, aspect).

More specifically, when applying the ELC, the following should be described and documented.

ELC Description Framework (Community Description and Classification data card)

The Description Framework helps to focus our attention on characterizing parent materials and the physiographic or topographic feature. You can use the ELC Word Keys **(FG,** page 117) to corroborate the findings for bedrock and surficial geology (Site, Substrate) from the above information sources (maps, land inventories, etc.). Similarly, the diagrammatic keys can be used to choose the appropriate physiographic Topographic Feature. Record observations on the Community. Description and Classification data card.



Physiographic features:
- parent's materials
- Soils
- Slope
  - degree (steepness)
  - shape
  - length
  - aspect (direction it faces)
- elevation

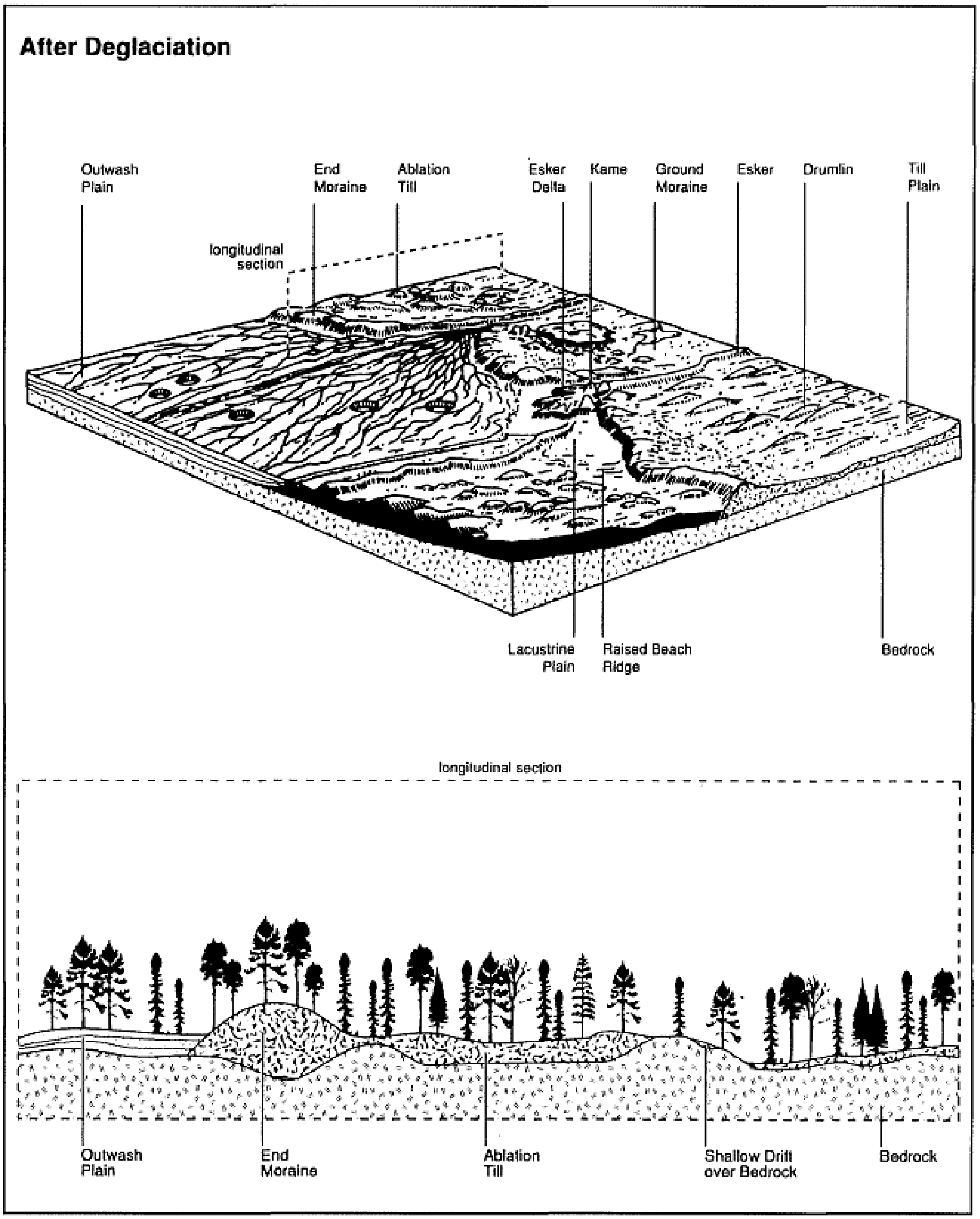


Figure 18

Glacial landform features and how they influence the underlying slopes and soils, along with the growth patterns of vegetation; from Sims and Baldwin, 1991.

Fine Scale

The goal of fine-scale work is two-fold: 1) to sample very specific locations, to 2) capture the prevailing conditions across the polygon, which has been already delineated on air photos. Capturing the variation at this scale is key. **Figure 18** shows an idealized sketch of a possible physiographic profile with associated vegetation patterns. Fine-scale sampling occurs at point locations across such profiles, to capture the inherent variation in site.

(Figure 19), as well as soils and vegetation. It is at these sample points that site description occurs, using the following established variables.

Measurement of Slopes

One of the first tasks at a site is to measure the slope. Slope can be assessed at different scales. Mesa-scale assessments provide a broader context and link sample observations with physiography and landform (see **Figure 19).** Microtopography looks at a very fine scale, such as hummocks and hollows, or mounding from fallen woody debris. Application of ELC in the field is done primarily at the site scale.

Helpful HINTS

Varying Scales to Measure Slope:

Mesa

- measure overall slope of the polygon.
- greater than 50 m

Site

- measure slope in relation to the soil pit.
- 10 to 50 m

Microtopography

- measure slope within sample area or plot.
- 0.5 to 10 m

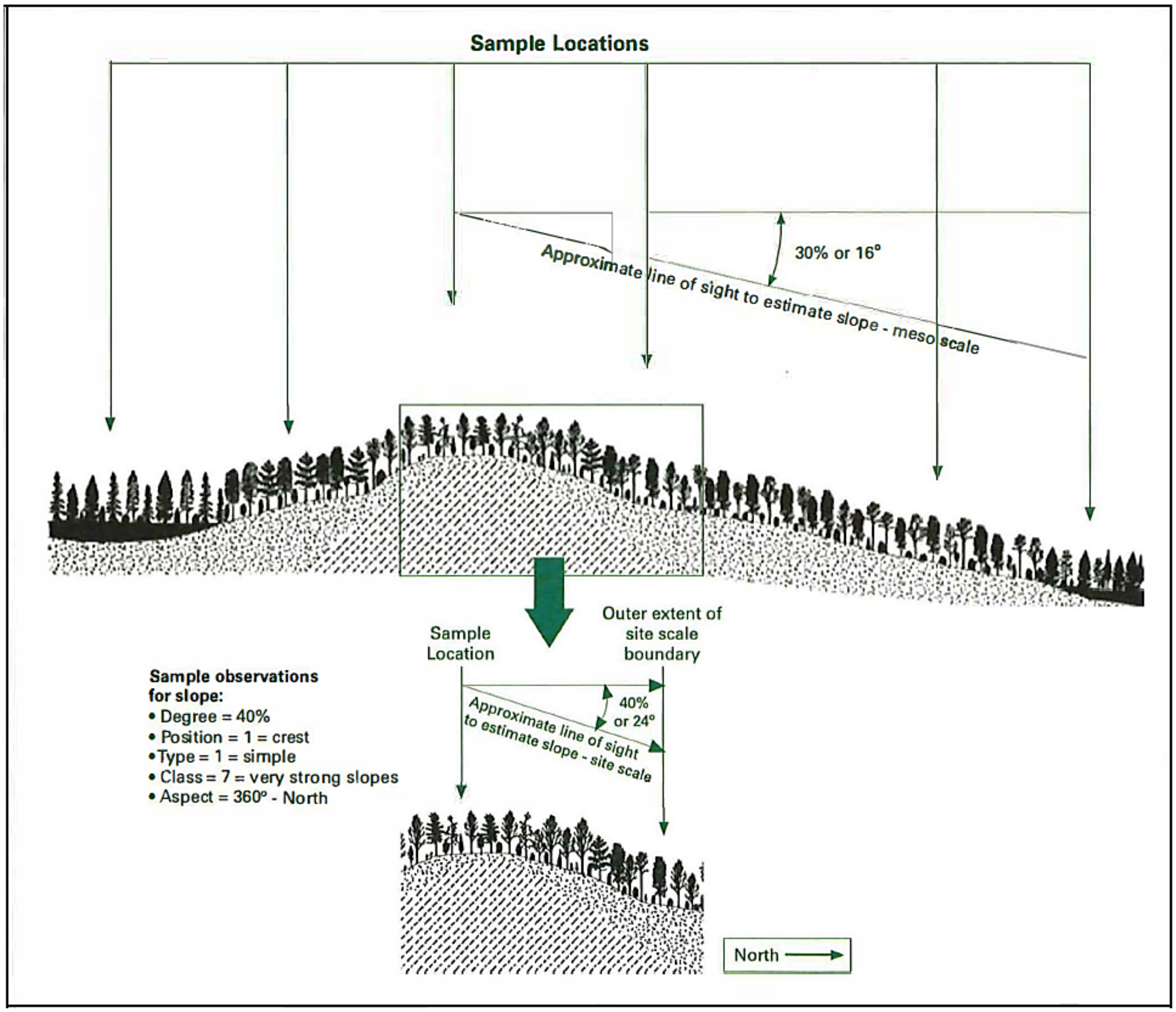
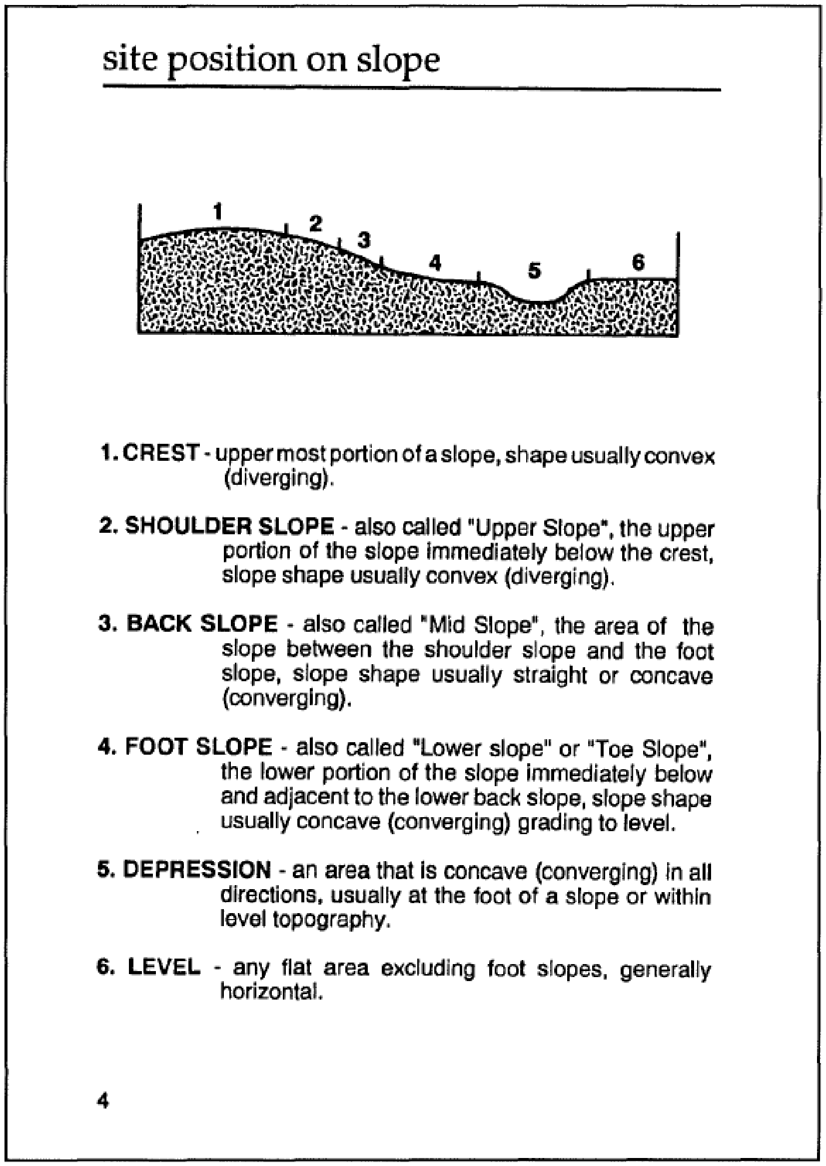


Figure 19

Illustration showing recommended placement of sample points to capture variation in slope, drainage, and soil texture across an idealized topographic sequence. Sample observations are made at the site-level scale (10 to 50 ml and later synthesized for meso-scale patterns. Included here is a hypothetical sample taken for the degree, position, type, class, and aspect of slope



site position on slope

1. **CREST** - upper most portion of a slope, shape usually convex (diverging).

2. **SHOULDER SLOPE** - also called "Upper Slope", the upper portion of the slope immediately below the crest, slope shape usually convex (diverging).

3. **BACK SLOPE** - also called "Mid Slope", the area of the slope between the shoulder slope and the foot slope, slope shape usually straight or concave (converging).

4. **FOOT SLOPE** - also called "Lower slope" or "Toe Slope", the lower portion of the slope immediately below and adjacent to the lower back slope, slope shape usually concave (converging) grading to level.

5. **DEPRESSION** - an area that is concave (converging) in all directions, usually at the foot of a slope or within level topography.

6. **LEVEL** - any flat area excluding foot slopes, generally horizontal.

4

Figure 20 Determination of site position on slope using page 4 of OIP; OIP 1993.

ELC Site Description (Soils Ontario data card) In the field, on- site, the finer-scale affects of slope are captured on the Soils Ontario data card. Keep in mind that the information on this data card is organized by sample location. At each sample location, other aspects such as soils and vegetation are also being described. Describe and record the slope Degree of steepness (%), Position, Type, Class, and Aspect using the established ELC field methods, at the site scale.

Steepness of Slope

At all scales, the degree of slope is measured with a "clinometer". Degree of slope can be measured using either the “degree” or "percent" scales on the clinometer. The degree scale measures the angle, in degrees, of the slope. The percent scale creates a hypothetical triangle out of the slope. The percentage represents the proportion of elevation (the “rise” or height above sample point) over horizontal distance (the "run"), as you would determine an angle using rise over run in geometry. When a slope angle equals 45°, the elevation is equal to the distance, and the slope is 1, or 100%. Therefore, any slope greater than 45° is equal to 100%. Any slope less than 45° is a fraction and is less than 100%. For ELC application, record the percent of slope for sample locations in the "%" field on the Soils Ontario data card.

Position on Slope

At all scales, the position of the sample point on the slope can be described using **OIP** chart of Site Position on Slope **(OIP,** page 4; reproduced in **Figure 20).** For ELC application, record the position of the sample point on the slope, at the site scale, on the Soils Ontario data card.

Slope Type and Class

Use the **OIP** charts **(OIP,** page 3; reproduced in **Figure 21)** to determine the Slope Type and Class. Record the slope type and class on the Soils Ontario data card, at the site scale.

Slope Aspect

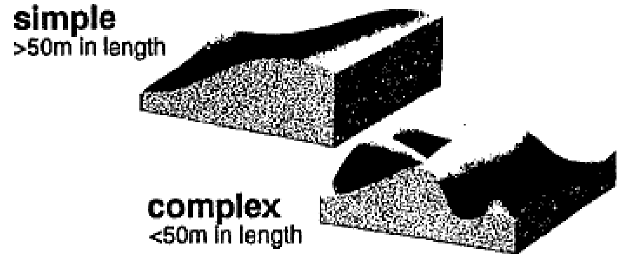
At each sample point, determine the compass direction the slope faces, in degrees. Use 0% for level sites (those which have no slope), and 360% when slope is facing directly north.
Record aspect on the Soils Ontario data card.

Synthesis

Ideally, a number of sample points are collected within a polygon, in order to capture the variation. The recorded observations at each sample point can now be synthesized to characterize the prevailing conditions within a polygon. The boundaries of the polygons can be adjusted with this level of on-site detail. Furthermore, patterns in these site-level variables can contribute to our understanding of the vegetation patterns across topographic sequences.

Use the Community Profile diagram on the Stand Characteristics data card to capture this variation. The prevailing slope type, shape, and class can be summarized here, along with characterization of microtopography, where present.

slope type, slope classes and microtopography



Class[1]	Percent slope	Approximate degrees	Class terminology
A,a or 1	0 - 0.5	0	level
B,b or 2	0.5 - 2.0	0.3 - 1.1	nearly level
C,c or 3	2 - 5	1.1 - 3	very gentle slopes
D,d or 4	5 - 9	3 - 5	gentle slopes
E,e or 5	9 - 15	5 - 8.5	moderate slopes
F,f or 6	15 - 30	8.5 - 16.5	strong slopes
G,g or 7	30 - 45	16.5 - 24	very strong slopes
H,h or 8	45 - 70	24 - 35	extreme slopes
H,h or 9	70 - 100	35 - 45	steep slopes
H,h or 10	>100	>45	very steep slopes

1 Letter designations are commonly used in soil surveys. Simple slopes (>50m in length) are designated by upper case letters i.e. A, B, C, and complex slopes (<50m in length) by lower case letters i.e. a,b,c.

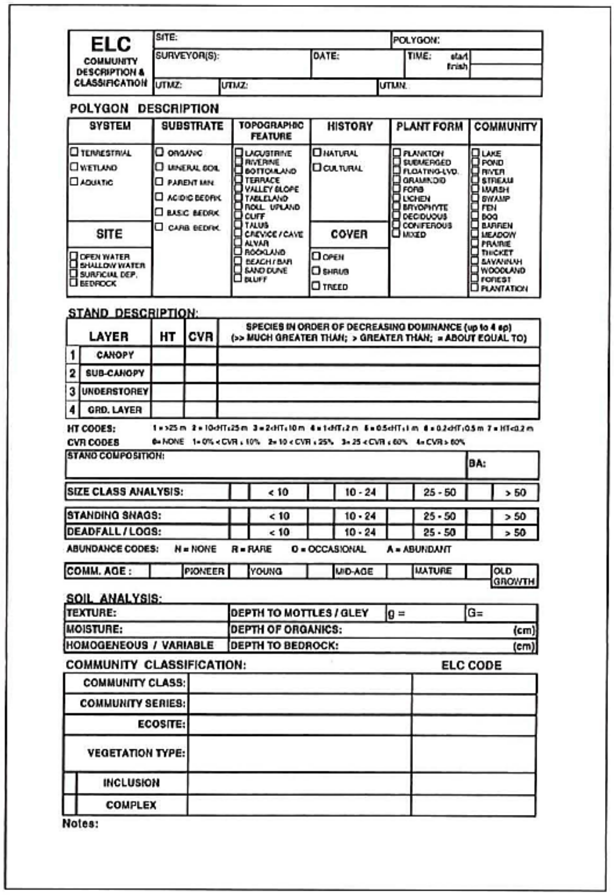
microtopography

Mound height (m)	Spacing between (m)	Class terminology
few	none	level
<.3	-	micro mounded
.3 -1	>7	slightly mounded
.3 - 1	3 - 7	moderately mounded
.3 - 1	1 - 3	strongly mounded
.3 - 1	.3 - 1	severely mounded
>1	>3	extremely mounded
>1	<3	ultra mounded

3

Figure 21

Determination of slope type, class, and microtopography using page 3 of **OIP; OIP** 1993.



ELC COMMUNITY DESCRIPTION & CLASSIFICATION

SITE: | POLYGON:
SURVEYOR(S): | DATE: | TIME: start / finish
UTMZ: | UTMZ: | UTMN:

POLYGON DESCRIPTION

SYSTEM	SUBSTRATE	TOPOGRAPHIC FEATURE	HISTORY	PLANT FORM	COMMUNITY
☐ TERRESTRIAL ☐ WETLAND ☐ AQUATIC	☐ ORGANIC ☐ MINERAL SOIL ☐ PARENT MIN. ☐ ACIDIC BEDRK. ☐ BASIC BEDRK. ☐ CARB. BEDRK.	☐ LACUSTRINE ☐ RIVERINE ☐ BOTTOMLAND ☐ TERRACE ☐ VALLEY SLOPE ☐ TABLELAND ☐ ROLL. UPLAND ☐ CLIFF ☐ TALUS ☐ CREVICE / CAVE ☐ ALVAR ☐ ROCKLAND ☐ BEACH / BAR ☐ SAND DUNE ☐ BLUFF	☐ NATURAL ☐ CULTURAL	☐ PLANKTON ☐ SUBMERGED ☐ FLOATING-LVD. ☐ GRAMINOID ☐ FORB ☐ LICHEN ☐ BRYOPHYTE ☐ DECIDUOUS ☐ CONIFEROUS ☐ MIXED	☐ LAKE ☐ POND ☐ RIVER ☐ STREAM ☐ MARSH ☐ SWAMP ☐ FEN ☐ BOG ☐ BARREN ☐ MEADOW ☐ PRAIRIE ☐ THICKET ☐ SAVANNAH ☐ WOODLAND ☐ FOREST ☐ PLANTATION
SITE: ☐ OPEN WATER ☐ SHALLOW WATER ☐ SURFICIAL DEP. ☐ BEDROCK			COVER: ☐ OPEN ☐ SHRUB ☐ TREED		

STAND DESCRIPTION:

LAYER	HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (up to 4 sp) (>> MUCH GREATER THAN; > GREATER THAN; = ABOUT EQUAL TO)
1 CANOPY			
2 SUB-CANOPY			
3 UNDERSTOREY			
4 GRD. LAYER			

HT CODES: 1 = >25 m 2 = 10<HT≤25 m 3 = 2<HT≤10 m 4 = 1<HT≤2 m 5 = 0.5<HT≤1 m 6 = 0.2<HT≤0.5 m 7 = HT<0.2 m
CVR CODES 0 = NONE 1 = 0% < CVR ≤ 10% 2 = 10 < CVR ≤ 25% 3 = 25 < CVR ≤ 60% 4 = CVR > 60%

STAND COMPOSITION: | BA:

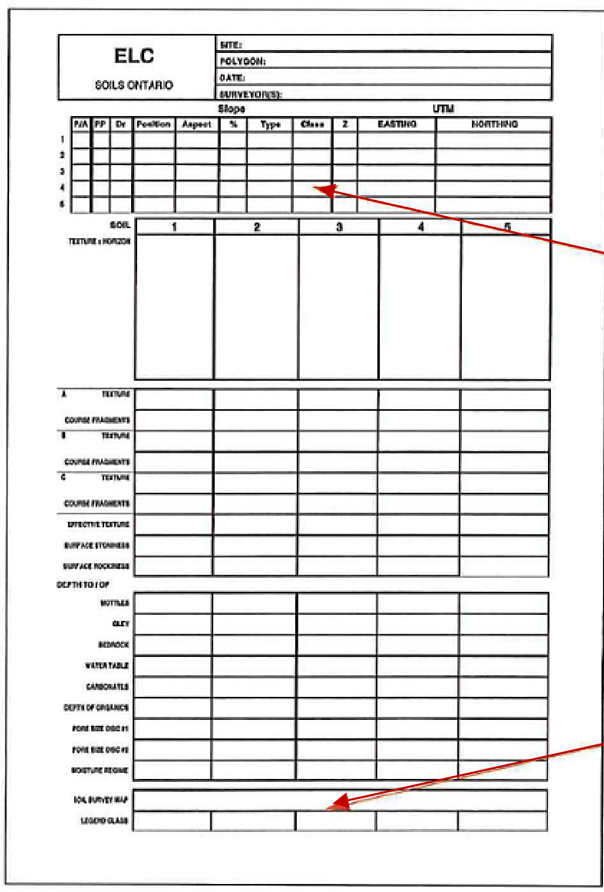
SIZE CLASS ANALYSIS:		< 10		10 - 24		25 - 50		> 50
STANDING SNAGS:		< 10		10 - 24		25 - 50		> 50
DEADFALL / LOGS:		< 10		10 - 24		25 - 50		> 50

ABUNDANCE CODES: N = NONE R = RARE O = OCCASIONAL A = ABUNDANT

COMM. AGE: | PIONEER | YOUNG | MID-AGE | MATURE | OLD GROWTH

SOIL ANALYSIS:
TEXTURE: | DEPTH TO MOTTLES / GLEY | g = | G=
MOISTURE: | DEPTH OF ORGANICS: (cm)
HOMOGENEOUS / VARIABLE | DEPTH TO BEDROCK: (cm)

COMMUNITY CLASSIFICATION: ELC CODE
COMMUNITY CLASS:
COMMUNITY SERIES:
ECOSITE:
VEGETATION TYPE:
INCLUSION
COMPLEX
Notes:



ELC SOILS ONTARIO

SITE: POLYGON: DATE: SURVEYOR(S):

Slope: P/A PP Dr Position Aspect % Type Class Z | UTM: EASTING NORTHING

SOIL 1 2 3 4 5 — TEXTURE + HORIZON

TEXTURE, COURSE FRAGMENTS, EFFECTIVE TEXTURE, SURFACE STONINESS, SURFACE ROCKINESS

DEPTH TO TOP: MOTTLES, GLEY, BEDROCK, WATER TABLE, CARBONATES, DEPTH OF ORGANICS, MOISTURE REGIME

SOIL SURVEY MAP, LEGEND CLASS

Summary for Physiography and Site - Attributes Used When Applying ELC

Broad Scale

Describe the following features by using the Notes sections on the data cards.

- landform and mode of deposition
- prevailing or dominant parent materials and soils from resource maps, such as county soil maps
- the slope and landscape pattern (e.g., elevation, relief, aspect)

This information can provide a pre-typing for the attributes in the Polygon Description. The attributes assigned using air photos should be re-assessed upon site visit field work.

Fine Scale

Assess site-level slope characteristics at each sample point, and record the following on the Soils Ontario data card:

- position - position on slope.
- aspect - aspect of slope
- % - degree or steepness of slope, in percent
- type - slope type.
- class - slope class.

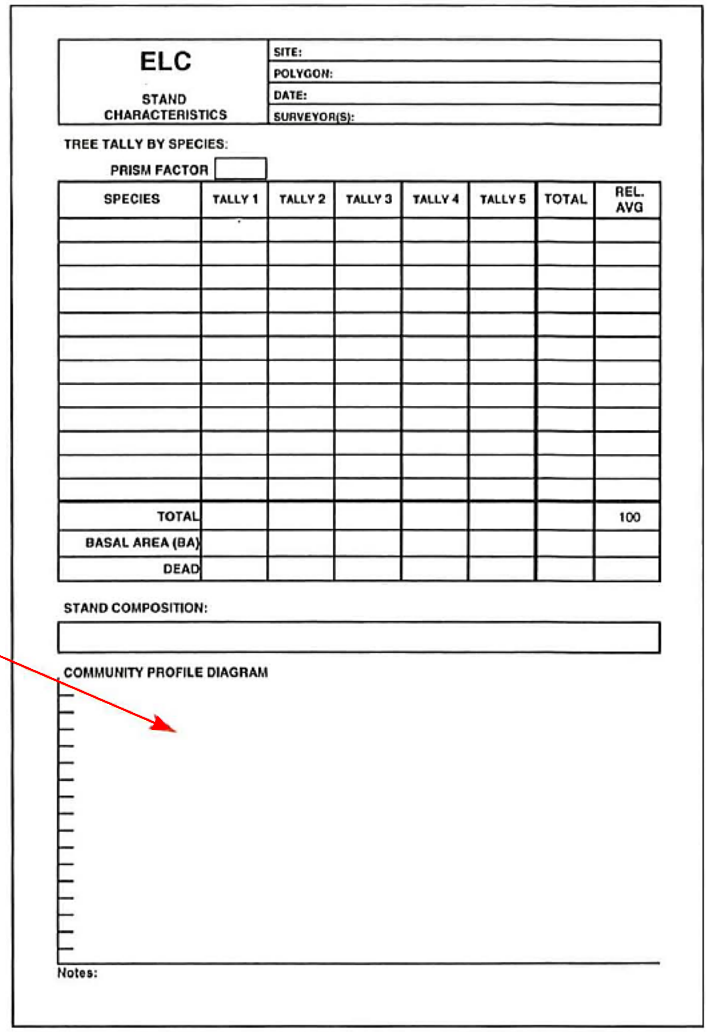
Soil Mapping

Record the following on the bottom of the Soils Ontario data card.

- name of the county soil map being used as a reference.
- name of the mapping unit, from the map legend, in which the samples reside

Community Profile Diagram

Depict an idealized topo sequence (see **Figure 19)** that represents the site and vegetation conditions of the polygon. It is important to record the height scale, on the left of the diagram. The objective here is to sketch a diagram which captures the relationship between meso and site scale patterns in the environment and the vegetation. Use the topo sequence in **Figure 19** as a guide to the scale and detail of diagrams to depict on the Community Profile Diagram on the Stand Characteristics data card.



ELC STAND CHARACTERISTICS	
	SITE:
	POLYGON:
	DATE:
	SURVEYOR(S):

TREE TALLY BY SPECIES:

PRISM FACTOR

SPECIES	TALLY 1	TALLY 2	TALLY 3	TALLY 4	TALLY 5	TOTAL	REL. AVG
TOTAL							100
BASAL AREA (BA)							
DEAD							

STAND COMPOSITION:

COMMUNITY PROFILE DIAGRAM

Notes:

7. Soils Fundamentals

An Introduction to Soils

The Soils Fundamentals section is intended to provide a set of practical methods for collecting and interpreting information about soils in Ontario.

Soils are a vital component of the environment. They are the medium for growth. Within climatic regions of the province, it is the nature of the soil that determines the occurrence and structure of many of our terrestrial and wetland ecosystems. Soils are the medium for growth for our agricultural and forest resources. Soil type, quantity, and fertility influence the land-use and conservation practices applied in resource management. Silvicultural ground rules, productivity trends, species restoration and reforestation, and vegetation diversity and development over time are all strongly influenced by the underlying soil conditions.

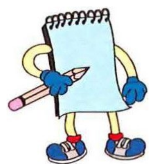
Knowledge about soils provides a common understanding of their nature and function. This information and insight can then be shared among various professionals, and can provide a common and consistent basis for communication and resource management.

Soils develop slowly and are relatively stable over long periods of time. Even after the natural vegetation is cleared or changed, the soils that remain can tell you a great deal about the biological responses that can be expected on that site over time. However, although stable, soils are not immune to damage through inappropriate management practices. It is important to understand both the potentials and sensitivities to damage. of various soil types so the soil resource can be conserved.

Soils are studied at both fine and broad scales. At fine or detailed scales, very specific soil conditions and characteristics can be observed in one or more soil pits or auger samples. However, at broad spatial scales, mapped soils or surficial geology data is a useful source of information for defining large ecosystem or landscape units. This broad-scale information increases our understanding of a variety of ecosystem trends, and, subsequently, helps in making strategic resource decisions.

What Is Soil?

Life is dependent on a thin mantle of soil which variably covers the surface of the earth. Without soils there would be only minimal vegetation and no agriculture or forestry as we know it. The tremendous diversity of terrestrial and wetland systems observed across the province and the entire globe is, to a great extent, a result of the underlying soil.



Soil is an important and functional part of the ecosystem, for:

- plant growth - it provides anchorage and a growing medium supplying essential mineral and water nutrients;
- hydrology - its properties control the movement and fate of water.
- recycling - organisms recycle mineral nutrients through the decomposition of plant and animal wastes, and their incorporation into the mineral substrate.
- habitat - a variety of organisms, from mammals, reptiles, and insects to arthropods and more, live in the soil (Briggs and Smithson 1985; Brady and Weil 1996).

Soil = Ƒ(pm + cl + l + o + t)

pm	parent material
cl	climate
l	landform
o	organisms
t	time

(After Jenny 1941)

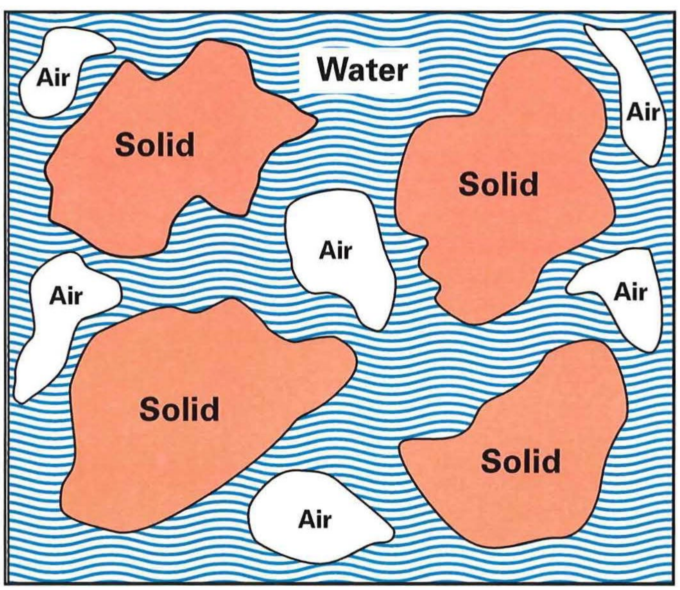


Figure 22

Pictorial representation of the three-phase nature of soil: Solid, Water (liquid), and Air (gas).

Soils are complex in their make-up and distribution. They have solid, liquid, and gaseous components. They are both mineral and organic. Although relatively stable, they are nevertheless constantly changing in both their chemical and physical properties. Soils define the environment for the growth of species and are, in turn, changed by the climate, and by the vegetation and organisms they support.

Soil provides the anchorage for roots, and it stores most of the critical nutrients and moisture plants need in order to grow. Soil is a dynamic material: within this thin layer, nutrients are exchanged with the atmosphere and groundwater systems through a variety of chemical processes such as decomposition and chemical weathering. Soluble minerals are then transported through the soil by water or released to the atmosphere.

Soil starts out as bare mineral material, such as that left by the recession of the glaciers, on the surface of parent materials, particularly bedrock. Through eons of erosion, deposition, weathering, leaching, disturbances, and organic incorporation, or pedogenesis, a soil evolves. These forces give rise to various horizons of textures and colours in a soil profile (see **Figure 24).**

Soil is a function of:

- parent materials - mineralogy; size of particles.
- climate - temperature, precipitation, evapotranspiration.
- landform - mode of deposition (i.e., ice, wind, water), erosion, slope; physical processes of water movement and leaching.
- organisms - biotic processes of incorporation and recycling; root penetration.
- time - changing properties with time.

Components of Soil

Soil is considered to be a three-phase system, made up of solid, liquid, and gas. All soils consist of varying proportions of these components:

Solids

- mineral material -varies according to the nature and texture of the parent materials (i.e., sand, silt, or clay)
- organic material - accumulates on top of, or incorporated and recycled into, the mineral material.

Water (liquid)

- enters by precipitation, seepage, and drainage.

Air (gas)

- diffuses from the atmosphere and is changed by biological activity.

In general, the solid phase makes up approximately 50% of the soil's total volume, with the air and water making up the rest **(Figure 23).** Changes in precipitation, seepage, drainage, and evaporation will alter the relative proportions of air and water, as they compete for the interstitial spaces. As soil texture changes, the relative proportions of different solids vary. For example, in a typical loamy soil, the mineral fraction is made up of 10% clay, 20% silt, and 14% sand, by volume.

"The composition of the three main components to soil varies to some extent. On the whole, the air within the soil is similar to that of the open atmosphere but enriched with carbon dioxide and deficient in oxygen. This is because of plant respiration. The composition changes over time, depending upon the rate of organic activity and the ease with which the gases can diffuse through the soil into the open atmosphere. The soil water also differs somewhat from the water we find in lakes or rivers. It tends to be much richer in dissolved substances [leached and] washed from the soil and vegetation and, because it comes under the attraction of the soil particles, is much less free to move.

"Both the organic and inorganic matter that make up the solid phase of the soil vary considerably in character. The inorganic fraction consists in the main of partially weathered rock fragments and minerals, including in particular the more resistant residues such as quartz, feldspars, clay minerals and compounds of iron and aluminum. The composition of the inorganic material depends upon the nature of the rocks from which they have been weathered, the climate and the time available for weathering so many other minerals may also be present. These materials vary considerably in their minute clay minerals. The finer particles - the sand, silt, and clay fractions of the soil - rarely occur as individual grains but are bound together by cohesion and various. cementing agents into aggregates. The organic fraction of the soil is similarly variable. It consists of the living and dead cells of animals and plants and the organic acids (e.g., fulvic and humic acid) which are formed by decomposition of plant materials in some cases, these compounds occur as discrete horizons or masses of organic matter. In peat, for example, almost the whole soil is composed of plant debris. But, in other cases, the organic matter is intimately mixed. with the mineral material so that we cannot see it, save perhaps by even in this state it plays an important part in the soil, helping to cement the particles together and acting as a vital source for plant nutrients.

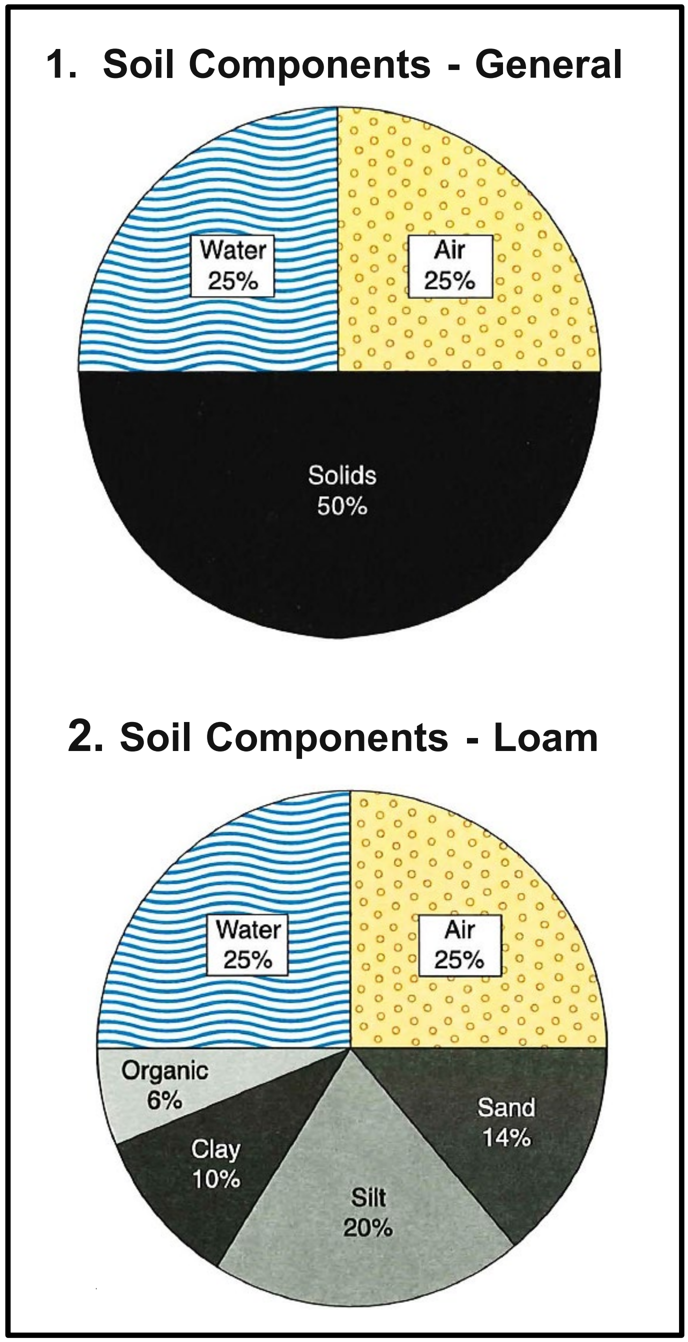


Figure 23
The relative proportions of soil components:
1) **the general proportions of the three-phase components of soil - solid, water, air**
2) **the proportions of components in a typical loamy soil - mineral has been broken down further into sand, silt, and clay.**

Helpful **HINTS**
CAUTION:
Remember that soil map- ping is done at generalized scales (e.g., 1:50,000). These maps provide generalized information that describes the prevailing conditions within a specified area (mapping unit). However, because of the local variability in soils, the maps cannot be relied on to give definitive soil proper- ties, such as texture and moisture, at finer, site level scales. For example, it is not uncommon to find pockets of organic soils within a mapping unit described as a miner- al material, such as a loam. This is why soil sampling must be done on site, during field work.

"Although much of the organic matter in the soil is relatively transient, soon decomposing to form organic acids or being liberated into the atmosphere as gases, some of it - the portion normally called humus - is persistent. This persistent fraction, together with the inorganic solid fraction, provides the main constituents of the soil profile, and it is differences in character, arrangement and proportions of these components that give rise to differences in soil profiles." (Briggs and Smithson 1985)

Soil Sampling and Description

Soil description is a standardized process by which important attributes of the soil are documented. The important attributes have been shown to influence the prevailing ecological conditions and, therefore, plant distribution. Measuring the variation in these attributes among sample sites enables their categorization according to how they influence plant distributions and the resulting vegetation assemblage. Soils are described using representative soil samples from the area of interest.

To describe the prevailing soils within a particular area, sample points must be established. Ideally, sampling should be done with the intent of capturing the variation in the soils across the area. This is done by, first, assessing the site's sources of variation that would lead to changes in soil attributes, including: slope, depressions, hummocks, and hollows, or rolling topography. Sampling points should be placed within the separate regimes produced by these variables. For example, when sampling a slope, soil samples at the top, middle, and bottom of the slope would be ideal for capturing the variation in soil attributes across the slope. Furthermore, the variation in the separate sample points should be synthesized to give a description of the prevailing soil conditions of the entire area, or site.

Helpful **HINTS**

A helpful hint for auguring:
- when you finish driving the auger into the soil for samples, mark the depth of your auger sample by placing and holding your thumb on the auger at the soil surface.
- keep your thumb there while you remove the auger from the hole.
- line up your thumb with the top of your sample (i.e., soil surface) that is laid out on the ground or in a sampling box.
- remove the sample and place it according to where your thumb indicates it should go, rather than lining it up with the bottom of your last sample.
- expect some overlapping of samples.

Pit or Auger Sampling

At each of the soil sampling points, either a soil pit is dug, or a soil auger is used. A soil pit is the best and most reliable approach. For a soil pit, a hole is dug (with an opening approximately 1 m square) straight down into the soil to a depth of 120 cm, unless bedrock or an obstruction is reached. Within a pit, the soil profile can be described while looking at the exposed and intact faces of the pit. While digging the pit, select one side for description, and avoid stepping on, or trampling, this side. This will help minimize the compaction of the organics and underlying soils that would lead to errors in measurement.

A soil auger (such as a Dutch soil auger) is a much faster technique for sampling soils yet has its limitations. Augers are either pushed or screwed into the soil to fill the barrel and to acquire soil samples up to 120 cm deep or to an obstruction. The pushing or screwing tends to compress or twist the samples.

Depending on which auger is used, this will lead to either stretching or compaction of the sample and mixing of soil layers, if care is not taken. Furthermore, it can be a challenge to remove auger samples, so they accurately represent the depths at which features are occurring. Holding the auger straight up and down while taking the sample and keeping to under 2 complete turns will minimize gouging, compressing, and mixing of layers. For a Dutch auger, about 1-1/2 to 2 complete turns of the auger will fill the barrel. With an auger, the sample has to be laid out either on the ground or in a sample box. Taking care in laying out the sample (see Helpful Hints) will ensure that depth measurements are accurate.

The choice between using pits or augers to sample the soil usually depends on the intensity of sampling needed and available time. When time allows for auger sampling only, reasonable accuracy can be achieved by knowing how the auger affects the soil sample.

Helpful **HINTS**

Demonstrate to yourself the effect of the auger in sampling:

1. first, auger by only lining up the samples as they come out of the auger hole
2. then, sample using your thumb on the auger as described above, indicating where the soil surface is, to line up samples

You will likely find that method 1 stretches the sample when using a Dutch auger (i.e., the sample is longer than the hole is deep) and compresses the sample when using a tube auger. Observe how the samples overlap a little bit, using method 2. Method 2 helps to maintain real depths to features.

The Soil Profile

The soil profile represents the overall organization of the soil sample. The vertical section of soil exposes this organization, typically into bands or layers of various textures and colours, called horizons. A soil horizon is a layer of mineral or organic material, running parallel to the land surface, and has characteristics that reflect processes of soil formation (Schut 1992). The formation of soil horizons occurs in three interacting ways.

Deposition

Stratification of soil into layers first arises from the mode of deposition of parent materials and, possibly, of other layers. The depositional processes of ice, water, and wind (see Surficial Geology) give rise to a variety of textures of material, from heterogenous tills to well-sorted and stratified fluvial, lacustrine, or aeolian deposits. Characterizing the texture of the material is an important feature in sampling the horizons in a soil profile.

Weathering

Weathering refers to the combined effects of physical forces to break down parent materials into smaller, coarse fragments, then into gravels, sands, silts, clays, and finally into their constituent minerals. Two processes are involved here: physical disintegration and chemical decomposition (Brady and Weil 1996). These processes contribute to the texture of horizons, as well as to their varying colours.

Organisms

Organic matter in the soil originates from dead and decomposing organisms. The primary source of organic matter is vegetation.

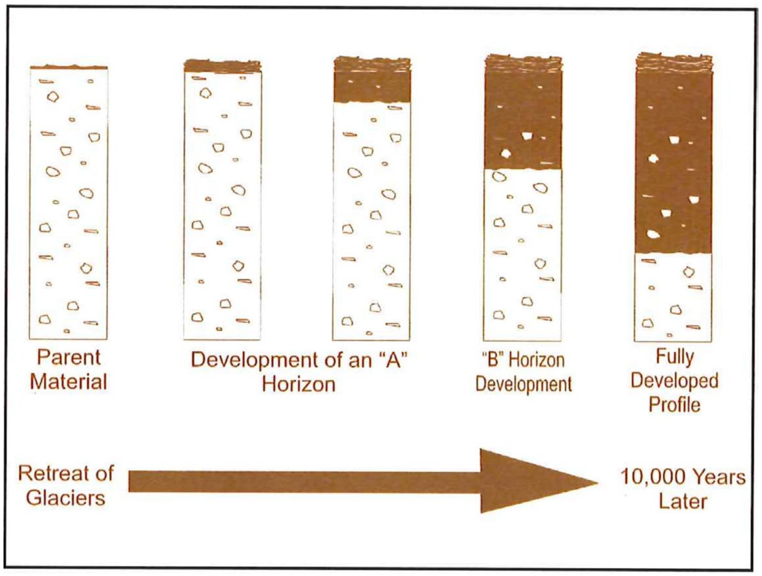


Figure 24

Organic materials accumulate from the top down, overlaying parent materials.

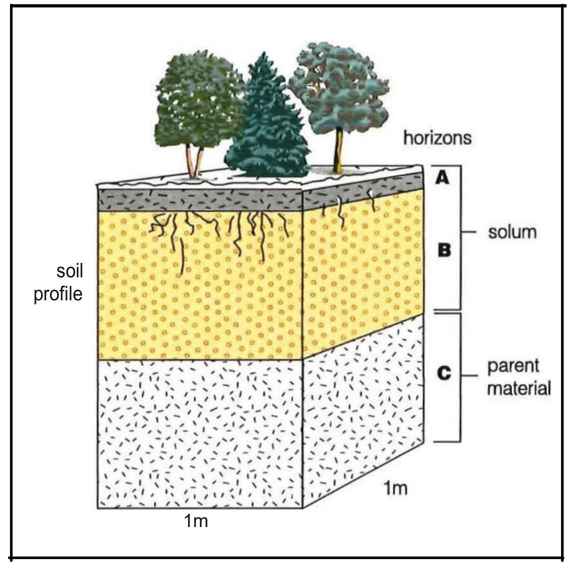
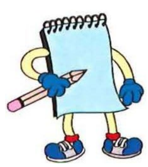


Figure 25

Soil profiles are described from the top down.

Secondarily, the burrowing actions of mammals can affect the soil by mixing and dumping layers. Similarly, smaller organisms, such as earthworms, digest decomposing organic debris and churn the top layers with their burrowing. These combined actions incorporate and mix organics into the mineral material. Organic matter affects the texture and colour of soil horizons. These three interacting factors act on a soil from the surface downwards. Therefore, the upper layers are changed the most, and the lower, deeper layers are more and more like the original parent materials (see **Figure 24).** A soil profile is described in the same fashion, from the top down (see **Figure 25).**



Organic vs. Mineral Soil

Organic Soil

- contains > 17% organic carbon (> 30% organic matter)
- material is black and greasy
- depth of organic accumulations: Oh or Om > 40 cm or Of > 60 cm deep

Mineral Soil

- contains < 17% organic carbon (< 30% organic matter)
- material is pale and typically grainy, not greasy
- organic accumulations < 40 cm deep

Describing a Soil Profile

First, the separation between the organic and mineral layers is identified and its depth measured. The depth of the organic material on top determines whether a soil is classified as organic or mineral. Typically, if the accumulated organics exceed 40 to 60 cm in depth, it is considered an organic soil (refer to **OIP,** page 9, reproduced in **Figure 39,** for criteria used to classify organic soils). In general, all soils with less than 40 cm of organic material are considered mineral soils.

Measurements to features in the soil profile are affected by whether the soil is classified as organic or mineral. If organic accumulations exceed 40 cm, then the "O" point for measuring depths becomes the top of the organic material (see **Figures 26** and **39).** If, however, the organic accumulations are less than 40 cm, the "O" point becomes the top of the mineral material (see **Figures 26, 28,** and **29).**

Documenting a soil profile description can be made easy using a "soil profile diagram". **Figures 26, 27,** and **28** show profile diagrams. Horizons and features within the profile are drawn onto the diagram and the depths to them are recorded along the vertical borders of the diagram. Start the diagram by placing the scale down the side, according to how deep the sample is and where the "O" mark is. Identify distinctive horizons in your profile and transcribe these to your diagram by drawing in what the horizon boundary looks like, along with the depth of the boundaries between them (as shown in **Figures 26** and **28).**

After deciding where the "O" point of the soil profile is, begin delineating horizons, or horizontal changes in soil texture and colour. Delineation of horizons should be done first, independent of any description or naming. Measure their depths in the profile according to the upper and lower boundaries of the horizon (see **Figure 26),** and record your observations on the soil profile diagram (as shown in **Figure 26).**

Once the horizons have been delineated, they can be classified, according to the standards set by the National Soil Classification Working Group The definitions and descriptions of the generalized soil horizons are as follows.

Mineral Horizons

Mineral horizons contain 17% or less organic carbon (about 30% or less organic matter) by weight.

A Horizons -Typically the upper-most horizons in the profile, unless buried. These horizons form near the surface in the zone where materials are removed and transported in suspension or in solution (leaching or eluviation). This is the zone of maximum in situ accumulation of organic matter. Incorporation of organic matter darkens the surface soil (Ah). Conversely, the removal of organic matter is usually expressed by a lightening of the soil colour in the upper part of the solum (Ae).

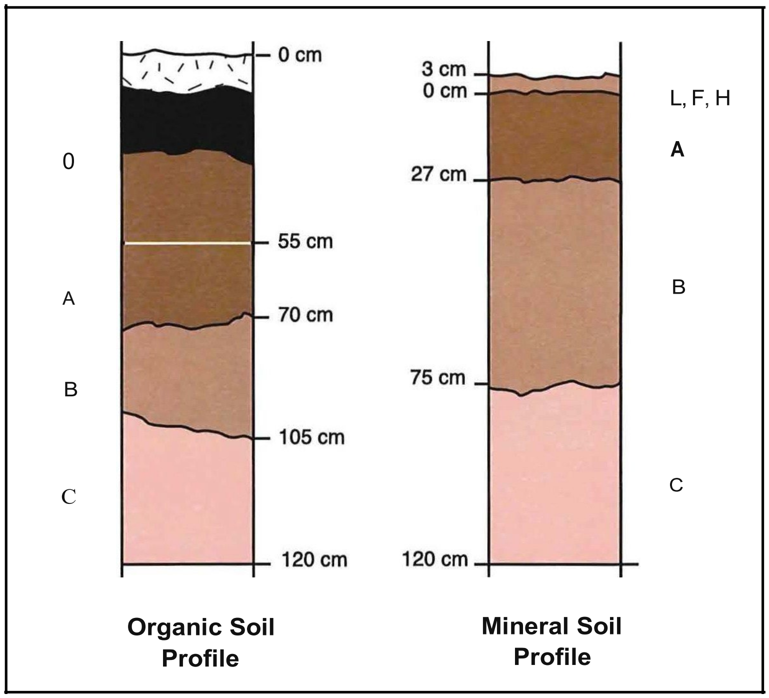


Figure 26
Examples of soil profile diagrams. Note how the “0” mark changes depending on the depth of organic material.

B Horizons - Typically the middle horizons in the profile, underlying the A horizons. This is the region of the soil profile where materials are being leached or transported to, and where they accumulate. Chemical decomposition leads to leaching and accumulations of silicate clays, iron and aluminum oxides, gypsum, and calcium carbonate (marl). Organic materials also get washed and migrate to the 8 horizons.

C Horizons - Typically the lowest horizons in the profile, underlying the 8 horizons. These are the mineral layers that are comparatively unaffected by weathering, and typically referred to as the parent material.

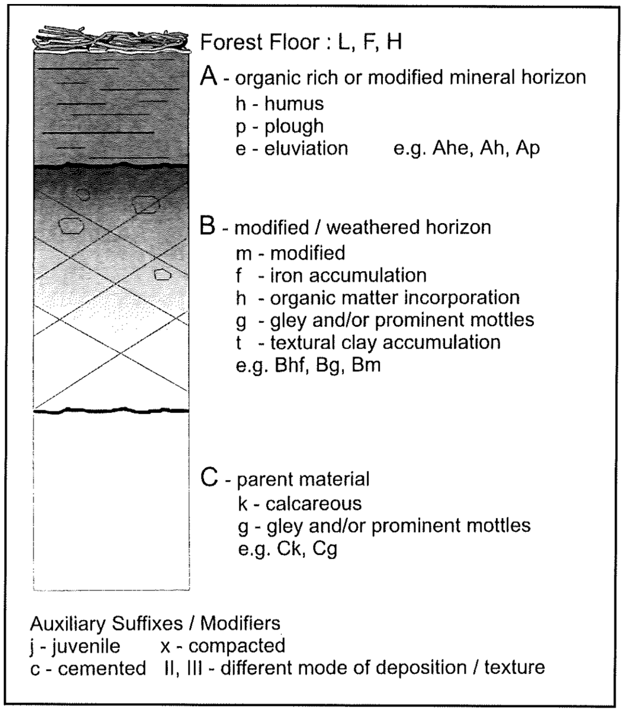


Figure 27

Soil horizon designation.

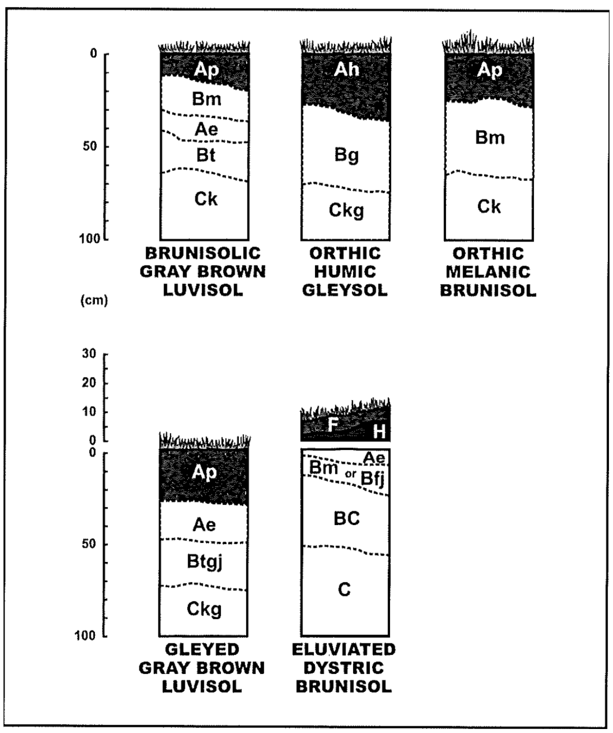


Figure 28

Typical soil profiles: southern Ontario.

Organic Horizons

Organic horizons occur in organic soils and commonly at the surface of mineral soils. They may occur at any depth beneath the surface in buried soils or overlying geologic deposits. They contain more than 17% organic carbon (about 30% or more organic material) by weight.

L, F, and H Horizons - Develop on top of mineral soil. They are accumulations of leaves, twigs, and woody materials, with or without a minor component of mosses. These horizons are typically associated with terrestrial soils, such as upland forests. rushes, and woody materials.

O Horizons - Organic accumulations that exceed 40 cm. This is organic soil, primarily peat materials developed from mosses, sedges, rushes, and woody materials.

Describing Soils

Reference to soil and soil description means describing specific attributes about the individual soil horizons or other features identified in the soil profile diagram. The soil profile diagram sets the context by which we record the very nature of the soil.

Although there are many different features and variables that can be described in a soil sample, a small suite of features and variables are chosen here. This specific set of features and variables has been shown to relate to ecosystem patterns and processes. The following soil features and variables are the minimum sampling standards for ecosystem mapping and application of ELC. In many ways, the selected variables are pragmatic. Although they might not be directly responsible for ecological mechanisms, they do represent features that are easily measured in the field and serve as good secondary surrogates for those ecological mechanisms. Once the soil profile diagram has been completed, with the soil horizons depicted and measured, further description of these features proceeds. The features that are delineated and described depend primarily on whether the sample is an organic or mineral soil.

Describing Mineral Soils

Mineral soils are those substrates that have less than 30% organic matter integrated into their texture or less than 40 cm of accumulated organic material on top. In these soils, the textures and chemical properties of the material influence vegetation growth and community patterns by affecting rooting depth, root penetration, hydrology, ion exchange with roots, and nutrient status.

The description and documentation of the following variables in soil sampling are recorded on the Soils Ontario data card. For more detailed annotations and naming of mineral soil horizons, refer to **Figures 29** and **30.** Although a complete and detailed description of these layers is ideal, as in these figures, it is not necessary in order to apply ELC.

Principle Variables Used to Describe Soils

Mineral Soil
- *Texture* - by horizon
- *Coarse Fragments* – proportions of rock fragments > 2 mm
- *Carbonates* - depth to
- *Colour*
- *Mottle and Gley* - description and depths
- *Drainage* - derived
- *Moisture Regime* - derived
- *Bedrock* - depth to
- *Water Table* - depth to

Organic Material and Organic Soils
- *Depth of Organics* - organic soils > 40 cm
- *Organic Horizons* - classification of surface organics
- *Humus Form* - based on the composition of organic horizons
- *Von Post* - degree of organic decomposition

Texture

Various erosional, depositional, and weathering factors have lead to the particular composition of soil particles that are observed within the soil horizons.
Texture of the soil is determined by assessing the relative proportions of different size classes of particles. For texture, we only assess the relative proportions of sand, silt, and clay, all particles less than 2 mm in diameter. Soil texture families, or classes, **(Figure 31)** represent unique suites of textures based on their relative proportions of sand, silt, and clay. These soil texture classes also represent unique ecological regimes, according to how their characteristics control water movement (drainage) and ion exchange with roots (see **Table 5).**

IN THE FIELD

Texture Assessment
- Grab a handful of material from a particular mineral horizon
- Remove all the organic debris – leaf litter roots, twigs, and bark
- Remove all the mineral particles greater than 2 mm in diameter – gravels, cobbles, stones, and other large coarse fragments (you might have to keep these to assess coarse fragment proportions later)
- Assess the texture: 1) in the field by using OIP tables and

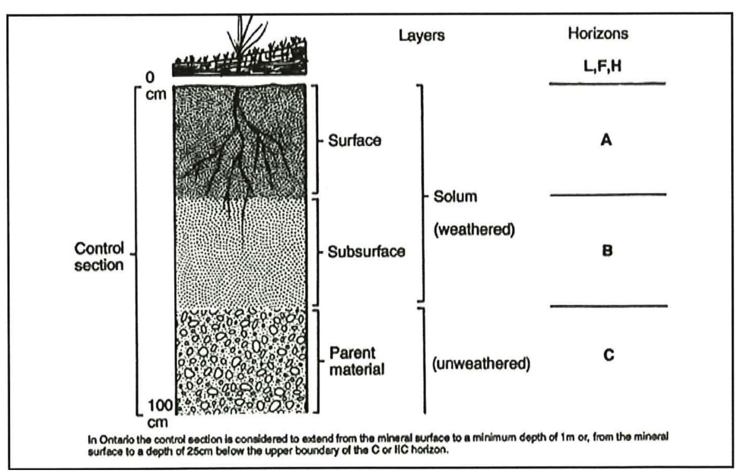


Figure 29
In Ontario the control section is considered to extend from the mineral surface to a minimum depth of 1m or from the mineral surface to a depth of 25 cm below the upper boundary of the C or IIC horizon.

mineral soil horizon descriptions

L,F,H organic horizons commonly found at the surface of mineral soils, and developed mainly from leaves, needles and twigs (litter layer).

Ah, Ap dark coloured, mineral surface horizons, enriched with organic matter (p - man modified e.g. plough layer).

Ae light coloured near surface horizon. Horizon of loss of iron, aluminum, organic matter or clay.

AB a transition horizon from A to B.

Bt brownish, subsurface horizon enriched with clay that has been moved from the Ae horizon.

Btgj a Bt horizon containing mottles but no gray gley colours. The suffix "gj" is also applied to other horizons containing mottles but no gray gley colours e.g. Bmgj, Ckgj.

Bm brownish subsurface horizon with only slight addition of iron, aluminum or clay.

Bf, Bhf reddish brown subsurface horizon with significant accumulation of iron, aluminum and/or clay.

Bg horizons with gray gley colours or prominent mottling or both. The suffix "g" is also applied to other horizons with these characterics e.g. Cg, Ckg.

BC a transition horizon from B to C.

C relatively unweathered material from which the soil profile has developed.

Ck a C horizon containing calcium and/or magnesium carbonates that will effervesce with diluted HCL (10%).

IIBt* a Bt horizon which has developed in materials which are significantly different in texture (mode of deposition) from the horizons above.

IIICk* a Ck horizon which is significantly different in texture (mode of deposition) from the horizon above e.g. IIBt, IICk.

Solum A and B horizons e.g. Ap, Bt, Bm in which the parent material has been modified and in which most plant roots are contained.

Parent material the unconsolidated and chemically unweathered mineral or organic material from which the solum of soil has developed.

Control section the vertical section upon which the taxonomic classification of soil is based.

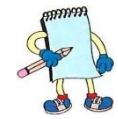
* Roman numerals which precede the horizon designation indicate a significant change in texture (mode of deposition) within the profile e.g. where silt loam occurs over coarse sand, the horizon(s) of coarse sand are preceded by "II". They are often applied to horizons in stratified soil e.g. IIBt, IIICk, IVCk, etc.

8

Figure 30

Mineral soil horizon descriptions.

charts; 2) in the office by drying the sample and sieving it into separate sand, silt, and clay components, or 3) by sending the sample to an analytical lab.



Soil Texture
% SAND
% SILT
% CLAY
= TEXTURE

- when assessing texture in the field, achieve "field moisture" with the handful of soil: add water to moisten it, or air-dry to make it drier, until the sample does not leave a stain on the back of the hand
- use the **OIP** Texture Field Tests chart **(OIP,** page 19; reproduced in **Figure 33)** and perform the tests on the sample. The recommended order is:

  1. taste test
  2. moist cast test
  3. ribbon test
  4. feel test
  5. shine test

- use the findings from the texture field tests and use the **OIP** diagrammatic key Finger Assessment of Soil Texture **(OIP,** page 21; reproduced in **Figure 34)** to determine the soil texture family or class (e.g., sandy clay loam)
- compare your assessment against the characteristics for that class using **OIP** Field Test Characteristics of Texture Classes **(OIP,** page 20; reproduced in **Figure 35)**
- use the texture card and table included with **OIP** manual (see **Figure 32)** to assess the particle sizes, as well as the sand size class (e.g., very fine sandy clay loam)
- assign a "soil texture" to each horizon in the soil profile or to designated groups of horizons (i.e., A, B, C)

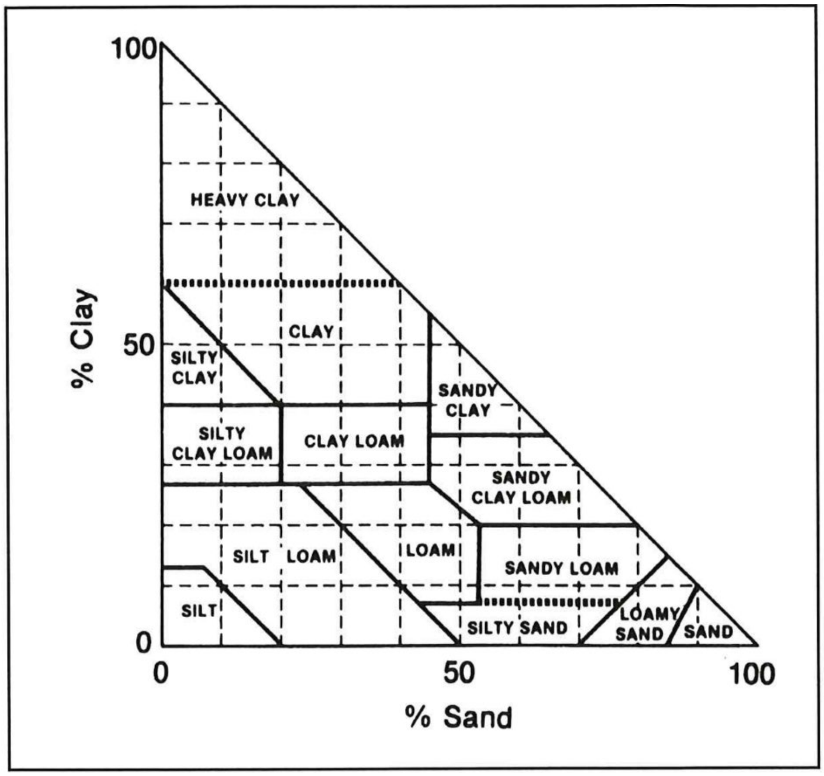


Figure 31

Soil texture triangle showing the family particle sized as a percentage of sand, silt, and clay; from OIP, page 18.

primary particles (<2 mm)

Class name	Diameter (mm)
very coarse sand	2.0-1.0
coarse sand	1.0-0.5
medium sand	0.5-0.25
fine sand	0.25-0.10
very fine sand	0.10-0.05
silt	0.05-0.002
clay	<0.002
fine clay	<0.0002

Figure 32

Primary particle sizes; from OIP, page 17.

texture field tests

Feel Tests:

Graininess Test - Soil is rubbed between thumb and fingers to assess the % sand . Sand feels grainy.

Dry Feel Test - For soils with >50% sand. Soil is rubbed in the palm of the hand to dry it and to separate and estimate the size of the individual sand particles. The sand particles are then allowed to fall out of the hand and the amount of finer material (silt & clay) remaining is noted.

Stickiness Test - Soil is wetted and compressed between the thumb and forefinger. Degree of stickiness is determined by noting how strongly it adheres to the thumb and forefinger upon release of pressure and how much it stretches.

Moist Cast Test - Compress some moist soil by clenching it in your hand. If the soil holds together (i.e. forms a cast), then test the strength of the cast by tossing it from hand to hand. The more durable it is, the more clay is present.

Ribbon Test - Moist soil is rolled into a cigarette shape and then squeezed out between the thumb and forefinger to form the longest and thinnest ribbon possible. Soils with a high silt content will form flakes or peel-like thumb imprints rather than a ribbon.

Taste Test - A small amount of soil is worked between the front teeth. Sand is distinguished as individual grains which grit sharply against the teeth. Silt particles are identified as a general fine grittiness, but individual grains cannot be identified. Clay particles have no grittiness.

Shine Test - A small amount of moderately dry soil is rolled into a ball and rubbed once or twice against a hard, smooth object such as a knife blade or thumb nail. A shine on the ball indicates clay in the soil.

19

Figure 33

Texture Field Tests; from OIP, page 19.

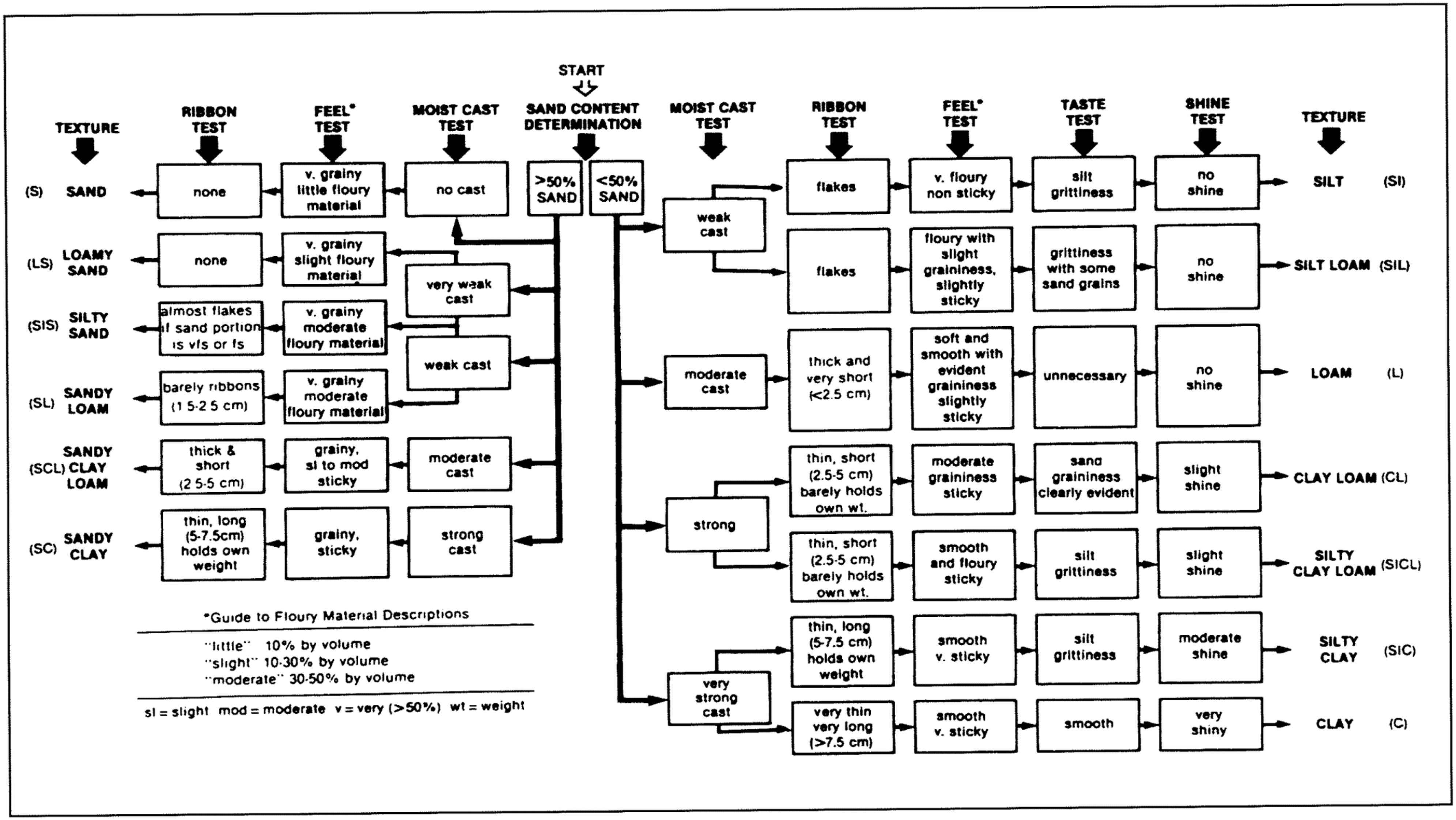


Figure 34
Finger assessment of soil texture; from OIP, page 21.

field test characteristics of texture classes

TEXTURE CLASS	FEEL TEST	MOIST CAST	RIBBON TEST	TASTE TEST	SHINE TEST
SAND	grainy, little floury material	no cast	none	unnecessary	unnecessary
LOAMY SAND	grainy with slight amount of floury material	very weak cast no handling	none	unnecessary	unnecessary
SILTY SAND	grainy with moderate amount of floury material	weak cast, no handling	almost flakes if sand portion is vfs or fs	unnecessary	unnecessary
SANDY LOAM	grainy with moderate amount of floury material	weak cast, allows careful handling	barely ribbons (1.5-2.5 cm)	unnecessary	unnecessary
LOAM	fairly soft and smooth with evident graininess	good cast, readily handled	thick and very short (<2.5 cm)	unnecessary	unnecessary
SILT LOAM	floury, slight graininess	weak cast, allows careful handling	flakes, rather than ribbons	silt grittiness, some sand gaininess	unnecessary
SILT	very floury	weak cast, allows careful handling	flakes, rather than ribbons	silt grittiness	unnecessary
SANDY CLAY LOAM	very substantial graininess	moderate cast	short and thick (2.5-5 cm)	sand graininess clearly evident	slightly shiny
CLAY LOAM	moderate graininess	strong cast	fairly thin, breaks readily, barely supports own weight	sand graininess clearly evident	slightly shiny
SILTY CLAY LOAM	smooth, floury	strong cast	fairly thin, breaks readily, barely supports own weight	silt grittiness	slightly shiny
SANDY CLAY	substantial graininess	strong cast	thin, fairly long (5-7.5 cm) holds own weight	sand graininess clearly evident	moderately shiny
SILTY CLAY	smooth	very strong cast	thin, fairly long (5-7.5 cm) holds own weight	silt grittiness	moderately shiny
CLAY	smooth	very strong cast	very thin, very long (>7.5 cm)	smooth	very shiny

20

Figure 35

Field test characteristics of texture classes; from OIP, page 20.

Table 5. Behaviour and properties typical of some generalized soil types; modified from Brady and Weil 1996.

Properties typical of very sandy soils	Properties typical of very silty soils	Properties typical of very clayey soils
low water-holding capacity	medium to high water-holding capacity	high water-holding capacity
well aerated, rapid drainage	moderate aeration, slow to medium drainage	poorly aerated, very slow drainage (unless cracked)
low in organic matter, rapid decomposition	medium to high in organic matter, medium rate of decomposition	high to medium in organic matter, slow decomposition
warms quickly in spring resists compaction (if coarse sand)	warms somewhat slowly in spring easily compacted	warms slowly in spring easily compacted
easily blown by wind (if fine sands)	very easily blown by wind	resists wind erosion
poor supply of plant nutrients, little capacity to hold them	usually good supply of plant nutrients and medium capacity to hold them	medium to excellent supply of plant nutrients, large capacity to hold them
acidity easily raised or lowered	moderately resists changes in acidity	resists change in acidity
allows leaching of most pollutants	moderately retards leaching of pollutants	retards leaching of most pollutants (unless cracking clay)
easily tilled shortly after rain	moderately difficult to till after rain	very difficult to till after rain
resists erosion by water (unless fine sand)	very susceptible to erosion by water	aggregated clay resists erosion by water, dispersible clay is easily eroded
poor sealing properties for dams or ponds	poor sealing properties, prone to rapid "piping", by which water washes out large channels in a soil mass	good to excellent sealing properties for dams and ponds
little or no shrinkage and swelling	little shrinkage and swelling	moderate to high shrinkage and swelling, depending on the clay type

coarse fragments (>2 mm)

Shape and kind of fragment	Size and name of fragment		
	≤ 8cm in dia.	8-25cm in dia.	>25cm in dia.
Rounded and subrounded fragments (all kinds of rocks)	Gravelly	Cobbly	Stony (or bouldery)*
Irregularly shaped angular fragments			
Chert	Cherty	Coarse cherty	Stony
Other than chert	Angular gravelly	Angular cobby	Stony
	≤ 15cm in length	15-3Bcm in length	>38cm in length
Thin flat fragments			
Thin flat sandstone, limestone, and schist	Channery	Flaggy	Stony
Slate	Slaty	Flaggy	Stony
Shale	Sha	Flaggy	Stony

• Bouldery Is sometimes used where stones are larger than 60cm.

Figure 36
Coarse fragment diameter size classes and names: OIP, page 17.

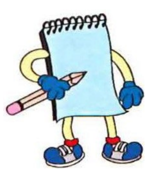
Coarse Fragments

Coarse fragments refer to materials in the soil sample that are greater than 2 mm in diameter, including gravels, cobbles, and stones. **Figure 36** shows the diameter size classes and names for each of these.

The primary influence of coarse fragments in a soil is the way they affect the moisture regime. Coarse fragments increase the size of the interstitial spaces between soil particles, thereby increasing the ability of water to be drained from the soil by gravity. The more coarse fragments the soil has, by volume, the better drained it will be. When the volume or size of coarse fragments is increased, the moisture regime of a soil will decrease, unless it is regularly flooded. A lower moisture regime means drier soils, often subject to draughty periods.

IN THE FIELD

- remove and set aside any large coarse fragments as the soil is being sampled (those fragments which may not be isolated to specific horizons and tend to be greater than 25 cm in diameter)
- depict these larger coarse fragments on the soil profile diagram, in relation to the other features in the profile
- assess the volume of coarse fragments, by horizon
- the texture classes assigned earlier to horizons in the soil profile may be modified by adding suitable adjectives when coarse fragments occupy greater than 20% of the soil volume **(OIP,** page 18; reproduced in **Figure 31)**
- for coarse fragment volumes of 20 to 50%, use coarse fragment class names **(OIP,** page 18; reproduced in **Figure 36)** - e.g., gravelly sandy loam, cobbly very fine sandy clay loam.
- for coarse fragment volumes greater than 50%, use **"very"** as an additional adjective - e.g., very gravelly loamy medium sand.



Note: Coarse fragments may be an impediment when using an auger:

1) they may inhibit the penetration of the auger, acting as a barrier. This barrier can be misinterpreted as bedrock.
2) they often cannot be removed from the auger hole. They might not fit into the barrel of the auger or they may fall out while you extract the auger from the hole.

Carbonates

Carbonates refer to the presence of calcareous material, or calcium carbonate (CaC03), in the soil profile. Carbonates are found in calcium - rich parent materials, typically those arising from sedimentary rocks, such as limestone, sandstone, and shale. The calcium carbonate content is an important mineral property of the soil, affecting pH and, therefore, many other soil properties (Briggs and Smithson 1985). Most importantly, carbonates tend to raise pH, increasing the availability and uptake of nutrients. Furthermore, calcium ions act as a cementing agent by bridging the colloidal structure of the soil, influencing soil structure. The test for carbonates involves the simple effervescent reaction when an is added to a base mineral constituent, the calcium carbonate. The presence of free carbonates in the soil profile is indicated by the effervescence (bubbling, hissing, crackling, or foaming) of soil material when 10% HCI (dilute hydrochloric acid) is added. The degree of effervescence of the soil sample indicates the amount of carbonates in the sample.

IN THE FIELD

- in a soil pit: apply the 10% HCI solution to the face of the soil profile by dripping it on with an eye dropper.
- using an auger: apply the 10% HCI solution with an eye dropper to the sample laid out on the ground or in a sampling box.
- work from the bottom of the soil profile upwards.
- record the depth, from the "0" point in the soil profile, to the point at which effervescence begins (use **OIP,** page 34; reproduced in **Figure 37).**

calcareous classes

Calcareous: the presence of carbonates in the soil material, with calcareousness being the amount of carbonates and expressed as CaCOa equivalent; estimated in the field by degree of effervescence (bubbling, hissing, crackling, or foaming) when 10% HCI is added to the soil material.

Class	Name	Description
N	Non-calcareous	Bubbling, hissing, crackling or foaming do not occur (are not seen or heard) when 10% HCI is applied
W	Weakly calcareous	Bubbles readily observed; hissing or crackling, but not easily heard; CaCOa <5%
M	Moderately calcareous	Bubbles form low foam; hissing or crackling easily heard; CaCOa 5 - 15%
S	Strongly calcareous	Bubbles form thick foam; strong hissing or crackling, very easily heard; CaCOa 15 - 25%
V	Very strongly calcareous	Bubbles form very thick foam; very strong hissing or crackling; $CaCO_3$ 25 - 40%
E	Extremely calcareous	Bubbles form very thick foam; materials react violently with 10% HCI - extremely strong hissing or crackling; CaCOa >40%

Figure 37

Calcareous classes: OIP, page 34.

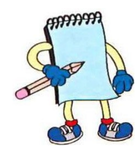
Bedrock

Bedrock refers to the location, in relation to the "O" point in the soil profile, of the underlying bedrock. The depth to bedrock can apply to particular sample points, or it can be generalized for a delimited area.

The depth of soil materials influences vegetation growth and patterns. First, depth of soil controls rooting depth. Shallower soils limit the growth of vegetation, and tend to select for different assemblages of plant species. Deeper soils tend not to limit rooting depth, and selection in these habitats is primarily by availability of water and sunlight. Second, shallower soils have limited resources, and tend to be less fertile.

IN THE FIELD

- measure, from the "O" point, the level in the sample where bedrock was encountered. This is the individual sample depth to bedrock
- depict and record the observation on the soil profile diagram
- use individual sample points to judge the prevailing depth for an area. Depths to bedrock can be averaged
- remember that the more samples done, the better the assessment.



Note: When using an auger, be aware that coarse fragments can impede the auger penetration. When this happens, it can be hard to judge whether it is bedrock or simply coarse fragments. Use other sources of information, such as geological survey maps, to help determine whether it is bedrock or coarse fragments in your sample.

Water Table

Water table refers to the location, in relation to the "O" point in the soil profile, of the underlying water table. The depth to water table can apply to particular sample points, or it can be generalized for a delimited area.

The depth of the water table influences vegetation growth and patterns. It is the relative position of the water table to the soil surface which determines higher level community organization (see System, **FG,** page 17). In terrestrial communities, the water table is rarely, if ever, at the soil surface. In wetlands, the water table is periodically or seasonally above the soil surface. In aquatic communities, the soil surface is nearly always flooded.

Depth to the water table can be a very problematic variable to measure. Depending on which time of the year a soil is sampled, the water table will be at different levels. When the water table can be seen in the soil sample - i.e., flooding at the bottom of the pit or auger hole - this is a significant finding and should be recorded on the profile diagram.
Visualization of the water table is important in making definitive decisions on whether an area is a wetland or not. However, if the water table is missed, because of when sampling took place, other correlated features can be used to judge the seasonal patterns of the water table (see Mottles and Gley).

Helpful **HINTS**

Note: When using an auger, the soil sample will become saturated and begin to flow out of the auger barrel when the water table is reached.

IN THE FIELD

- measure, from the "O" point, the level at which the water table was encountered in the sample. This is the individual sample depth to water table
- depict and record the observation on the soil profile diagram
- use individual sample points to judge the prevailing depth for an area, e.g., depths to water table can be averaged
- remember that the more samples, the better the assessment.

Colour

One of the more readily apparent and characteristic features in soils is colour. The colour of soil provides valuable clues to the origin and nature of soil properties, and colour reflects other features such as moisture levels in the soil.

Soils are, first and foremost, the colour of the chemical constituents of their parent materials (mineralogy). The parent materials, however, become coated in various metal oxides (primarily iron) and organic matter. These coatings change the colour of the parent material (Brady and Weil 1996). Organic coatings prevail in the upper (A) horizons and tend to darken and mask other colours. In the lower horizons (B and C), metal oxide colours prevail, especially iron oxide.

As soils accumulate and mature over time (see **Figure 24),** through weathering and organic material incorporation, their colours change. Colours vary among layers of the soil profile, as material is leached and transported downwards. Colour can also be diagnostic of certain processes that occur only under specific climatic conditions and in certain types of organic materials.

For these reasons, soil colours have been used extensively to classify soils. The mineralogy and the formation of organic and iron oxide coatings create the overall "matrix" colour of soils.

Further influences on soil colour are environmental processes that manipulate and change chemical properties in the soil. Key among these influences is moisture and the secondary effects of moisture.

Although it is not necessary to assess and record the matrix colours for soil horizons when applying ELC, it is a valuable exercise. However, when assessing soil moisture regime, it is necessary to assess colours of certain features when applying ELC.

Munsell Colour Charts

Soil colours are most conveniently assessed by comparison with a standardized colour chart. Standardization of colour charts allows consistent observations, and enables us to establish patterns and relationships among soil colour and important ecological features, such as soil moisture levels. The Munsell Colour Charts have long been adopted as the standard for colour assessment in soils.

The collection of nine Munsell Colour Charts for describing soils has 321 different standard colour chips systematically arranged according to their Munsell notations. These colour chips are arranged in three dimensions; Hue, Value, and Chroma. When indicating the colour, follow the standardized notation, e.g., "10YR 6/4", where 10YR is the Hue, 6 is the Value, and 4 is the Chroma. The Hue notation of a colour indicates its relation to Red (R), Yellow (Y), Green (G), Blue (B), and Purple (P). The Value notation indicates lightness. The Chroma notation indicates its strength (or departure from a neutral of the same lightness).

The colours displayed on the individual Soil Colour Charts are of constant, or the same, Hue. The hue is indicated in the upper right hand corner of the chart. Within a card, or hue, the colours of the chips become successively lighter from the bottom of the chart to the top, in visually equal steps. This indicates an increase in value, as indicated by the vertical scale up the left side of the chart. Horizontally, within a chart, the colour chips increase in chroma from left to right. The chroma notation is indicated by the scale along the bottom of the chart.

Components of the Munsell Colour Charts:

Hue, Value, and Chroma (e.g., lOYR 6/4)

Hue: denotes the wavelength from the visible portion of the spectrum. Frequently in the range of 7.5 YR to 2.5 Y.

Value: denotes the darkness or lightness of the colour, relating to the amount of light reflected which depends on the moisture content.

Chroma: denotes the purity of the colour (e.g., more monochromatic when bright reddish or yellow; more panchromatic when greyish.

Describing Soil Matrix Colours

Matrix colours refer to the overall background colours we observe, by layer, in a soil profile. In southern Ontario, soil matrix colours are typically in greys, reds, and yellowish browns. The majority of soil colours encountered in Regions 6E and 7E are of 10YR Hue or clustered closely thereabout (7.5YR, 2.5Y). These ranges indicate soils of strong brown to yellow colour.

IN THE FIELD

Because matrix colour often varies among soil horizons, it is best to assess the colour and texture of the soil horizon at the same time:

- grab a large pinch of soil from a horizon

- overlay the Munsell colour chart so you can see the soil sample through the holes in the chart
- move the soil sample across the charts until a colour chip is found that best matches the colour of the soil sample
- record the Hue, Value, and Chroma either on the soil profile diagram or in the notes section.

Mottles and Gley

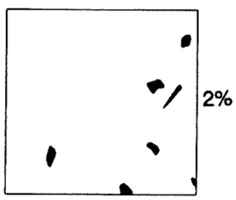
Secondary to the matrix, are other colours created by environmental influences. The key secondary colours that we describe arise from soil moisture levels and the influence this has on soil chemistry. The resulting features are called mottles and gley.

To understand the development of mottles and gley, it helps first to understand the soil chemistry that gives rise to a change from the soil matrix. Surrounding each soil particle are coatings that contain different minerals and metals. The most prevalent and significant of these is ferrous iron. As moisture and oxygen levels vary in the interstitial spaces around the soil particles, so does the chemical state of the iron. In typical upland conditions, the matrix soil exists without any secondary influences: it is not saturated, and it is well aerated (oxygen present). Under these conditions, the oxidized iron state prevails, imparting a red to brown colour to the iron oxide coating on the soil particles. This, in part, explains why much of the upland soils in southern Ontario have a red to yellowish brown colour. Bright (high chroma) colours throughout the profile are typical of well-drained soils through which water easily passes and in which air is generally plentiful (Brady and Weil 1996). In contrast, under saturated conditions, the ferrous iron is in the reduced chemical state (i.e., ferric sulfide). When saturation is prolonged, the typical red to brown iron oxide is converted to the gray or bluish colours of reduced iron. These two states of iron, representing an alternation between oxidation and reduction, generate colours that reflect the drainage of a particular soil, and seasonal moisture budget.

mottle description

Abundance - the proportion of the exposed surface occupied by mottles (%) (refer to Appendix II for additional area percentage charts).

Few <2% Common 2 - 20% Many >20%



Size - the diameter of the mottle if round, or, the greatest dimension if length is not more than 2 or 3 times the width, or, the width if the mottle is long and narrow.

Fine <5mm Medium 5 - 15mm Coarse >15mm

Contrast - the difference between the mottle colour and the matrix colour, using the Munsell Soil Color Charts.

	Difference from matrix in		
	Hue* pages	Value* units	Chroma* units
Faint	0	≤2	≤1
	1	0	0
Distinct	0	3 - 4	2 - 4
	1	≤2	≤1
Prominent	0	≥4	≥4
	1	≥2	≥1
	2+	≥0	≥0

*Hue, Value, and Chroma differences are determined using the Munsell Soil Color Charts (see page 25) e.g. common, fine, distinct brown (10YR 5/3) mottles. Values in the table are taken from 1982 CanSIS manual for describing soils in the field.

27

Figure 38
Contrast table; from OIP, page 27.

In soils where flooding or saturation rarely occurs, the iron is almost always in an oxidized state. In these conditions, matrix colours prevail. When soils are subjected to prolonged saturation, the reduced iron is more soluble and is leached from the soil. Furthermore, the reduced state of the iron produces the gray or bluish colours that are referred to as gley. In the intermediate state, where the soil is subjected to an alternation between saturated and drier conditions, the iron also alternates between the oxidized and reduced states. The alternation of iron between these states creates patchy distributions of iron, as it becomes more soluble and is intermittently transported in its reduced form. This patchy distribution of iron then results in a patchiness, or mottling, of colours. When the soil dries out, when the water table drops, the soil is aerated and the iron oxidizes, creating localized patches of the reddish-brown colour, called mottles.

Gley and mottling colour patterns in the B and C horizons are strong indicators of seasonal moisture budgets, soil landscape moisture regimes, and drainage conditions. "The presence of gray, low-chroma colors, either alone or mixed in a mottled pattern with brighter colors, is indicative of waterlogged conditions during at least a major part of the growing season. The depth in profile at which gley colors (low-chroma) are found helps to define the drainage class of the soil. Colour can also provide qualitative information about the current moisture status of a soil, dry soils generally having lighter (higher-value) colors than moist soils" (Brady and Weil 1996).

It is difficult sometimes to determine whether mottles and gley exist within the soil profile, because the difference between matrix and mottle colours may be barely perceptible. In practice, expect matrix and adjacent mottle colours to have the same Hue (to occur on the same Munsell colour chart). In order for it to be a mottle or gley, it has to vary from the matrix colour by a few units of Value and Chroma. The explicit rules to determine mottles and gley are on page 27 of the **OIP** manual. The Contrast Table **(OIP,** page 27; reproduced in **Figure 38)** also shows how the degree of contrast between colour chips can be used to classify faint, distinct, and prominent mottles.

Depth to mottles and gleying refers to the location, in relation to the"O" point in the soil profile, of these features. The depth to mottles and gleying can apply to particular sample points, or it can be generalized for a delimited area.

IN THE FIELD

• measure the depth, from the "O" point, to the mottle or gley

• depict and record the observation on the soil profile diagram.

Helpful **HINTS**

- Break, crack, or chip a piece of soil open with the hands to observe the colours; avoid cutting pieces of soils open with knives, augers, or shovels because this can smear the soul and distort the size and contrast of the mottles.
- Observe colours in a moist, but not saturated or slaked condition. A few drops of water on each sample ensure uniform moisture, especially when conditions are dry.

Describing Organic Material and Organic Soils

Organic materials exist on top of mineral substrates. Organic materials begin to accumulate when the amount deposited exceeds the rate of decomposition. In general, cooler, and often wet, or acidic conditions slow the decomposition process and cause organic material to accumulate.

Organic Horizon Description and Naming

L, F, and H Horizons
- on "mineral" soils - organics< 40 cm
- developed primarily from the accumulation and decomposition of leaves, twigs, and woody materials, with or without a minor component of mosses
- usually not saturated for prolonged periods
- typically associated with terrestrial soils, such as upland forests

L typically called "Litter"; accumulations of intact, or little decomposed, organic matter; primarily leaves, twigs, wood, and bark, where much of the original structure is easily discernable

F typically called "Fibrous" or "Fibric"; accumulations of partly decomposed organic matter; some of the original structures are difficult to recognize

H typically called "Humus"; accumulations of decomposed organic matter; differs from the F by having greater humification, chiefly due to organisms; material is broken down so that no original structure is apparent; typically black and greasy

Hi typically called "Hi"; an organic horizon representing an intermediate stage between H and Ah horizons; considerable mixing of organic and mineral material; accumulations of spherical or cylindrical organic granules (animal droppings) intermixed considerably with mineral particles

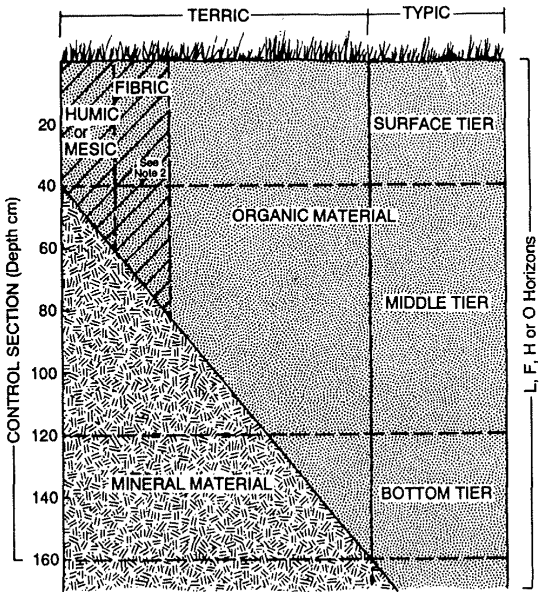
0 Horizons
- "organic" soils - organics> 40 cm
- primarily peat materials developed from mosses, sedges, rushes, and woody materials
- typically associated with cool, wet, or acidic sites; more often than not a wetland soil

Of "Fibric"; least decomposed organic horizon containing large amounts of organic fibres whose botanical origins are readily identifiable (van Post 1 to 4)

Om "Mesic"; an organic horizon which is at an intermediate stage of decomposition; plant structure clear but becoming indistinct (van Post 5 and 6)

Oh "Humic"; the most decomposed organic horizon containing only small amounts of well-preserved fibres whose botanical origins are discernable; the majority of material is at an advanced stage of decomposition; typically black, greasy, and stains hands (van Post 7 to 10)

organic soil profile description



Notes:

1. Organic soils that are commonly saturated with water and consist mainly of mosses, sedges, or other hydrophytic vegetation, must extendto a depth of at least 40cm.
2. If the surface layer consists of humic or mesic organic materials (Oh or Om horizons), the materials must extend to a depth of at least 40cm. If the surface layer consists of fibric organic material (Of horizon), the material must extend to a depth of at least 60cm.
3. Organic materials contain 30% or more organic matter (17% or more organic carbon).
4. Classification of organic soils at the Great Group level (e.g. Fibrisol, Mesisol, Humisol) is based primarily on the dominant degree of decomposition of the materials which compose the middle tier.
5. A terric layer is an unconsolidated mineral layer at least 30cm thick, which occurs beneath the surface tier and within 160cm of the surface. This layer differentiates Terrie subgroups from the deeper Typic subgroups (e.g. Terrie Mesisol vs. Typic Mesisol).
6. Folisolic soils are composed of upland materials of forest origin (L, F,H horizons) and may be:
   a) >10cm deep if the materials overlie a lithic contact or fragmental material; or
   b) >2x the thickness of a mineral soil layer if the mineral layer is <20cm thick over a lithic contact or fragmental material.

9

Figure 39
Organic soil profile description from OIP, page 9.

IN THE FIELD

- first, determine whether an organic or mineral soil is being described
- describe and name horizons based on the Organic Soil Profile Description chart in **OIP,** page 9 (reproduced in **Figure 39),** and the Organic Soil Horizon Descriptions chart in **OIP**, page 10 (reproduced in **Figure 40**), see also information box on page 78.
- use the Degree of Decomposition of Organic Material and the van Post Scale of Decomposition charts in **OIP,** page 22 (reproduced in **Figure 41**), to describe and name the organic soil horizons
- use subscript numbers to identify various horizons that have the same classification – e.g. Of1, Of2, Om1, Om2, Om3.

Helpful **HINTS**

In general, if organic accumulations are less than 40 cm, the soil is considered to be "mineral". If organic accumulations are greater than 40 to 60 cm (see **Figure 39**), the soil is considered to be "organic."

organic soil horizon descriptions

L,F,H organic horizons developed primarily from the accumulation of leaves, twigs and woody materials with or without a minor component of mosses; usually not saturated for prolonged periods (>17% organic carbon, >30% organic matter by weight).

L a horizon characterized by an accumulation of mainly leaves (and needles), twigs and woody materials in which the original structures are easily discernible.

F a horizon characterized by an accumulation of partly decomposed organic matter derived mainly from leaves, twigs and woody materials; some of the original structures are difficult to recognize; materials may be partly comminuted by soil fauna as in a MODER, or it may be a partly decomposed mat permeated by fungal hyphae as in a MOR.

H a horizon characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible; differs from the F by having greater humification chiefly due to the action of organisms; it may be sharply delineated from the mineral soil as in a MOR where humification is chiefly dependent upon fungal activity, or it may be partially incorporated into the mineral soil as in a MODER (see Hi horizon).

Hi a horizon characterized by an accumulation of spherical or cylindrical organic granules (animal droppings) with considerable intermixing with mineral particles; generally an intermediate stage between an H and an Ah horizon.

Of, Om, Oh organic horizons developed mainly from mosses, rushes and woody material (>17% organic carbon, >30% organic matter by weight).

Of (fibric) the least decomposed organic horizon containing large amounts of organic fibres which are readily identifiable as to botanical origin (von Post 1-4).

Om (mesic) an organic horizon which is at an intermediate stage of decomposition (properties are between those of Of and Oh horizons (von Post 5 and 6).

Oh (humic) the most decomposed organic horizon containing only small amounts of well preserved fibres which are readily discernible as to botanical origin; the major amount of material is at an advanced stage of decomposition (von Post 7 - 10).

Note: organic soil horizon designations are currently under review by ECSS Working Group.

10

Figure 40
Organic soil horizon description; from OIP, page 10.

Degree of Decomposition of Organic Material

Fibric: the least decomposed type of organic material, containing large amounts of well-preserved fiber which can be Identified as to botanical origin; containing 40% or more of rubbed fiber by volume; commonly designated as **Of** horizons.
Mesic: organic materials which are at an intermediate stage of decomposition; these materials fall to meet the requirements of either fibric or humic materials; contains 10-40% rubbed fibre by volume; commonly designated as **Om** horizons.
Humic: the most decomposed type of organic material, with few recognizable fibres for determination of botanical origin; humified materials which contain <10% rubbed fibre by volume; commonly designated as **Oh** horizons.

von Post scale of decomposition

In this field test, squeeze a sample of the organic material within the closed hand to remove almost all excess water. Squeeze sample one final time and observe the colour of the solution that is expressed between the fingers, the nature of the fibers, and the proportion of the original sample that remains in the hand. Ten classes are defined as follows:

FIBRIC (Of)

1. **Undecomposed:** plant structure unaltered; yields only clear water coloured light yellow brown.
2. **Almost undecomposed:** plant structure distinct; yields only clear water coloured light yellow brown.
3. **Very weakly decomposed:** plant structure distinct; yields distinctly turbid brown water, no peat substance passes between the fingers, residue not mushy.
4. **Weakly decomposed:** plant structure distinct; yields strongly turbid water, no peat substance escapes between the fingers, residue rather mushy.

MESIC (Om)

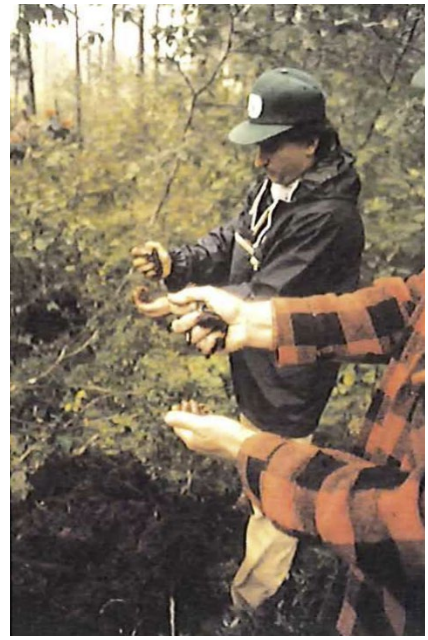
5. **Moderately decomposed:** plant structure clear but becoming indistinct; yields much turbid brown water, some peat escapes between the fingers, residue very mushy.
6. **Strongly decomposed:** plant structure somewhat indistinct but clearer in the squeezed residue than in the undisturbed peat; about a third of the peat escapes between the fingers, residue strongly mushy.

HUMIC (Oh)

7. **Strongly decomposed:** plant structure indistinct but recognizable, about half the peat escapes between the fingers.
8. **Very strongly decomposed:** plant structure very indistinct; about two-thirds of the peat escape between the fingers, residue almost entirely resistant remnants such as root fibres and wood.
9. **Almost completely decomposed:** plant structure almost unrecognizable; nearly all the peat escapes between the fingers.
10. **Completely decomposed:** Plant structure unrecognizable; all the peat escapes between the fingers.

22

Helpful HINTS



Determine the degree of decomposition of organic materials by

- Placing a small sample of organics in the palm of the hand
- Close hand carefully, to contain all of the organics
- Place thumb over the top of the hand, to prevent the organics from readily squishing out
- Place other hand under the sample, to catch the organics and water that escapes from the hand
- Squeeze sample once, hard

Figure 41
Von Post scale of decomposition for organic matter; from OIP, page 22

Humus Form

Organic material decomposes or accumulates in different ways,

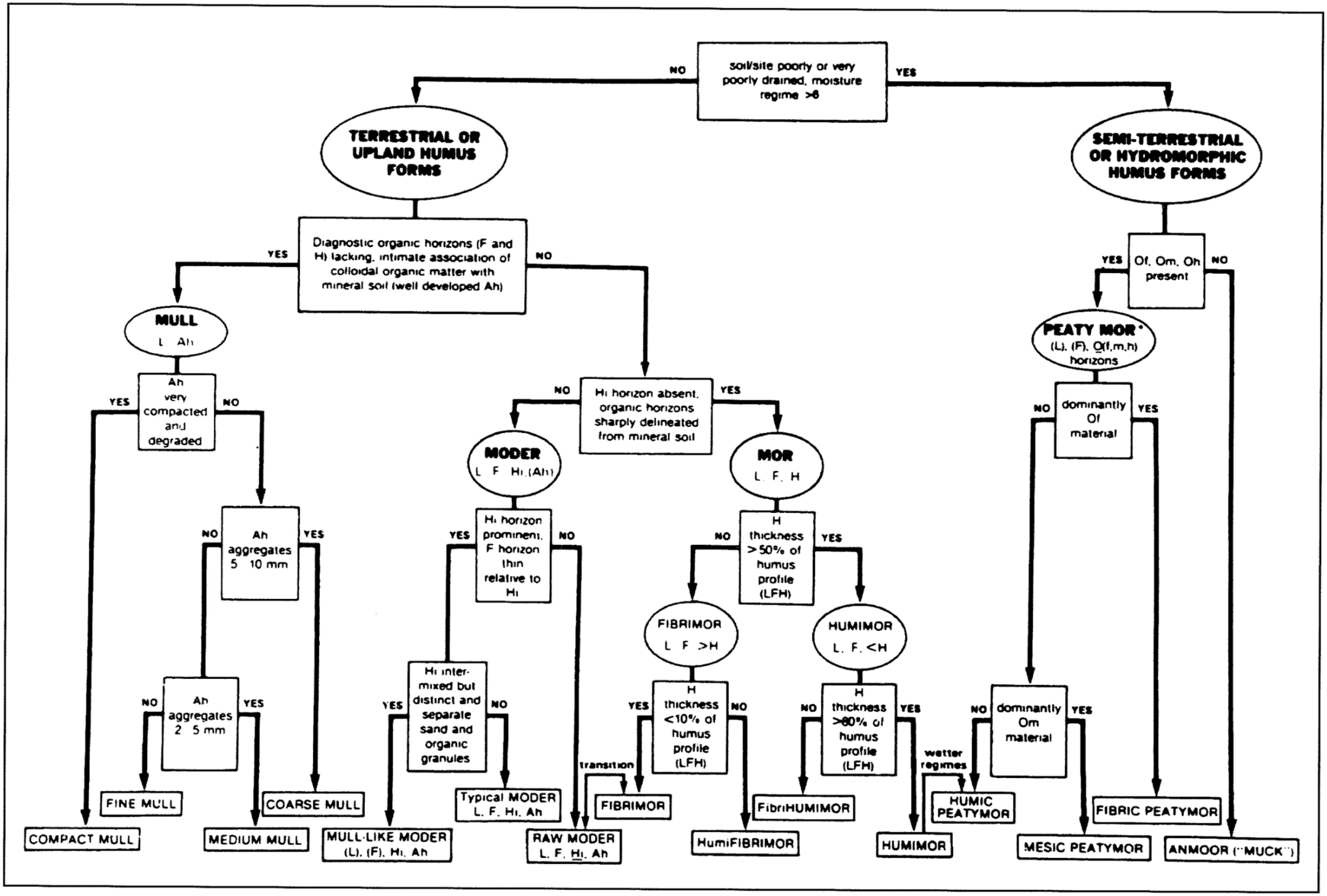


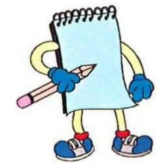
Figure 42
Forest humus determination; from OIP, page 12.

depending on the prevailing environmental and climatic conditions. Therefore, soils can vary, from those with little or no organic material on top to those which have substantial accumulations. A classification for types of organic material processing and accumulation has been developed by **OIP,** called humus form.

The determination of humus form is not needed for application of ELC but is a useful exercise in soil description and classification.

IN THE FIELD

- upon excavation of the soil pit or auger sample, describe and label the organic horizons
- use the OIP chart Forest Humus Classification on page 12 (reproduced in **Figure 42)** to classify the humus form
- record the humus form on the profile diagram or in the note section of the Site and Soil data sheet.



Factors affecting soil moisture availability:

- climate of the area
- amount and seasonality of precipitation
- temperature regime and evapotranspiration
- topography or slope
- depth of soil material over bedrock
- soil texture or porosity
- soil structure
- water table
- impediments - ie. bedrock, compaction, stratification, cementation, coarse fragments

Soil Moisture Regime and Drainage

Water is a primary resource required by all plants. It is not surprising, then, that the availability and supply of moisture in a soil affects plant species distribution and community assembly.

To this point in our study of site, we have seen many factors that affect local environments. They include landform, slope, and soil texture. The supply of water at any site, then, is influenced by the interaction of all these factors. Moisture may be excessive, such as in wetlands, limited, or adequate depending on the site's characteristics, such as slope, and the soil's characteristics, such as texture.

Determining moisture regimes is complicated by changes in water tables and moisture levels. Storms and seasonal precipitation levels may briefly raise water tables and moisture levels. If the soil is not sampled at these times, the effects and trends of these moisture variations are missed.
Short-term variations in moisture supply mean that a single measurement of the moisture in a particular soil sample is not accurate.

Moreover, short-term variations in moisture levels mainly affect plant physiology and responses. However, long-term trends in moisture availability better reflect the overall moisture budget of a particular soil and tend to influence community assembly. In addition, all features of soil and site interact to influence the hydrology and, therefore, moisture availability. As a result, assessment of moisture regime has been problematic. Ideally, assessment of moisture availability should:

- assess long-term, seasonal trends in moisture availability (i.e., meso - climate)
- be based on measurable and persistent features in the soil.

Ecologists have long recognized that the distributions of plant species reflects the totality of ecological influences, including available moisture. In this case, plant species act as response variables, reflecting the ecologically available moisture in a soil. All plant species have a range of moisture levels in which they can grow, and a particular species is most abundant at an ideal, or optimum, moisture level for that species. Assessment of soil moisture, for many, has long depended, in part, on which species were growing on the soil. For example, Sensitive Fern *(Onoclea sensibilis)* tends to grow best in moist soils. However, this fern also occurs across a range of moisture levels. So, if we use the presence of Sensitive Fern to decide it is a moist soil, the other moisture levels on which this fern occurs are not adequately characterized. This approach makes the assessment of soil moisture dependent on the distribution of plant species, creating an autocorrelation or circular logic. With this approach, analyses of data to gain insights into the distribution of species across moisture gradients becomes limited, because the moisture levels recorded were dependent on the presence of the species in the first place. Furthermore, assessment of soil moisture based, in part, on plant species depends on adequate and consistent knowledge of the relationship between individual plant distributions and moisture. Having this adequate knowledge often requires expertise, limiting its consistent use among a wide range of practitioners.

If, however, long-term moisture levels in soil were assessed based solely on the physical characteristics of the soil, plant species become uncoupled from the assessment. This would allow statistical analysis to establish the relationships between plant species distributions and moisture levels.
Furthermore, using easily observed and measured characteristics of the soil would make soil moisture assessments more objective, consistent, and more available to a wide range of practitioners.

The Ontario Institute of Pedology's Field Manual for Describing Soils in Ontario **(OIP** 1993) has developed such an objective approach to assessing moisture levels of soil. The development of ELC in Ontario has relied on the OIP approach, using derived variables such as drainage and moisture regime.

Factors Affecting Moisture in Soils

In Ontario's prevailing climate, there is usually more precipitation in the late fall, winter, and early spring than during the warmer months of the year. This results in a significant moisture deficit at some point in most growing seasons. However, soil and topographic conditions can significantly modify local moisture supply across the landscape. Hence, we have observations of dry, moist, or wet sites. However, the question remains, how wet or dry is a site, and how do we tell the difference?

Ideally, at each site this question would be approached with intensive studies of moisture input and soil water storage capacity, and with multiple measurements of the soil's actual moisture content and water table throughout several growing seasons. For some research studies this is feasible.

For our work, we often have no more than one chance to visit a site and collect data. Moreover, all sites cannot always be visited at the same time of year. Therefore, we need to develop rapid and accurate methods for field assessment which allow collection of the required data and calculation of the moisture supply for a given location.

The methods detailed below work for all climates except for arid or semi - arid (desert and dry prairie), tropical, and very wet coastal conditions.

Once a particular site is located in the appropriate climatic regime, the focus is on determining soil attributes that affect moisture dynamics. From the list above, these are:

- total depth of soil over bedrock
- soil texture
- specific colour characteristics (mottles and gley), and their location in the soil profile.

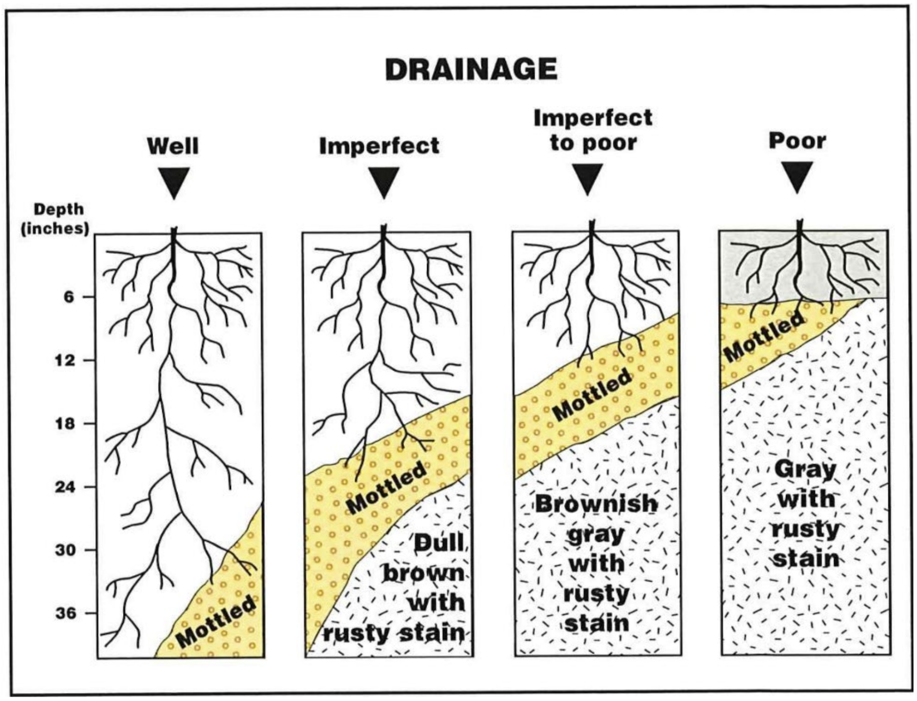


Figure 43-A
Why soil drainage and moisture regime are important.

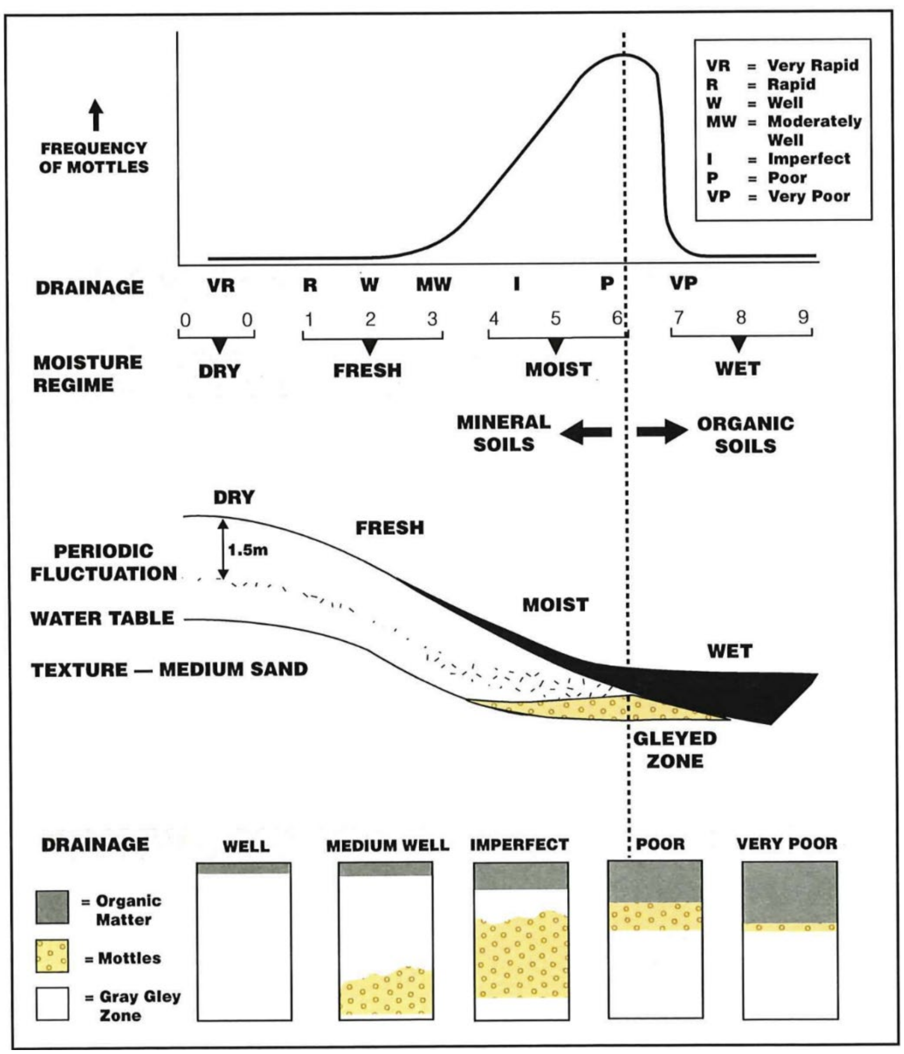


Figure 43-B
Mottling: soil moisture and topography.

There are two main methods of data collection, site evaluation, and interpretation of mapped soil inventories:

- Soil Moisture Regime (MR) method: This method provides an indication of the long-term, seasonal moisture supply for a given location. The moisture regime for a site is particularly appropriate for evaluating the ecological impact of moisture on species distribution and community assembly. **Figure 43** shows how soil attributes vary with moisture levels: as you move from a water-shedding site position to a water-accumulating site position (i.e., from the top of a slope to the bottom of a slope), you see an increase in moisture levels, which is reflected in mottles and gley rising in the soil profile, and accumulations of organic matter increasing. All ecological surveys such as ELC, Growth and Yield, Wetlands and Natural Heritage programs use the moisture regime method (developed by Angus Hills and several colleagues).

- Soil Drainage method: This method has evolved from the agricultural sciences and provides a good indication of a soil's ability to drain excess moisture following spring melt, run-off, and rain. The method is particularly useful for evaluating a site's limitations for seasonal activities such as use by vehicles, plowing or site preparation, or planting, and for evaluating engineering risks such as rutting, compaction, or seasonal ponding. All soil surveys and many engineering documents use the soil drainage method.

Moisture regime and drainage methods are used as complementary tools for site evaluation. The **OIP** manual provides information which correlates the two scales.

Factors Affecting Soil Moisture Regime

Texture

The soil texture, affected by particle size and proportional mix of materials, determines the abundance and size of soil pores. These pores make up the sponge that is available to hold water. Texture helps determine how quickly water will move into, through, and out of a soil.

Stratification

Often, variable depositional processes will lay different textures one on top of the other. These layered textures will affect how water moves through the soil. Dramatic differences in texture between layers will have a greater effect on the movement of water. **Figure 44** shows how a coarse-textured layer over a fine-textured layer creates a barrier that impedes water movement. In contrast, **Figure 45** shows the influence of a fine-textured layer over a coarse-textured layer.

Soil Depth

The depth of soil at a given location determines the total amount of material available to hold water. Shallow soil cannot hold as much water initially and will dry out during warm periods.

Landscape Position and Topography

The position of a site on a slope and the shape of the slope changes the way water flows and how long water stays on the site. Upper slope positions shed water quickly due to gravity. Lower slopes receive this moisture through surface and groundwater movement, making more water available. Convex slopes shed water, whereas concave slopes concentrate and retain moisture. These effects are more pronounced in shallow soils. **Figure 43** shows a slope and its corresponding influence on soil features, and on moisture and drainage regimes.

Soil Morphology or Structure

A range of physical conditions in a given soil change the way moisture moves. The secondary impact of these conditions is assessed after the texture, depth, colour, and position on a slope are measured. These conditions include:

- presence or absence of compacted or cemented layers
- presence of large amounts of coarse fragments
- type and continuity of the underlying bedrock
- stratification of the soil texture
- soil structure.

Determining Soil Moisture Regime

In the determination of soil moisture regime, three charts are used from the **OIP** manual: Charts A, B, and C. Follow the guidelines on **OIP** page 28, (reproduced in **Figure 46)** using the soil characteristics you have described for the soil sample, to select which chart to use.

- Chart A for soils greater than 120 cm deep (reproduced in **Figure 47)**
- Chart B for stratified soils greater than 60 cm deep (reproduced in **Figure 48)**
- Chart C for soils less than 120 cm over bedrock (reproduced in **Figure 49).**

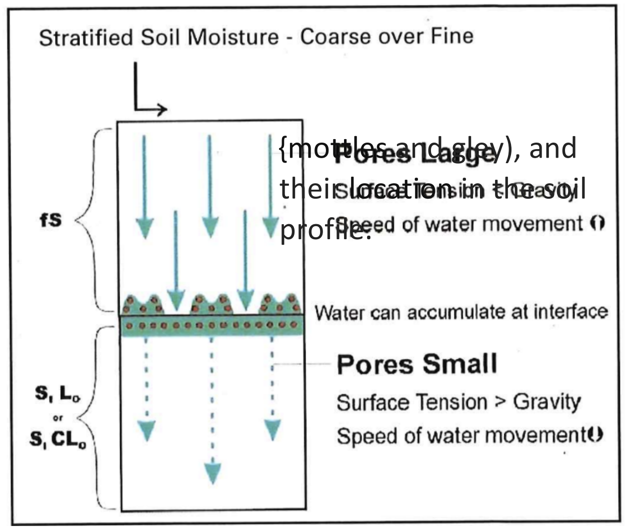


Figure 44
Stratified soil moisture, coarse texture over fine.

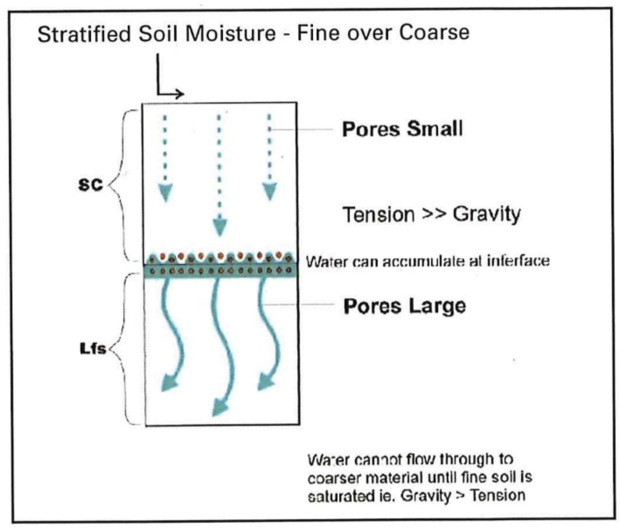
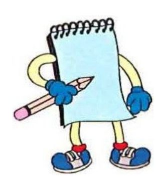


Figure 45
Stratified soil moisture, fine texture over coarse.



Primary factors used to determine moisture regime:
- total depth of soil over bedrock
- soil texture
- specific colour characteristics (mottles and gley) and their location in the soil profile

soil moisture regime

Selection of moisture regime chart:

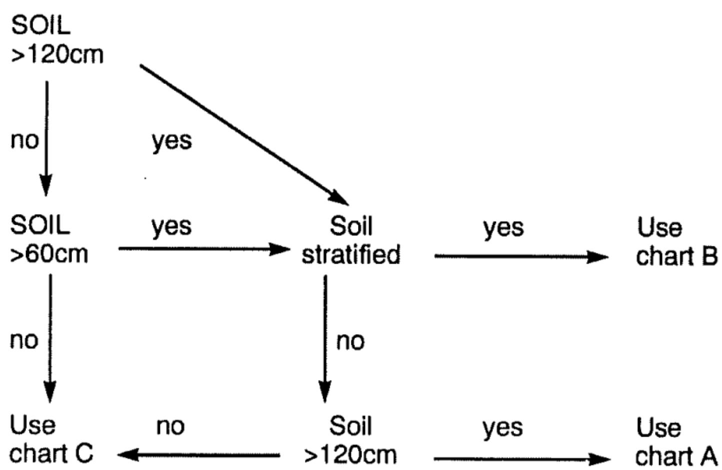
1. Determine organic matter depth, mineral soil depth, texture, structure, pore pattern, coarse fragment content and stratification.

2. If mineral soil is stratified and >60cm, use "stratified mineral soil" **Chart B** (page 31) to determine the effective texture.

3. If organic matter depth is >40cm or mineral soil depth is >120cm, use "deep" moisture regime **Chart A** (page 29) or soil drainage chart (page 26).

4. If mineral soil is <120cm, use "mineral soils over bedrock" **Chart C** (page 32) for calculating both moisture regime and drainage.

5. If mineral soil is >120cm use **Chart A** (page 29) for calculating moisture regime , and soil drainage chart (page 26) for drainage.



(from Northeastern Region Forest Site Evaluation Field Manual, 1990)
28

Figure 46
Decision to select chart for soil moisture regime determination; from OIP, page 28

Drainage

To determine drainage classes of a particular soil, use **OIP** Drainage Classes, page 26 (reproduced in **Figure 50).**

This is the same soil drainage classification that is used on soil mapping. This establishes the knowledge link between field studies and soil mapping.

DEEP MINERAL SOILS (>120 cm) | ORGANIC SOILS[4]

PORE PATTERN[1] of MINERAL SOIL MATERIALS: PERVIOUSNESS CLASS[1]	EXAMPLES OF TEXTURES WITHOUT COMPACTION[2]	PORE PATTERN CLASS/SYM	SOIL MOISTURE REGIME[3] — DRY (d): DRY 0	DRY (d): MOD. DRY 0	FRESH (f): MOD. FRESH 1	FRESH (f): FRESH 2	FRESH (f): VERY FRESH 3	MOIST (m): MOD. MOIST 4	MOIST (m): MOIST 5	MOIST (m): VERY MOIST 6	WET (w): MOD. WET 7	WET (w): WET 8	WET (w): VERY WET 9
RAPIDLY	ALL MATERIAL >2.0 mm	EXTREMELY OPEN 0	ALL SLOPES [VR]										
	VERY COARSE AND COARSE SANDS, LOAMY VERY COARSE AND COARSE SANDS	VERY OPEN 0		ALL SLOPES [R/VR]	g 100-180 or G 150-200 [R/VR]	g 80-100 or G 120-150 [MW/I]	g 50-80 or G 90-120 [MW/I]	g 30-50 or G 60-90 [MW/I]	g 15-30 or G 45-60 [I/P]	g 5-15 or G <45 [P/I]			
	MEDIUM SAND, LOAMY MEDIUM SAND	OPEN 1		ALL SLOPES [R/VR]	g 100-180 or G 180-240 [R/VR]	g 80-100 or G 150-180 [MW/I]	g 50-80 or G 90-150 [MW/I]	g 30-50 or G 60-90 [MW/I]	g 15-30 or G 45-60 [I/P]	g 5-15 or G <45 [P/I]	Of 60-180 or Om 40-100 or Oh 40-100 with g 0-5; if g is >5 use mineral soil criteria	Of >160 or Om >100 or Oh >100 with upper part not saturated all year and G present to top of mineral soil	Of >160 or Om >100 or Oh >100 with saturation to surface all year and G present to top of mineral soil
	FINE SAND, LOAMY FINE SAND, SILTY FINE SAND	MODERATELY OPEN 2			ALL SLOPES [R/W]	g 100-150 or G 150-210 [R/W]	g 60-100 or G 120-150 [MW/I]	g 40-60 or G 80-120 [MW/I]	g 20-40 or G 45-60 [I/P]	g 5-20 or G <45 [P/I]			
MODERATELY	SANDY LOAM, VERY FINE SAND; LOAMY VERY FINE SAND; SILTY VERY FINE SAND	MODERATELY RETENTIVE 3				ALL SLOPES [W]	g 60-120 or G 150-210 [MW/I]	g 40-60 or G 90-150 [MW/I]	g 20-40 or G 60-90 [I/P]	g 5-20 or G <60 [P/I]			
	LOAM; SILT LOAM, SANDY CLAY LOAM; STRUCTURED SILTY CLAY AND CLAY (aggregates <10 mm)	RETENTIVE 4				ALL SLOPES [W/MW]	g 60-120 [MW/I]	g 45-60 [MW/I]	g 30-45 [I/P]	g 5-30 [P/I]			
	SILT; SILTY CLAY LOAM, CLAY LOAM, SANDY CLAY, STRUCTURED SILTY CLAY AND CLAY (aggregates >10 mm)	VERY RETENTIVE 5			s >100% [W/MW]	s <100% [MW/W]	g 60-120 [MW/I]	g 45-60 [MW/I]	g 30-45 [I/P]	g 5-30 [P/I]			
SLOWLY	STRUCTURELESS SILTY CLAY AND CLAY	MODERATELY RESTRICTED 6			s >70% [MW]	s <70% [MW]	g 60-120 [MW/I]	g 45-60 [MW/I]	g 30-45 [I/P]	g 5-30 [P/I]	[VP]	[VP]	[VP]
	POROUS OR FRACTURED BEDROCK	RESTRICTED TO VERY RESTRICTED 7, 8											
	NON POROUS BEDROCK	EXTREMELY RESTRICTED 9											

1 Pore Pattern and Perviousness Classes indicate the numbers and sizes of spaces (pores) between the soil particles which determine the drainage and moisture retention characteristics of the soil. The classes are inferred from soil texture, structure and compaction.
2 Significant compaction can increase the pore pattern usually by one class (e.g. a 3 to 4)
[ ] Not considered as mineral soil

SYMBOLS
g a layer with distinct or prominent mottles indicative of periodic saturation and aeration
g 15-30 the top of the mottled layer lies between 15 and 30 cm below the mineral surface
G a grey gley layer indicative of prolonged saturation
G 60-90 the top of the grey gley layer lies between 60 and 90 cm below the mineral surface
G<45 the top of the grey gley layer lies within 45 cm of the mineral surface.
s degree of slope which results in significant surface run-off
■ the 'normal' site with no slope or drainage restrictions.

3 Soil Moisture Regime is an integration of all the variations in soil moisture supply throughout the complete vegetation cycle. The moisture regime classes are inferred from the pore pattern and depth of the mineral soil material, the topographic position of the site and characteristics of the soil profile such as mottling or grey gley horizons which indicate impeded drainage.
Soil Drainage is the rapidity and extent of removal of water from soils in relation to additions.
[W/R] most probable drainage class(es); the dominant drainage class is shown in the first position
VR very rapid, R rapid, W well, MW mod. well, I imperfect, P poor, VP very poor

4 Of >60 cm or Om, Oh >40 cm
SYMBOLS
O organic horizons developed mainly from mosses, rushes and woody material (numbers indicate depth of O)
Of (fibric) the least decomposed organic horizon containing large amounts of well preserved fibre
Om (mesic) an intermediately decomposed organic horizon with properties intermediate to an Of and Oh horizon
Oh (humic) the most decomposed horizon containing only small amounts of well preserved fibre and the major amount of material at an advanced stage of decomposition

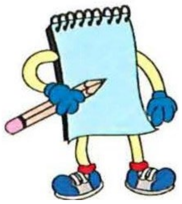
EXPLANATION: This chart is for rating the moisture regime of a site in the field by examination of soil physical properties and soil profile characteristics.

If the depth of organic material over mineral soil is less than that required for an organic soil (see right side of chart) and the mineral soil is >120 cm over bedrock, first determine the pore pattern from the texture, allowing for an increased pore pattern if significant compaction is evident (left side of chart). Next, determine if and where mottles (designated "g") or a grey gley layer (designated "G") are present in the soil profile. If g and G are absent, proceed horizontally into the centre section of the chart, along the appropriate pore pattern line, to the box outlined heavily. If the box is labelled "ALL SLOPES," read the moisture regime class at the top of that column. If the box has a slope designation ("s"), determine the degree of slope on which the site is located, then choose the appropriate box between the heavily outlined box and the box to the left and read the moisture regime at the top of the appropriate column. If g or G is present, measure the minimum depth from the top of the mineral soil to g or G and proceed horizontally along the appropriate pore pattern line to the box containing the correct depth value. Then read the moisture regime at the top of that column.

For organic soils, determine if the depth of organic material exceeds the criterion for MR 7. If this is so, choose between MR 8 and MR 9 as indicated. If this is not so, determine the depth from mineral surface to g and decide if this meets the MR 7 criterion (g: 0-5 cm) or if the mineral soil criteria are to be used to rate the moisture regime in a class lower than 7.

A chart for rating moisture regime in soils less than 120cm deep over bedrock is shown on page 32. For shallow soils, consider that 1) shallow soils have a smaller reservoir of "held" water, so that upper-slope sites may be drier than deep soils of the same texture, and 2) seepage water moves on bedrock surfaces down slope and increases the moisture regime of lower-slope sites. In mid-slop and lower slope sites, mottling (g) will occur slightly higher in the mineral soil than the characteristic depths indicated for deep soils in the chart above.

Figure 47
Chart A: moisture regime; from OIP, pages 29 and 30.



g = depth to distinct or prominent mottles; a layer with distinct or prominent mottles indicative of periodic saturation and aeration; measured from the "O" point in the soil profile

G = depth to gley; a gray gley layer indicative of prolonged saturation; measured from the "O" point in the soil profile

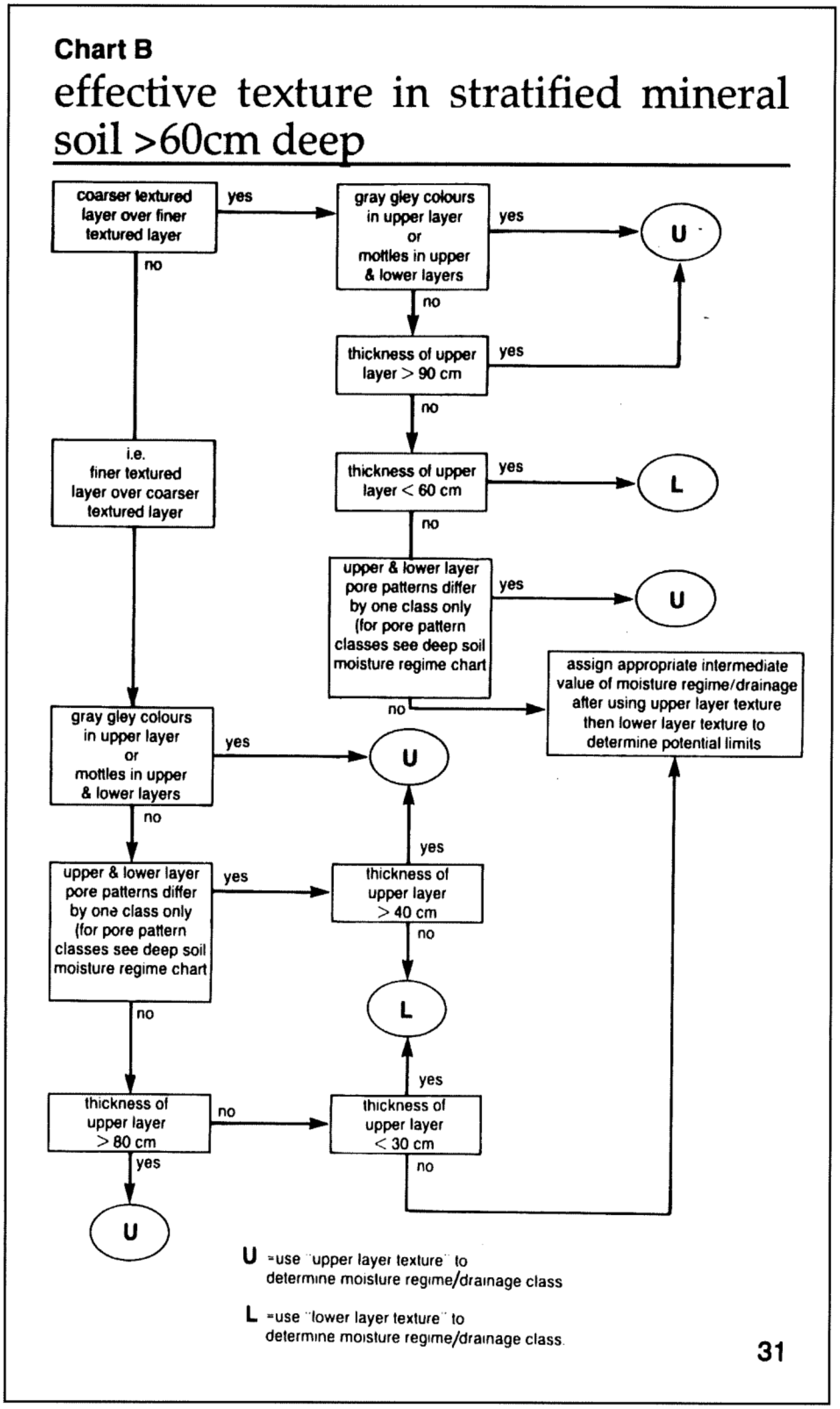


Figure 48
Chart B: stratified mineral soils; from OIP, page 31.

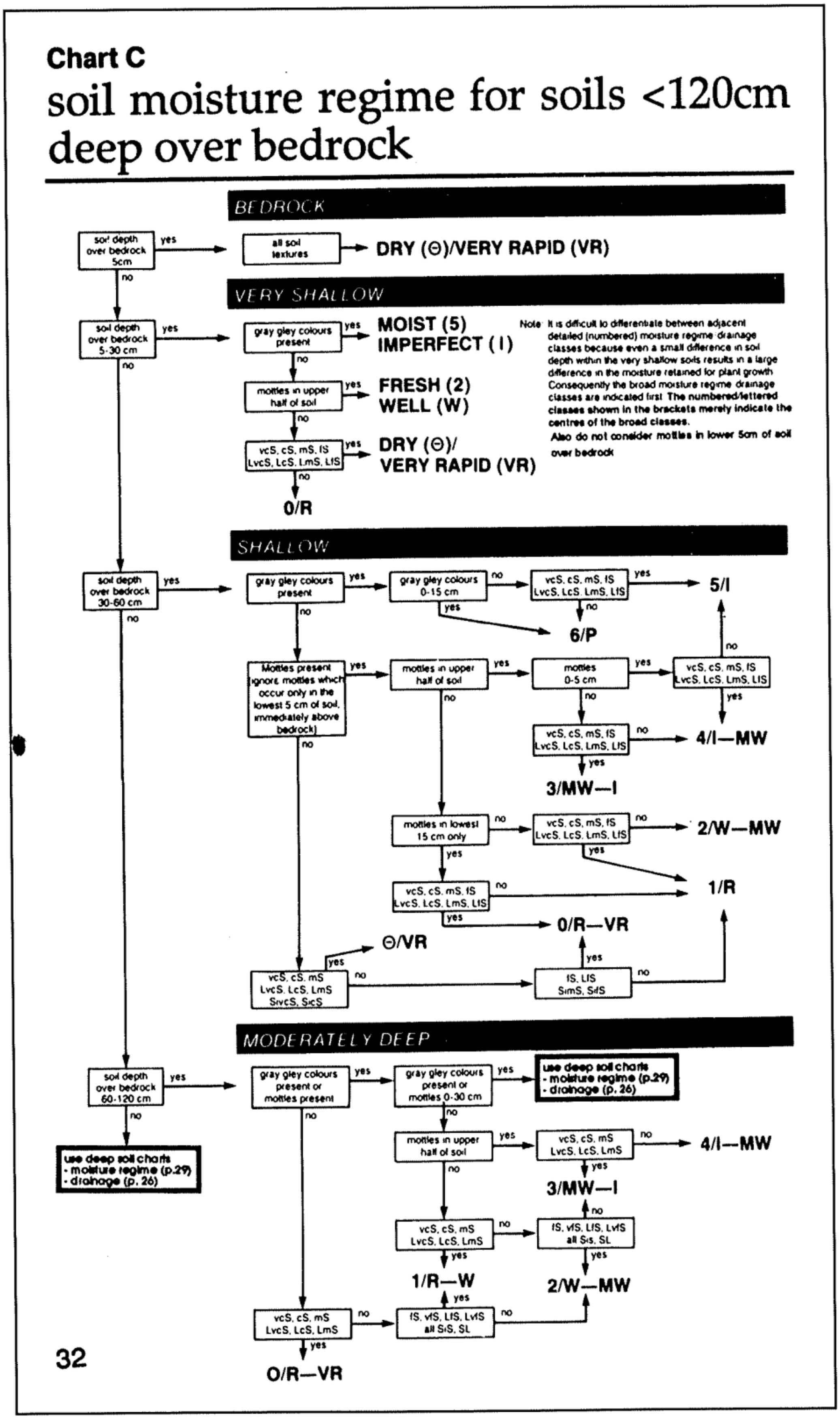


Figure 49

Chart C: mineral soils over bedrock, from OIP, page 32.

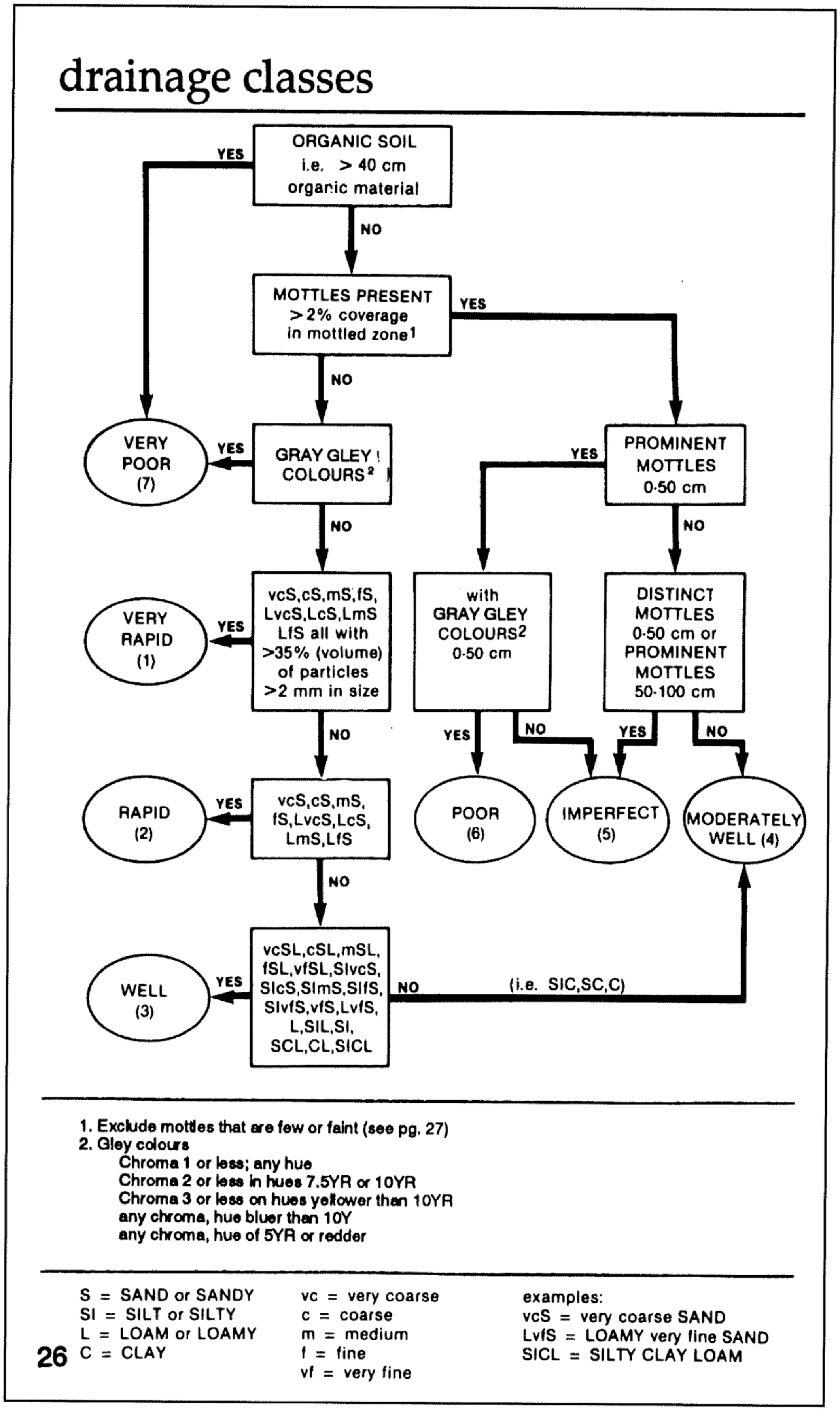


Figure 50
Soil drainage chart; from OIP, page 26.

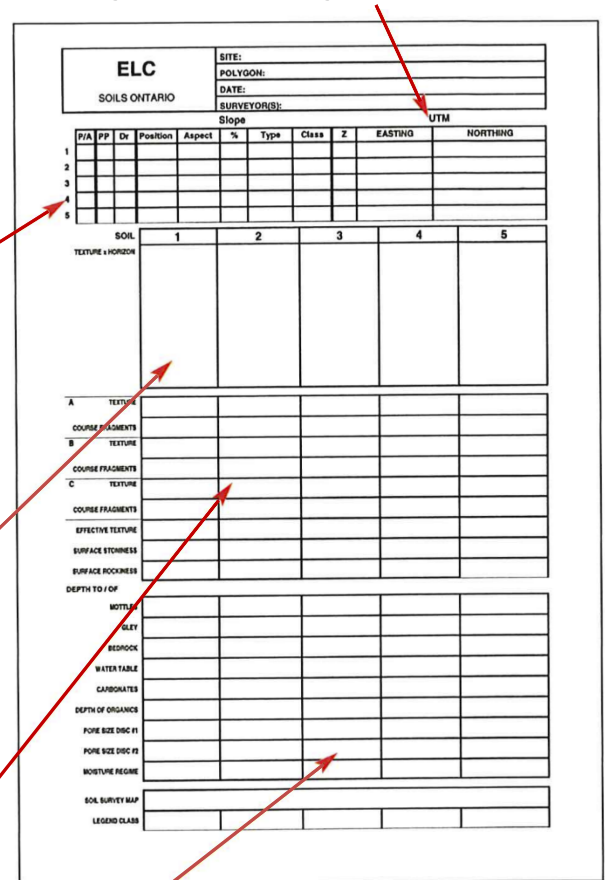
Summary for Soils – Attributes Used When Applying ELC

Soils are described at sample sites (columns) within a particular polygon (data card).

Location: accurate and precise location data is important for GIS applications. Record the location of each sample point using UTM (Universal Transverse Mercator) grid coordinates.

Note: make sure that all locations are done according to consistent standards. We recommend that NAD 83 be used where possible. OBM maps are according to NAD 27, yet the MNR Natural Resource Values and Information System (NRVIS) uses NAD 83. New Global Positioning Systems (GPS) should have both NAD 27 and NAD 83 as options in their setup.

Z – UTM grid zone
Easting – UTM easting coordinate
Northing – UTM northing coordinate



P/A – Indicate whether sampling was done using a dug Pit or Auger.

Soils Description

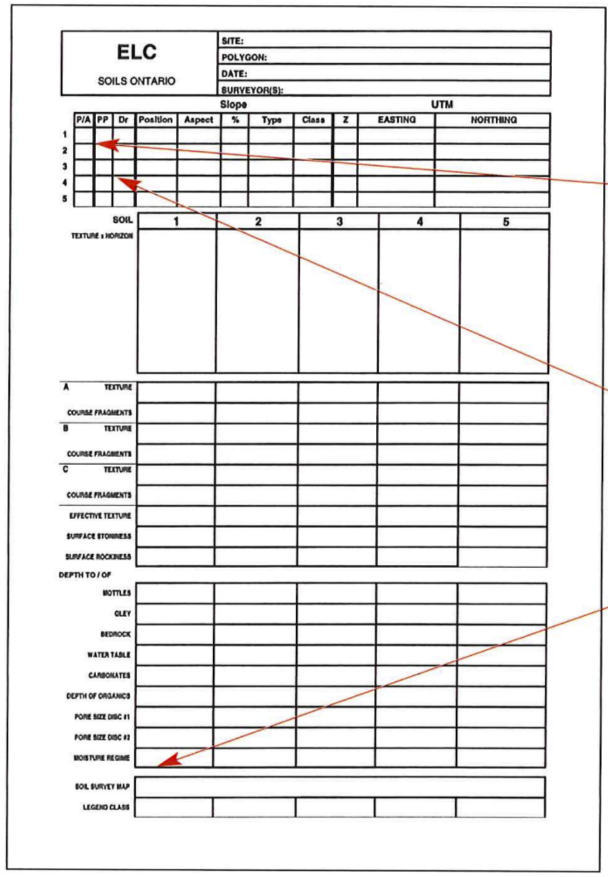
Soil Profile Diagram

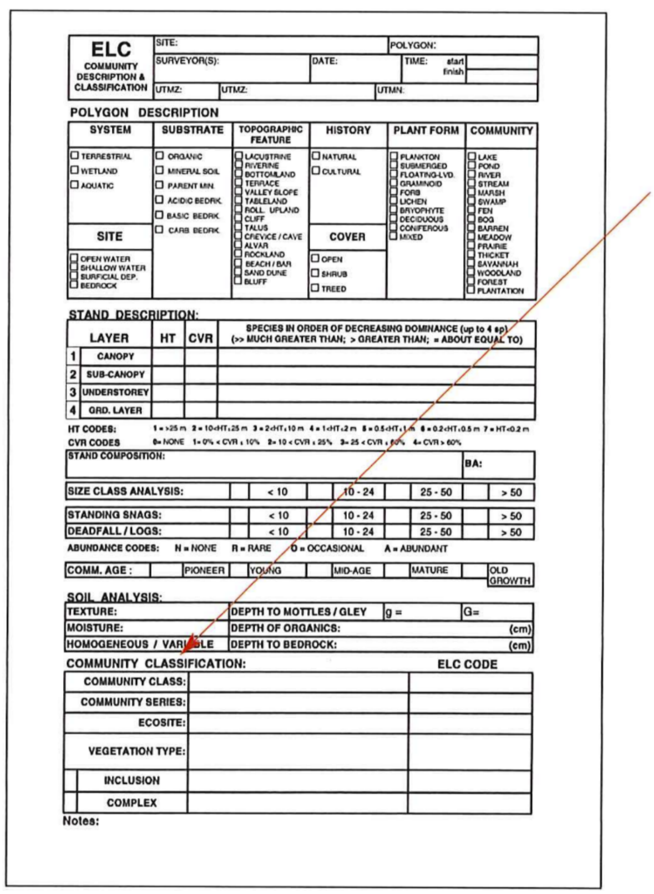
Depict the horizon boundaries, their depths, and any significant features, such as coarse fragments, mottles, or gley, on the soil profile diagram There is room for five profile diagrams on the Soils Ontario card.

Soil Attributes

Record the following soil attributes for each sample, in the columns of the Soils Ontario data card:

- texture and coarse fragments within the A, B, and C horizons
- effective texture for your sample - i.e., the texture used for soil moisture regime and drainage determinations (use Chart B, OIP page 31)
- surface stoniness and rockiness
- depth to/of
  - mottles
  - gley
  - bedrock
  - water table
  - carbonates
  - pore size discontinuities -i.e., depths where texture differences occur
  - organics





Derived Soil Characteristics

Record the following soil attributes for each sample, in the columns of the Soils Ontario data card:

Pore Pattern

- determine pore pattern for a soil texture using moisture regime Chart A
- record as PP in the top section of the Soils Ontario data card

Drainage

- determine soil drainage using OIP, page 26
- record as DR in the top section of the Soils Ontario data card

Moisture Regime

- determine soil moisture regime, using OIP, pages **29-32**
- record as moisture regime in lower section of the Soils Ontario data card

The soil mapping used as a reconnaissance for the area should be recorded, along with the mapping legend units into which the samples were taken.

Synthesis

Summarize soil conditions within the polygon by recording the prevailing soil characteristics in the Soil Analysis section of the Community Description and Classification data card.

8. Air Photo Interpretation

Fundamentals of Air Photo Interpretation

Remotely sensed imagery was originally developed for military applications. For decades now it has been used as a tool for identifying landscape features, including land cover, for land-use inventories, thematic maps focused on engineering or natural heritage features, site- specific assessments, and Ontario Wetland Evaluations. It is a fundamental tool in landscape ecology analyses and calculation of landscape metrics such as wildlife area sensitivity and landscape fragmentation.

Aerial photography and satellite imagery are the basis for remote sensing, and they are available in a variety of formats. The format is chosen to suit the application. Currently, aerial photographs are the standard on which interpretation of ELC polygons relies. However, release of new satellite imagery at larger scale resolution may expand the capability of satellites to provide images that can be classified at a lower level of ELC detail.

Why Use Air Photo Interpretation?

Air photo interpretation is used as the basis for ELC because it is the least expensive and most universally obtainable remote imagery available to date. It does not require elaborate equipment in order to be useful. Therefore, it is an efficient mechanism by which we can survey large areas for broad ecosystem mapping, and it permits the classification of large areas very quickly. Because of the level of effort and time involved in delineating community boundaries on site, community boundaries delineated on air photos are the standard for ELC sampling and mapping.

Air photo interpretation provides a landscape context for the study area and alerts the interpreter to unique conditions or the potential for impact on features (e.g., the presence of a landfill or quarry). The photos are available at a variety of scales, although not all sites have been photographed at all scales, and this is sometimes a limitation. However, the photos provide the context by which field work is carried out on site. The photos also provide a historical context to examine landscape changes over time. Historical photographs are particularly helpful in determining landforms, because often photos from the 1950s to 1970s have much less forest cover, making drainage and geological patterns easier to see.

Figure 51

An example of a black and white air photo from northwestern Ontario at 1:20,000 scale.

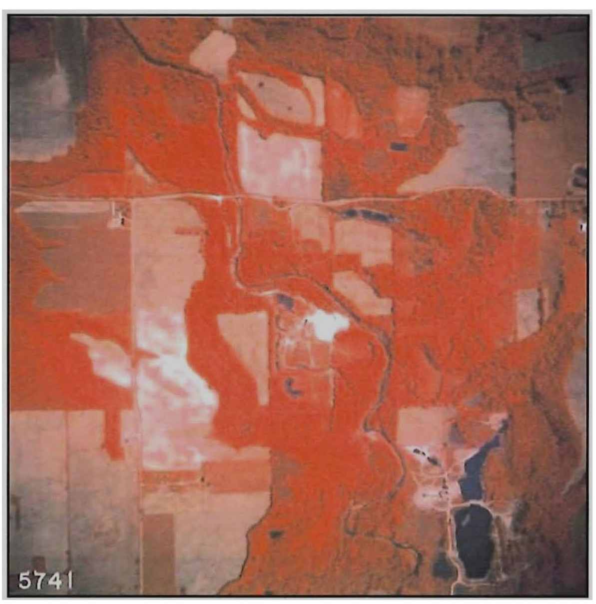


Figure 52

An example of colour infrared photography from southern Ontario at 1:10,000 scale.

Types of Photos and Availability

Traditional Black and White Photography:
- the most commonly used type of photography (see **Figure 51)**
- readily available
- provides a good selection of historic images
- available in stereoscopic pairs
- provides great contrast and expression of tones

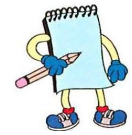
Colour Photography:
- becoming increasingly available
- available in stereoscopic pairs
- colours can provide additional clues
- can be useful for fall deciduous forest species identification

Colour Infrared Photography (IR):
- highlights living things: vegetation will appear red (see **Figure 52)**
- restricted to summer photography
- superior for identification of wetland and aquatic systems
- not as widely available as other types of aerial photography

Digital Orthogonally Rectified Photography:
- images based on air photos, but are true to scale and free of distortion
- available in most formats
- provides stereoscopic interpretation utilities
- facilitates use of GIS, as it eliminates the step of digitizing hardcopy maps and photos
- more applicable for large-scale resource planning

Seasonality: Summer Photography (trees in leaf):
- better for identifying variation in deciduous communities
- better for wetland community mapping
- acceptable for identifying species based on tone and canopy form
- not recommended for identifying physical site (i.e., landform, watercours es, topographic relief, soil type, moisture)

Spring and Fall Photography (trees leafless):
- better for identifying physical site conditions
- better for contrasting system types (i.e., terrestrial, wetland, aquatic)
- better for identifying mixed (i.e., both deciduous and coniferous) community series



Sources and Cost

- most conservation authorities and planning departments will have historical and current air photos of their jurisdictions, at various scales
- depending on your application, air photo prints can be enlarged to any scale; however, this may result in a loss of detail
- costs are $15.00 and up per photo; usually, there is a minimum set-up fee of $50.00; bulk costs are lower

The skills of the photo interpreter contribute significantly to the quality of the interpretation. The ability to see in stereo and in colour is not universal. The ability to integrate other data (mapping data, ecological principles) and to determine patterns is important. It takes patience, practice, and field experience to become a good air photo interpreter.

Scale of Air Photographs

The standard operational scale for ELC is the Ontario Baseline Mapping (OBM) standard 1:10,000 (southern Ontario) to 1:20,000 (central and north- ern Ontario). At these scales of resolution, landform and topographical features are still visible, while patterns in vegetation physiognomy and species assemblages are emerging. Physiognomy simply refers to a combination of external appearances of the vegetation, its vertical structure, and the growth form (i.e., herb vs. shrub vs. tree, deciduous vs. coniferous vs. mixed) of the dominant species (Barbour et al. 1999).

Using Air Photos to Delineate Polygons

The objective of air photo interpretation for ELC is to: 1) identify physical attributes of the landscape (such as landform, rivers, creeks, and slopes); and 2) delineate the associated vegetation patterns. Each of the landform elements, or polygons, is a discrete and unique, irregularly shaped area outlined on a map or air photo that contains a more or less homogeneous site, and differs from the adjacent and surrounding land (Lee et al. 1998). The pattern elements are determined by the interaction of critical attributes that should be used to delineate polygons in the following sequence (adapted from Arnup et al. 1999):

- landform pattern (e.g., drumlins, eskers, clay plains, outwash; refer to geologic maps for the study area)
- soils and drainage pattern (refer to the largest available scale soils map for your study area); dark tones on the photograph imply poor drainage
- topographic position (e.g., upland, bottomland)
- vegetation patterns by plant species characteristics (e.g., forests,
- wetlands, coniferous, deciduous)
- vegetation cover (i.e., amount and pattern of "canopy" closure, where canopy refers not only to treed areas, but to the tallest vegetation in any unit. Therefore, cattail may form a closed canopy or an open canopy in a marsh)

Figure 53
An example of an interpreted black and white air photo from northwestern Ontario at 1:20,000 scale.

The observable and mappable patterns that emerge on air photos are the accepted operational units for ecosystem management and planning

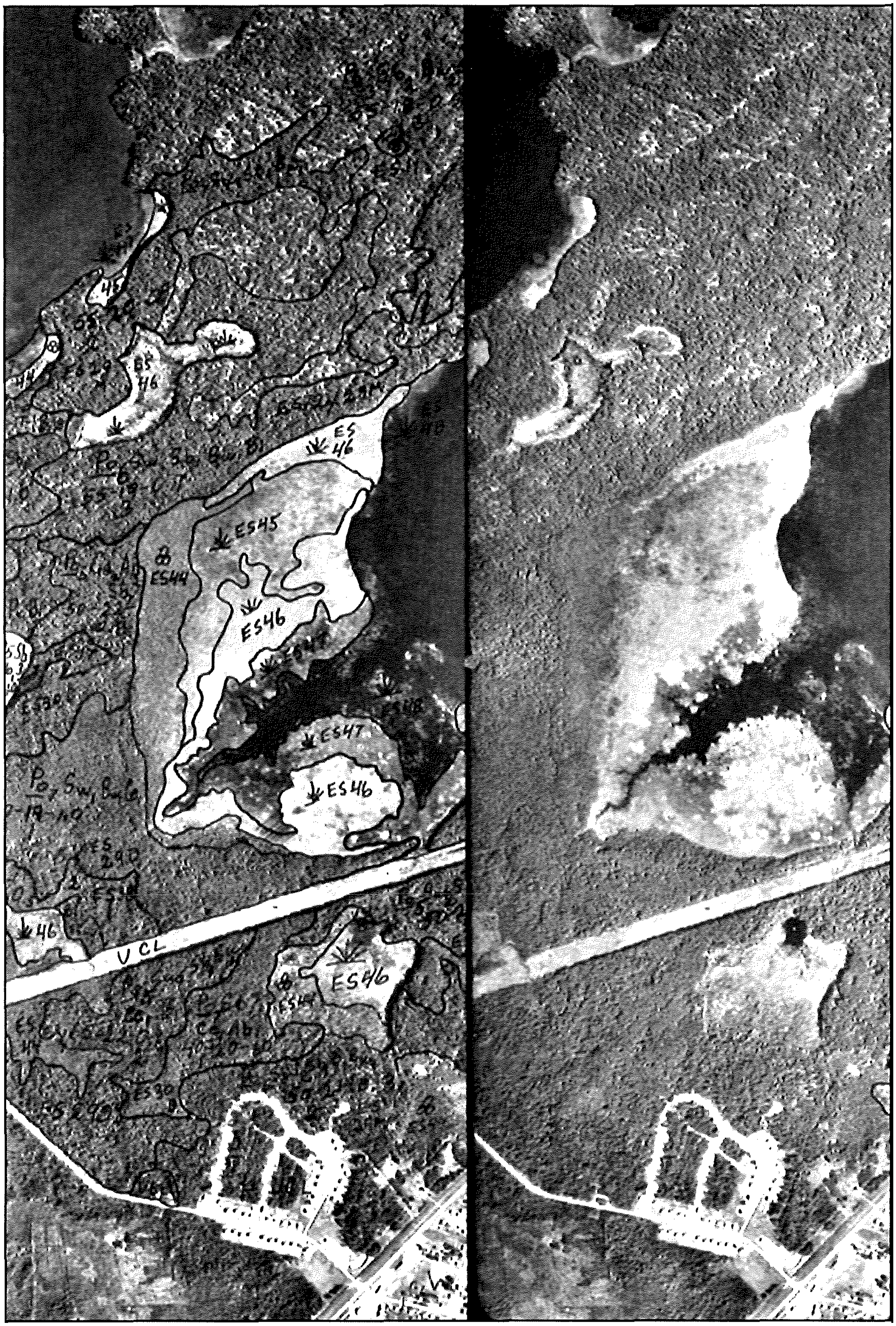


Figure 54

An interpreted black and white air photo at 1:20,000 scale; from Arnup et al. 1999.

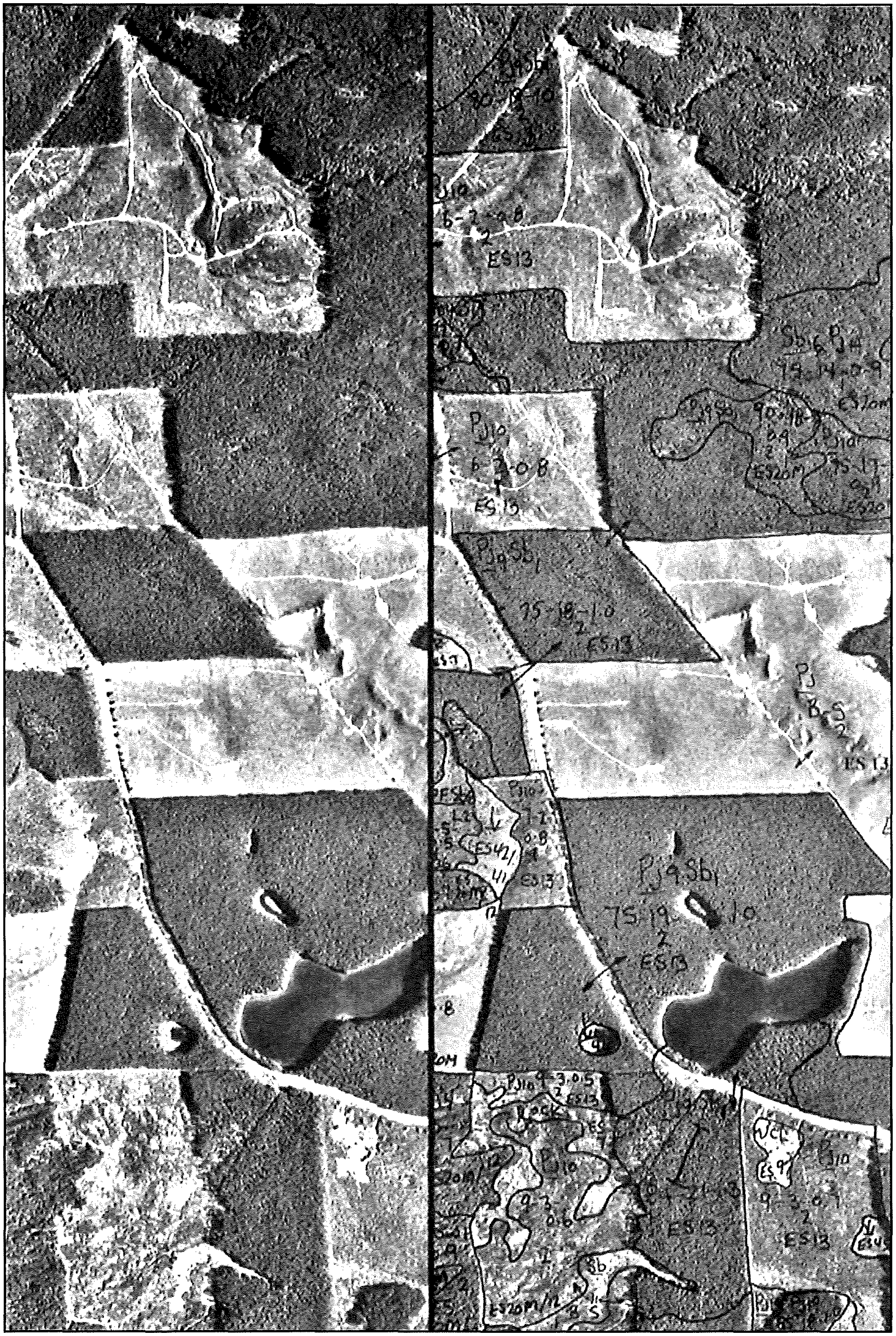


Figure 55

Another example of an interpreted black and white air photo at 1:20,000 scale; from Arnup et al. 1999.

across Ontario. Used in this way, air photos are the most pragmatic, accessible, and inexpensive tool to describe and inventory large areas. The units delineated at this scale on air photos are Community Series elements and Ecosites. Therefore, the polygons drawn on air photos are the foundation for the development of Ecosites (see **Figures 53, 54,** and **55).**

Helpful **HINTS**

- always preview any area you will be working on
- attempt to describe the areas you will visit
- jot down concise notes on the air photos in grease pencil for later reference (species, height, age, landform, soil, Ecosite)
- return to the field and review the air photo interpretation whenever possible
- take notes of all forest conditions and site relationships
- read other resource materials to fully under- stand the physical features and processes which make up the landscape (geo-fantasize)
- read and interpret archival photos and information for disturbance history

At the scale for ELC application, 1:10,000, the minimum mappable unit (mmu) is 0.5 hectares (ha). Any distinct patterns smaller than 0.5 ha should be included in a larger polygon as a complex or as an inclusion. Where site conditions and vegetation patterns are variable, complexes and inclusions are used to record this heterogeneity within a reasonable mapping scale. Inclusions are distinct communities that are too small to map as a separate polygon (i.e., <0.5 ha), and occur in one or more isolated pockets within a more or less homogeneous polygon. Complexes occur where site and vegetation conditions vary and create a mosaic of two or more communities. These communities are intermingled to such an extent that the individual patterns are too complex to map.

In order to control errors in mapping, the preferred mapping base is orthogonally rectified (ortho-rectified) photography. This photography is without distortion and can be laid directly over Ontario Base Maps (OBM) which facilitates its use in the Geographical Information Systems environment. Stereo pairs can be used for interpretation, but the polygons are recorded on the "orthos". This method can be limiting without a high-quality printer or plotter to provide good resolution at larger scales. Otherwise, the aerial photography can be photocopied very successfully on a colour photocopier, and the polygons delineated directly onto the copy. This layer can be scanned and stretched to fit the OBM base if required. Use of a Sketchmaster to transfer the boundaries is discussed in the Field Guide (Lee et al. 1998).

Complicating factors include photographs that were taken too late in the day, which creates long shadows, or photos that are poorly exposed. Colour infrared photography provides a wider range of colours and tones than true colour, which is an advantage for interpretation of vegetation types. Black and white photography is better for determining textural differences and gray tones (related to drainage). It also penetrates water better than colour and is more useful for detecting submerged aquatic vegetation.

A Step by-step Approach to Air Photo Interpretation

Used by the Forestry Resource Inventory Section for Ecosites (FRI)

1. Scan air photos for the sampled areas. Use this data to interpret the landscape pattern on the photos. Look at these areas in particular to establish the real relationship between what you see on the air photo and what is actually there, according to data sheets. Note the vegetation physiognomy, landform, soil type, and slope position.

2. Cross reference photography to the appropriate soils inventory map. Transfer the outline of different soil depositions to the air photos using a grease pencil. Do this by flight line or basemap, whatever your personal preference is.

3. Starting at the left hand corner of the flight line, begin the delineation of non-forested polygons. Using the non-forested interpretation, assign the appropriate Ecosite designation to each polygon. This would include cultural urban and parkland areas, agriculture, and pasture.

4. With Steps 1 and 2 in mind, delineate wooded and forested areas of the air photo. Delineate "with" or along terrain features, not "across" them. For example, keep lowland areas with lowland, upland with upland, mid-slope with mid-slope, and upper slope with upper slope. In this way you will avoid crossing and mixing Ecosite conditions. Delineate and assign woodland and forested Ecosite designations for each polygon.

5. The Ecosite designation will be based on:
    a. site: slope position, landform
    b. soil: texture, moisture regime
    c. physiognomy: life form of dominant vegetation (herb vs. shrub vs. tree), growth form (deciduous vs. coniferous vs. mixed)
    d. plant species assemblage: recurring species patterns
    e. FRI: use Forest Resource Inventory characteristics to judge height, age, stocking, growth, and yield.

6. Use the appropriate ELC tool to process these observations through the "keys" to assign Ecosite designations.

Additional Mapping Techniques

The finest writing tool available should be used when delineating, because if the polygons must be scanned or digitized, the width of the line will introduce error. The 1:10,000 OBM scale contains a source error of 0.5 mm, or 5 metres on the ground. An average pencil width of 1.0 to 2.0 mm generates a further error of 10 to 20 metres on the ground. The accuracy of the polygon can be calculated from these data, and the error is not usually less than 7 metres at 1:10,000 (Credit Valley Conservation 1995).

Each polygon should be given a unique code. A simple numbering system is often best because combinations of letters and numbers become ambiguous if part of the code is omitted. For example, Polygons M25 and S25 are distinct, but if the letters are lost, the data cannot be properly assigned.

From air photo information, the Community Description and Classification card should be filled out in as much detail as possible. Evidence should include observations from the stereo aerial photography, as well as data available from geologic maps, soil maps, and all reports for the site. All sources should be properly cited, including date of mapping and scale. Sources should be identified on the interpreted map. The Community Description and Classification cards are completed with Polygon Identifier, Site and the Polygon Description, plus the interpreted aerial photography, and Stand and Soil Characteristic cards and Plant Species List. These are the minimum records taken into the field to complete the site investigations.

Factors Influencing Air Photo Interpretation

Factors that Assist Air Photo Interpretation

Knowledge of the Area

- the more you are familiar with the area, the better the interpretation
- familiarity assists in interpretation of species, age, height, and stocking

Knowledge of Species Distributions

- it helps to know whether a species is expected to be found in this area of the province
- it helps to know which species will typify changes in site conditions

Field Control

- provides a benchmark or reality check, based on areas for which field data has already been obtained, by which interpreter verifies interpretation
- ensure that plots are well distributed
- sample a wide variety of conditions

Field of View or Scale

- mesa-scale photography provides a better view of vegetation and environmental patterns
- mesa-scale photography allows view of topography, relief, physiognomy, and species

Exaggerated Vertical Scale

- enhances heights and differences in heights
- an advantage in air photo interpretation of forests, because differences in tree heights are more readily discernable and more accurately measured
- important for forest resource inventories

Radial Displacement

- definition: objects appear more in side-view
- species identification is improved but height determination is not improved

Helpful HINTS

Photo Illumination

- fluorescent light is best for viewing air photos

Monocular Inspection

- using one eye at a time can be useful

Features that Hinder Air Photo Interpretation

Shadow-point

- definition: a point in the air photo that represents a direct line between the sun and the airplane; an area in which there is no shadow at all
- appears as large, strongly illuminated circle
- disturbs the stereo effect because it appears as the absence of shadow in one photo and the presence of a shadow in the other

Areas of Maximum Shadow

- definition: caused by uneven illumination; photos are darker on western, southern, or eastern sides depending on the time of day
- the camera records the greatest proportion of shadow aggravated by glare in areas facing away from the sun

Overcast Conditions (Clouds)

- definition: an undesired atmosphere condition
- creates a shadow pattern

Attributes of Air Photos Used in Interpretation:

Texture

- created by tonal repetitions of groups of objects
- species identification is dependent on variations in crown texture

Pattern

- the arrangement of tree crowns produces stand patterns

Shape

- landform and species can be distinguished by their shapes

Tone

- influenced by many factors
- relation of tone within a photo is a useful identification tool

Shadow

- provides profile of trees; used for height and identification
- provides relief of crown texture

Delineation of Shape (on different parts of photo)

- front and back lighting yields different views of trees
- you can view photos upside down or on different stereo pairs

Table 6. Summary of Air Photo Interpretation Methods

Task	Materials	Product
Delineate polygons	Stereo air photography for study area: recent, large scale Steroscope Background information	Air photograph with all patterns delineated
Label with unique identifiers and Site	Database	Reference system for data collection
Complete Community Description and Classification Card, Polygon Description	ELC Field Guide data card copies	Baseline community descriptions to Community Series level and field collection materials

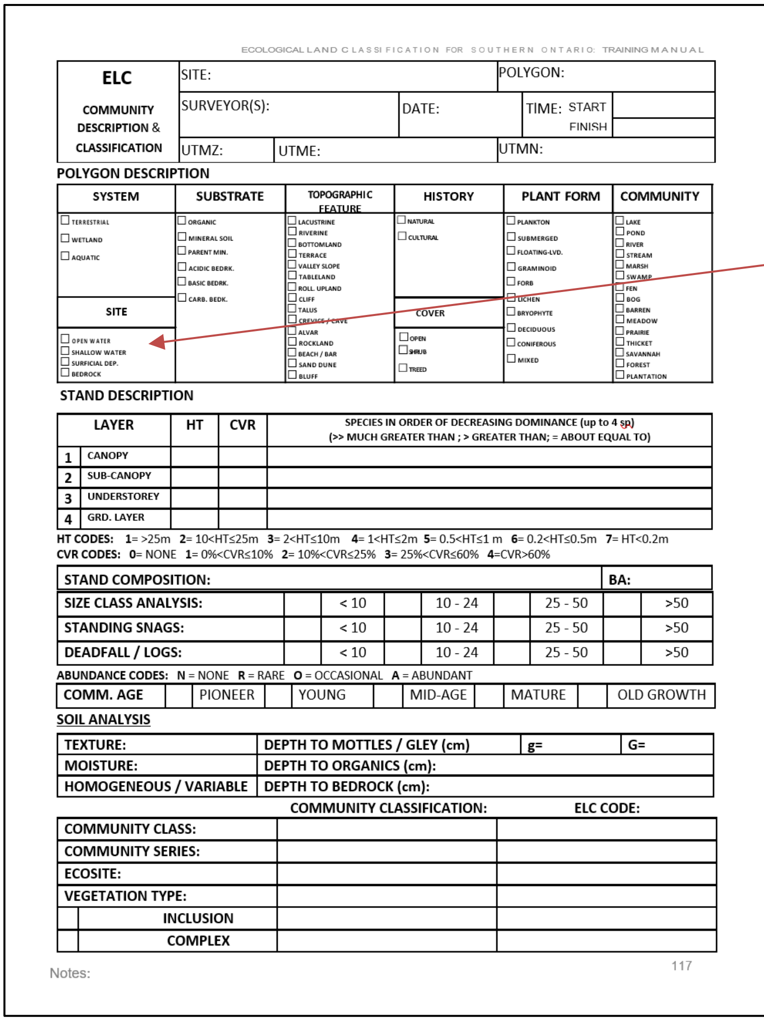
Summary for Air Photo Interpretation – Attributes Used When Applying ELC

Broad Scale

Use various Resource Mapping to describe the following features by using the Polygon Description and Notes sections on the data cards

- landform and mode of deposition
- prevailing or dominant parent materials and soils from resource maps, such as county soil maps
- the slope and landscape pattern (e.g., elevation, relief, aspect)

This information can provide a pre-typing for the attributes in the Polygon Description section of the Community Description and Classification data card. The attributes assigned using air photos should be re-assessed upon site visit field work.



ECOLOGICAL LAND CLASSIFICATION FOR SOUTHERN ONTARIO: TRAINING MANUAL

ELC COMMUNITY DESCRIPTION & CLASSIFICATION			
SITE:		POLYGON:	
SURVEYOR(S):	DATE:	TIME: START	FINISH
UTMZ:	UTME:	UTMN:	

POLYGON DESCRIPTION

SYSTEM	SUBSTRATE	TOPOGRAPHIC FEATURE	HISTORY	PLANT FORM	COMMUNITY
☐ TERRESTRIAL ☐ WETLAND ☐ AQUATIC	☐ ORGANIC ☐ MINERAL SOIL ☐ PARENT MIN. ☐ ACIDIC BEDRK. ☐ BASIC BEDRK. ☐ CARB. BEDK.	☐ LACUSTRINE ☐ RIVERINE ☐ BOTTOMLAND ☐ TERRACE ☐ VALLEY SLOPE ☐ TABLELAND ☐ ROLL. UPLAND ☐ CLIFF ☐ TALUS ☐ CREVICE / CAVE ☐ ALVAR ☐ ROCKLAND ☐ BEACH / BAR ☐ SAND DUNE ☐ BLUFF	☐ NATURAL ☐ CULTURAL	☐ PLANKTON ☐ SUBMERGED ☐ FLOATING-LVD. ☐ GRAMINOID ☐ FORB ☐ LICHEN ☐ BRYOPHYTE ☐ DECIDUOUS ☐ CONIFEROUS ☐ MIXED	☐ LAKE ☐ POND ☐ RIVER ☐ STREAM ☐ MARSH ☐ SWAMP ☐ FEN ☐ BOG ☐ BARREN ☐ MEADOW ☐ PRAIRIE ☐ THICKET ☐ SAVANNAH ☐ FOREST ☐ PLANTATION
SITE			COVER		
☐ OPEN WATER ☐ SHALLOW WATER ☐ SURFICIAL DEP. ☐ BEDROCK			☐ OPEN ☐ SHRUB ☐ TREED		

STAND DESCRIPTION

LAYER		HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (up to 4 sp) (>> MUCH GREATER THAN ; > GREATER THAN; = ABOUT EQUAL TO)
1	CANOPY			
2	SUB-CANOPY			
3	UNDERSTOREY			
4	GRD. LAYER			

HT CODES: 1= >25m 2= 10<HT≤25m 3= 2<HT≤10m 4= 1<HT≤2m 5= 0.5<HT≤1 m 6= 0.2<HT≤0.5m 7= HT<0.2m
CVR CODES: 0= NONE 1= 0%<CVR≤10% 2= 10%<CVR≤25% 3= 25%<CVR≤60% 4=CVR>60%

STAND COMPOSITION:								BA:
SIZE CLASS ANALYSIS:		< 10		10 - 24		25 - 50		>50
STANDING SNAGS:		< 10		10 - 24		25 - 50		>50
DEADFALL / LOGS:		< 10		10 - 24		25 - 50		>50

ABUNDANCE CODES: N = NONE R = RARE O = OCCASIONAL A = ABUNDANT

COMM. AGE	PIONEER		YOUNG		MID-AGE		MATURE		OLD GROWTH

SOIL ANALYSIS

TEXTURE:	DEPTH TO MOTTLES / GLEY (cm)	g=	G=
MOISTURE:	DEPTH TO ORGANICS (cm):		
HOMOGENEOUS / VARIABLE	DEPTH TO BEDROCK (cm):		

	COMMUNITY CLASSIFICATION:	ELC CODE:
COMMUNITY CLASS:		
COMMUNITY SERIES:		
ECOSITE:		
VEGETATION TYPE:		
INCLUSION		
COMPLEX		

Notes:

117

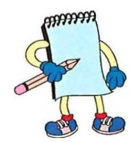
9. Vegetation Fundamentals

Introduction to Vegetation

Vegetation is a function of climate, parent material, landform, soils, organisms, and time.

The physical environment we have studied so far provides opportunities for, and imposes constraints on, the vegetation communities that can exist. The complexity of environmental variables manifests itself as patterns in vegetation. We can interpret the influence of the environment by studying vegetation patterns, which are presumed to act as a response variable for the composite effects of the environment. In other words, recurring vegetation characteristics can be used to establish patterns in ecosystems.

Plants require five primary resources to grow, all of which are part of the physical environment: light, water, carbon dioxide, mineral nutrients, and a substrate for anchorage and resource acquisition. The varied physical environment creates different regimes of availability of these primary resources. Differences in bedrock, surficial geology, and landform, as well as site-level differences in slope and soil properties, all contribute to variations in availability of these resources.



Vegetation = *f* (cl + pm + l + s + o + t)

cl	climate
pm	parent material
l	landform and physiography
s	soil
o	organisms
t	time

The sheer number of plant species in the world demonstrates co-evolution and adaptation to these varying regimes of resource availability in the environment. Co-existence is possible through the evolution of species' preferences and tolerances. As a result, species are distributed along environmental gradients. Specific thresholds along these gradients cause subtle or dramatic changes in vegetation species composition. For example, if we move away from a shoreline, from the margin where shallow water is persistent to upland conditions where the water table is always below the substrate surface, the vegetation changes from wetland herbaceous vegetation to possibly a deciduous forest. More subtle changes may be present without substantial changes in life or growth form, such as the difference between a Silver Maple swamp, Red Oak forest, or Hemlock forest.

Vegetation Description

Vegetation can be described in many different ways, in terms of plant species, populations, or assemblages of plant species called vegetation communities. Vegetation can be, in fact, described using any number of attributes, depending upon your objectives. For example, foresters describe a stand of trees in terms of wood volume per unit area, while wildlife conservationists may describe the same stand in terms of the number of standing snags suitable for nesting for a particular bird species. Similarly, ecologists have long used intensive and quantitative assessments of abundance, such as frequency, density, and stem counts, to investigate patterns and processes in plant community assembly.

Our goal here is to describe vegetation within a polygon, only to the extent that is suitable for ecosystem description, classification, and mapping. Furthermore, our descriptions need to balance the desire to be rigorous and comprehensive with the time and effort required for sampling. The vegetation description methods adopted by ELC have been developed to meet this balance - providing good information that is applicable for community description and classification, stand composition, age structure, and wildlife habitat, while remaining easy to measure in the field.

The application of ELC primarily focuses on easily measured features to describe vegetation structure and composition.

Vegetation Structure

Vegetation structure refers to the vertical layering of plants found in community assemblages, whether they are forests, thickets, meadows, or marshes.

Vertical layering:

- arises from different plant growth forms (i.e., tree vs. shrub vs. herb), and different ages of plants
- has significance not only for the visual character of the vegetation but also for the ecological processes that occur within the vegetation community
- depends primarily on the
- community's maturity, or time since last disturbance
- responses of vegetation to environmental factors, such as moisture and nutrient regimes
- competition, particularly for light
- is very important for providing and stratifying wildlife habitat.

Layers

Vegetation is categorized according to pre-defined layers:

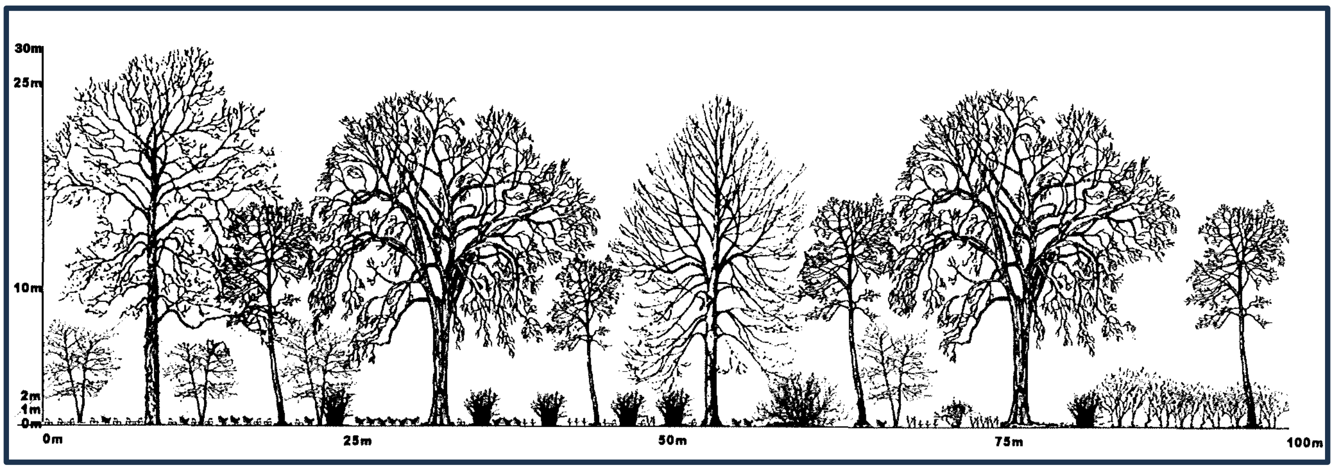
- canopy
- sub-canopy
- understorey
- ground layer

These layers are ecological strata. They are not based on height. The definitions of the layers (see **Figures 56** and **57)** are:

- **Layer 1 - canopy:**
  - the topmost layer of vegetation in any community
  - the layer that receives direct (incident) sunlight
  - i.e., can refer to the topmost layer of a forest, made up of trees, or to the topmost layer of a marsh, made up of cattails
- **Layer 2 - sub-canopy:**
  - the layer of vegetation that occurs directly below the canopy
  - primarily shaded by the canopy; receives only scattered patches or flecks of incident sunlight
- **Layer 3 - understorey:**
  - the vegetation layer intermediate in height between the canopy layers (canopy and sub-canopy) and ground layer
  - entirely shaded
  - e.g., in a forest it would be the shrub and sapling layer
- **Layer 4 - ground layer:**
  - vegetation layer that is nearest to the substrate surface
  - further shaded by all three above layers

Figure 56

The vegetation layers found in a typical forest, with trees occupying canopy and sub-canopy positions, trees and shrubs occupying the understorey, and herbaceous and woody vegetation occupying the ground layer.



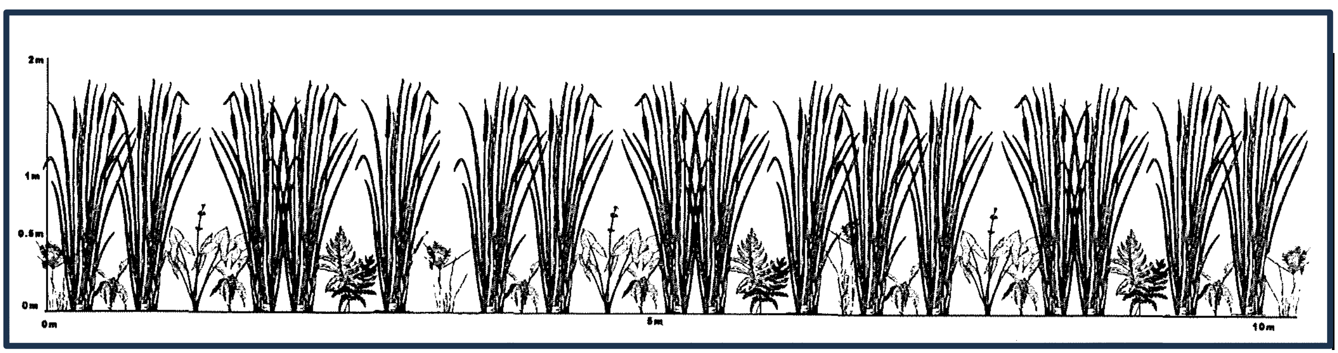
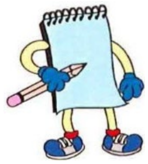


Figure 57

The vegetation layers found in a marsh community, showing cattails occupying the canopy layer, and other herbaceous vegetation occupying the sub-canopy, understorey, and ground layers.

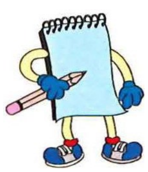


It is very important to stay within the boundaries of the polygon while doing the reconnaissance to document plant species or doing the tree tallies using a prism. Thiswill minimize the number of plant species documented from adjacent ecological land units and save sampling time. The more variation in plant species that is recorded, because species from other polygons are included, the more difficult it will be to describe and classify the polygon. We strongly recommend that only the core of the polygon is used for the documented plant species list. Stay within a perimeter buffer strip of 10 metres or more, depending on the size of the polygon. When doing the plant species list, use the changing patterns in understorey, ground layer vegetation, and site conditions (i.e., topography, slope position, moisture regime)as a guide to stay within the core area and to minimize heterogeneity.

Vegetation Composition

Composition is simply the plant species found within a polygon. For ELC application, composition is expressed in two ways:

- for every community (polygon) sampled, a plant species list is compiled, and recorded on the Plant Species List data card,
    - plant species lists are the standard way to document those species present within a particular area, or polygon
    - ELC also uses simple codes to assess the relative abundance of each species: whether they are rare (R), occasional (0), abundant (A), or dominant (D)
    - the plant species list is later summarized, as the Stand Description on the Community Description and Classification data card, to highlight the few prevailing or principal species found within the polygon
- for treed communities, a tree tally is included, and later summarized in the Stand Composition sections on both the Stand Characteristics data card, and the Community Description and Classification data card
    - a tree tally represents an objective way to census the tree species in a polygon, and to estimate their relative abundance and volume, using basal area
    - stand composition is a listing of the tree species found within the polygon, in order of decreasing dominance, as indicated by their relative proportions
    - the stand composition, here, is assessed using a forester's prism (Basal Area Factor **2X),** and is the same as those traditionally used in Forest Resource Inventories.



The Plant Species List uses layer codes that are applicable to any type of community. That is, these layer codes can be used to describe a Dry- Fresh Sugar Maple Deciduous Forest Type or a Cattail Mineral Shallow Marsh Type. In these two examples, both Sugar Maple and Cattails would be documented in the canopy layer (Layer 1).

IN THE FIELD

Plant Species List

A plant species list can be compiled in two ways:

1. "walk-about" - plant species are recorded while walking throughout the polygon doing the other sampling required
    - this is qualitative sampling which covers more area in less time
    - this cannot be used for rigorous statistical analyses
2. "plot-based" - plants are recorded within plots of defined size and area. Plots are placed throughout the polygon according to some prescribed sampling scheme
    - plot size will vary according to vegetation layer you are sampling
    - this is quantitative sampling which represents a statistical sample of the polygon

- this can be used in rigorous statistical analyses
- consult ecology textbooks and scientific papers for determining appropriate sampling techniques for specific purposes

For general application of the ELC, the walk-about is the most general, efficient, and widely used method.

- begin by recording plant species in the Species Code column on the Plant Species List data card, as species are encountered during a reconnaissance of the polygon
- keep track of, mentally and by using notes, the layers in which species occur and their abundances
- ultimately, for each species, record the layers in which species occurs **(Table 7),** and record the abundance code **(Table 8)** which best summarizes their abundance across the polygon
- collect samples of unidentifiable species for later identification
- note that a particular species can occur in more than one layer - i.e., you can have a mature Sugar Maple tree in the canopy layer, a Sugar Maple in the sub-canopy layer, and Sugar Maple saplings and seedlings in the understorey and ground layers, respectively.

Table 7. Codes used to stratify vegetation according to layers

Code	Layer	Definition
1	Canopy	highest layer of vegetation; receives incident (direct) sunlight
2	Sub-canopy	vegetation layer under the canopy; does not, for the most part, receive direct sunlight
3	Understorey	vegetation layer intermediate in height between the canopy and ground layer, e.g., in a forest it would be represented by the shruband sapling layer
4	Ground layer	vegetation layer that is nearest to the substrate surface

Table 8. Codes used in estimating the abundance of plant species within the polygon.

Code	Abundance	Definition
R	Rare	represented in the polygon by less than about three to five individuals or small clumps
O	Occasional	present as scattered individuals throughout the polygon or represented by one or more largeclumps of many individuals; most species will fall into this category
A	Abundant	represented throughout the polygonby large numbers of individuals or clumps; likely to be encountered anywhere in the polygon; usually forming > 10% ground cover
D	Dominant	represented throughout the polygonby large numbers of individuals or clumps; visually more abundant than other species; forming > 10% ground cover and >35% vegetation cover in any one stratum

Tree Tally

A tree tally is compiled using a forester's prism (Basal Area Factor 2X) at sample points selected within the polygon. The tree tally is later summarized for the Stand Composition sections on both the Stand and Soil Characteristics data card, and the Community Description and Classification data card.

IN THE FIELD

- the sample points, at which prism sweeps are done, should be selected according to the size and variability of the polygon. Prism sweeps should be made in parts of the polygon that are typical or representative of the stand. The number of prism sweeps depends on how many sweeps are required to suitably capture the variation in the environment and in the stand - i.e. sweeps on upper, middle, and lower slopes would be ideal for capturing the variation of a polygon on a slope
- sweeps should not overlap, so no tree is counted in more than one sweep
- if subsequent sweeps prove to be essentially similar in number and species composition to those preceding, no more sweeps may be needed. This is largely a judgement call and depends on the type of vegetation and variability of the site.

Prism Sweep

At each sample location:

- using a prism, count and record the number of trees, by species, that are determined as "in" (see Appendix D in **FG,** page 220) on the Stand Characteristics data card
- after the sweeps have been completed, total the tallies for each species. Calculate the relative value for each species by dividing the grand total (total of all tree species) by the total for each species except dead trees. Multiply the fraction by 100

  Basal Area (m^2/ha) in each sweep is estimated by multiplying the total number of live trees counted by the "factor" of the prism or gauge (e.g., x 2). Mean Basal Area (BA) is the average of these estimates.

Stand Composition

Stand Composition is a formula based on the results of the sweeps. Up to four of the most dominant species are listed in order of importance, followed by their relative abundance, on the Stand Characteristics data card, and the Community Description and Classification data card.

Format: SPECIES(%) SPECIES(%) SPECIES(%)

Example: ACESASA$_{75}$ – FAGGRAN$_{10}$ – FRAAMER$_{10}$ - TILAMER$_{5}$

Stand: Stand is made up of 75% Sugar Maple *(**Ace**r **sa**ccharum),* 10% Beech *(**Fag**us **gran**difolia)* 10% White Ash *(**Fra**xinus **amer**icana)* and 5% Basswood *(**Til**ia **amer**icana).*

Synthesis

Upon completion of the Plant Species List and Tree Tally, we have the necessary detailed information we can use to create a concise synthesis of the vegetation within a polygon, which is the Stand Description section on the Community Description and Classification data card. The objective here is to collapse the detailed species information to obtain a description of the polygon based on the prevailing and principal species found. This is primarily a subjective exercise done by the surveyor, based on their impressions as they traversed the polygon, and the data they recorded.

IN THE FIELD

The Stand Description section of the Community Description and Classification data card records this vegetation summary:

- the four vertical layers are already documented and coded for the species recorded on the Plant Species List: canopy (1), sub-canopy (2), understorey (3), and ground layer (4)
- using these layer designations, first, assign heights to each layer, using the height codes **(Table 9)**
- because the vertical structure of vegetation can be complex, up to two height codes can be recorded to characterize or represent a range of heights for a particular layer of vegetation. For example, in a forest, the understorey layer can comprise shrubs and tree saplings from 0.5 m to 10 m. In this case, a height code of 3-5 or 5-3 can be recorded to show this range. This first number of the range represents the height class that is considered to be most important. The only restriction is that a particular height code cannot be dominant in more than one layer; heights cannot overlap between layers.
- next, assess the absolute cover of each vegetation layer; this is expressed as absolute cover, in percent. Absolute cover is the area of the ground covered by the shadow of that vegetation layer (see **Table 10)**
- finally, characterize the vegetation by organizing up to four plant species, in each layer, in order of decreasing dominance or importance. This ordering of species is analogous to the traditional "dominance type". Use the following symbols to characterize the relative abundance of species in the listing: >> much greater than; > greater than; or= equal to.

Format: SPECIES >> SPECIES = SPECIES > SPECIES

Example: ARANUDI >> TRIGRAN = ACESASA > ALLTRIC

Vegetation: Ground layer within this forest is dominated by Sarsaparilla (***Ara**lia **nudi**caulis*), which is much greater than White Trillium (***Tri**llium **gran**diflorum*), which is about equal in abundance to Sugar Maple (***Acer sa**ccharum*) seedlings, which is greater than Wild Leek (***All**ium **tric**occum*).

Table 9. Height (HT) codes used to describe vegetation within the polygon.

Height (HT) Codes	Definition
1	HT > 25 m
2	10 m < HT ≤ 25 m
3	2 m < HT ≤ 10 m
4	1 m < HT ≤ 2 m
5	0.5 m < HT ≤ 1 m
6	0.2 m < HT ≤ 0.5 m
7	HT ≤ 0.2 m

Table 10. Cover Codes used to estimate vegetation cover (i.e., absolute cover) by layer.

Cover (CVR) Codes	Definition
0	none (vegetation layer not represented in the stand)
1	0% < CVR ≤ 10%
2	10% < CVR ≤ 25%
3	25% < CVR ≤ 60%
4	CVR > 60%

Size Class Analysis

Size Class Analysis categorizes tree diameters into size classes **(Table 11)**. It is useful for portraying the age or state of succession of a particular treed stand. For example, a stand in which you find smaller diameters, with very few larger trees, in southern Ontario, is relatively evenly aged and young. On the other hand, a stand in which all size classes are equally represented is a multi-aged stand.

Helpful **HINTS**

Any type of vegetation community can be characterized using all four of the Layer codes, the Height codes and the Cover codes shown above, whether it be a Cattail Mineral Shallow Marsh Type or a Dry-Fresh Sugar Maple Deciduous Forest Type. In the case of the Cattail Mineral Shallow Marsh Type, Cattail would be recorded in the Canopy layer, along with the appropriate Height and Cover codes. This system can, therefore, characterize the vertical structure of herbaceous and shrub vegetation communities in the same way treed communities have traditionally been characterized.

Table 11. Tree size classes. Represents DBH (diameter at breast height; 1.3 m above ground) measured in cm.

Tree Size Classes
< 10 cm
10 - 24 cm
25 - 50 cm
> 50 cm

IN THE FIELD

- make a visual estimate of the abundance of stems using the abundance codes. This provides a general portrayal of the size class distribution within the stand.

Standing Snags and Deadfall

Analysis of standing snags and deadfall assesses the amount of standing and fallen dead woody material, which is important for wildlife, within the polygon.
The number of standing snags is estimated using the abundance codes **(Table 12)** by four tree diameter size classes. Similarly, the amount of deadfall is estimated by using the abundance codes **(Table 12)** by four tree diameter size classes.

Community Age

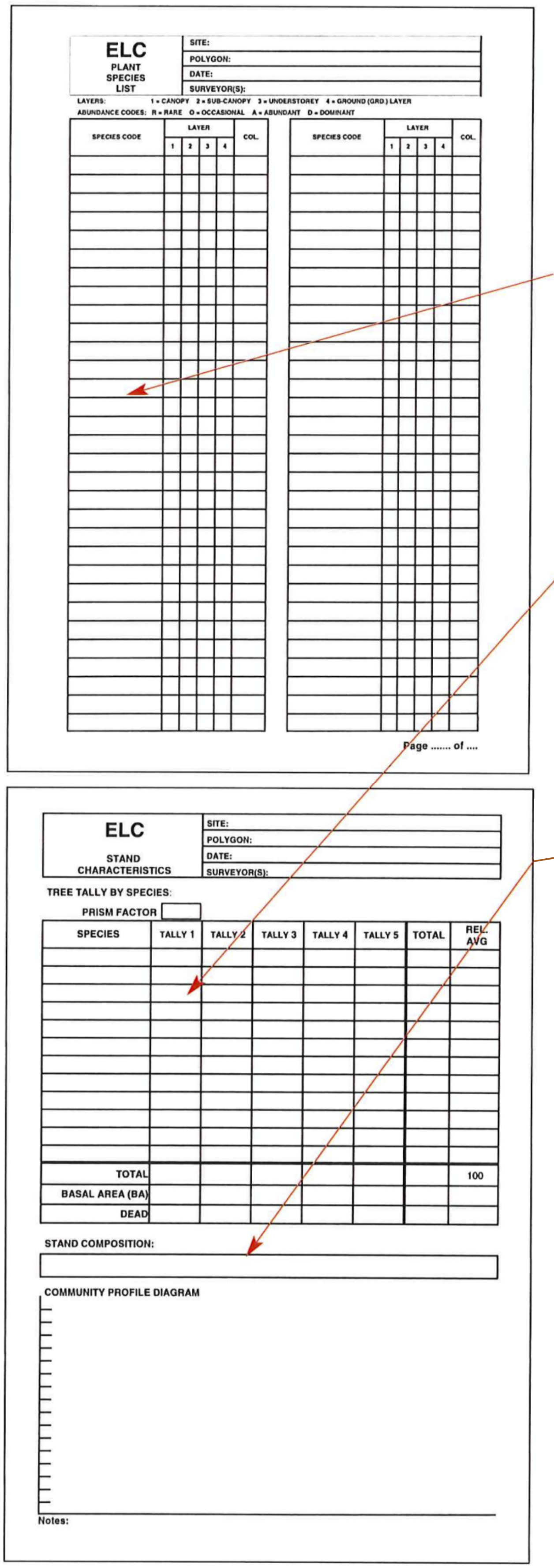
Community age is the estimated seral age or successional stage of the community represented in the polygon. Terms are defined in **Table 13.**

Table 12. Codes for estimating the abundance of live and dead, standing and fallen, woody stems.

Abundance Code	Term	Definition
N	None	no standing or fallen woody stems
R	Rare	represented by only one to a few standing or fallen woody stems
0	Occasional	represented as scattered standing or fallen woody stems throughout a community, or represented by one or more large clumps
A	Abundant	represented throughout the polygon or community by large numbers of standing or fallen woody stems; likely to be encountered anywhere in the polygon

Table 13. Codes for community age and their associated definitions (adapted from National Vegetation Working Group 1990).

Code	Definition
Pioneer	a community that has invaded disturbed or newly created sites and represents the early stages of either primary or secondary succession
Young	a community that has not yet undergone a series of natural thinnings and replacements; plants are essentially growing as independent individuals rather than as members of a phyto-sociological community
Mid-aged	a community that has undergone natural thinning and replacement as a result of species interaction, and often contains examples of both early successional and late successional species
Mature	a successionally maturing community dominated primarily by species that are replacing themselves and are likely to remain an important component of the community if it is not disturbed again; significant remnants of early seral stages may still be present
Old Growth	a self-perpetuating community composed primarily of late seral species that show uneven stand age distribution, including large old trees (generally older than 120 years) without open-grown characteristics



ELC PLANT SPECIES LIST

SITE:
POLYGON:
DATE:
SURVEYOR(S):

LAYERS: 1 = CANOPY 2 = SUB-CANOPY 3 = UNDERSTOREY 4 = GROUND (GRD.) LAYER
ABUNDANCE CODES: R = RARE O = OCCASIONAL A = ABUNDANT D = DOMINANT

SPECIES CODE	LAYER 1	LAYER 2	LAYER 3	LAYER 4	COL.	SPECIES CODE	LAYER 1	LAYER 2	LAYER 3	LAYER 4	COL.

Page .... of ....

ELC STAND CHARACTERISTICS

SITE:
POLYGON:
DATE:
SURVEYOR(S):

TREE TALLY BY SPECIES:
PRISM FACTOR

SPECIES	TALLY 1	TALLY 2	TALLY 3	TALLY 4	TALLY 5	TOTAL	REL. AVG
TOTAL							100
BASAL AREA (BA)							
DEAD							

STAND COMPOSITION:

COMMUNITY PROFILE DIAGRAM

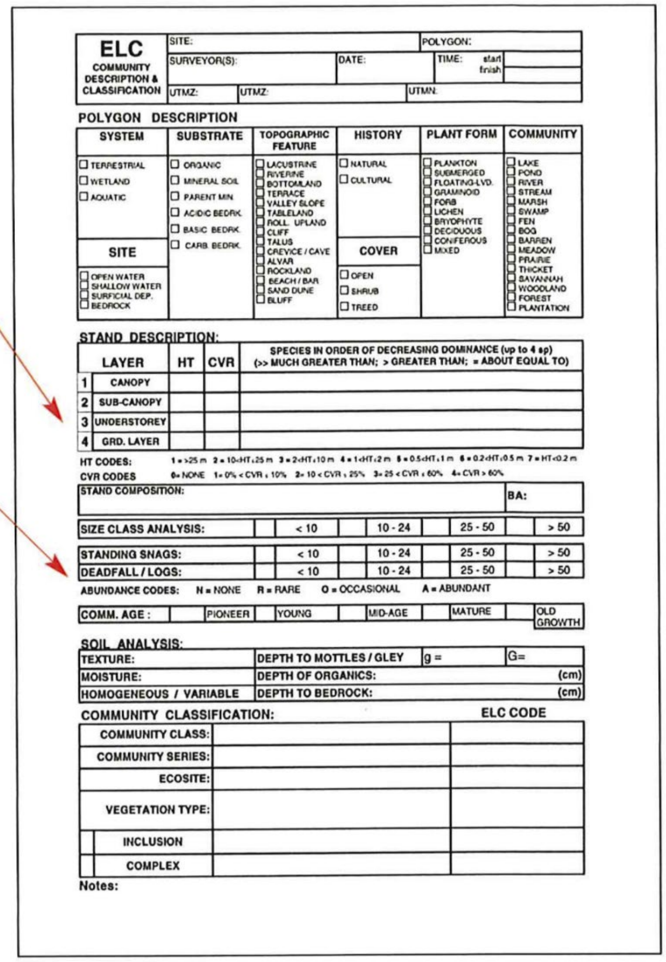
Notes:

Summary for Vegetation – Attributes Used When Applying ELC

Vegetation Sampling

- As part of your reconnaissance of the polygon to decide on sample points, begin by recording plant species composition. Record each plant species in the Species Code column of the Plant Species List data card.
- Determine the structure of the vegetation by beginning to assess the abundance of species and recording it within the four ecological layers on the data card.
- At each sample point, if the polygon has trees, record a prism sweep in the Tree Tally section of the Stand Characteristics data card.
- Continue concomitant sampling of plant species information on the Plant Species List while carrying out enough Tree Tallies to capture the variation in the polygon.
- Upon completion of the sampling, calculate the relative proportions of trees, by species, on the Stand Characteristics data card. Then record the species, in order of decreasing importance, in the Stand Composition section, according to their Relative Average.

- Next, complete the layer designations, with abundance codes, for each species on the Plant Species List.
- Create a summary of the Plant Species List in the Stand Description section of the Community Description and Classification data card.
- Finally, summarize the size class distributions of standing and fallen woody stems in the Size Class Analysis, Standing Snags, and Deadfall / Logs sections of the Community Description and Classification data card.



ELC
COMMUNITY DESCRIPTION & CLASSIFICATION

SITE:		POLYGON:	
SURVEYOR(S):	DATE:	TIME: start / finish	
UTMZ:	UTMZ:	UTMN:	

POLYGON DESCRIPTION

SYSTEM	SUBSTRATE	TOPOGRAPHIC FEATURE	HISTORY	PLANT FORM	COMMUNITY
☐ TERRESTRIAL ☐ WETLAND ☐ AQUATIC	☐ ORGANIC ☐ MINERAL SOIL ☐ PARENT MIN. ☐ ACIDIC BEDRK. ☐ BASIC BEDRK. ☐ CARB. BEDRK.	☐ LACUSTRINE ☐ RIVERINE ☐ BOTTOMLAND ☐ TERRACE ☐ VALLEY SLOPE ☐ TABLELAND ☐ ROLL. UPLAND ☐ CLIFF ☐ TALUS ☐ CREVICE / CAVE ☐ ALVAR ☐ ROCKLAND ☐ BEACH / BAR ☐ SAND DUNE ☐ BLUFF	☐ NATURAL ☐ CULTURAL	☐ PLANKTON ☐ SUBMERGED ☐ FLOATING-LVD. ☐ GRAMINOID ☐ FORB ☐ LICHEN ☐ BRYOPHYTE ☐ DECIDUOUS ☐ CONIFEROUS ☐ MIXED	☐ LAKE ☐ POND ☐ RIVER ☐ STREAM ☐ MARSH ☐ SWAMP ☐ FEN ☐ BOG ☐ BARREN ☐ MEADOW ☐ PRAIRIE ☐ THICKET ☐ SAVANNAH ☐ WOODLAND ☐ FOREST ☐ PLANTATION
SITE			COVER		
☐ OPEN WATER ☐ SHALLOW WATER ☐ SURFICIAL DEP. ☐ BEDROCK			☐ OPEN ☐ SHRUB ☐ TREED		

STAND DESCRIPTION:

LAYER		HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (up to 4 sp) (>> MUCH GREATER THAN; > GREATER THAN; = ABOUT EQUAL TO)
1	CANOPY			
2	SUB-CANOPY			
3	UNDERSTOREY			
4	GRD. LAYER			

HT CODES: 1 = >25 m 2 = 10<HT≤25 m 3 = 2<HT≤10 m 4 = 1<HT≤2 m 5 = 0.5<HT≤1 m 6 = 0.2<HT≤0.5 m 7 = HT<0.2 m
CVR CODES 0= NONE 1= 0% < CVR ≤ 10% 2= 10 < CVR ≤ 25% 3= 25 < CVR ≤ 60% 4= CVR > 60%

STAND COMPOSITION:	BA:

SIZE CLASS ANALYSIS:		< 10		10 - 24		25 - 50		> 50
STANDING SNAGS:		< 10		10 - 24		25 - 50		> 50
DEADFALL / LOGS:		< 10		10 - 24		25 - 50		> 50

ABUNDANCE CODES: N = NONE R = RARE O = OCCASIONAL A = ABUNDANT

COMM. AGE :		PIONEER		YOUNG		MID-AGE		MATURE		OLD GROWTH

SOIL ANALYSIS:

TEXTURE:	DEPTH TO MOTTLES / GLEY	g =	G=
MOISTURE:	DEPTH OF ORGANICS:		(cm)
HOMOGENEOUS / VARIABLE	DEPTH TO BEDROCK:		(cm)

COMMUNITY CLASSIFICATION: ELC CODE

COMMUNITY CLASS:		
COMMUNITY SERIES:		
ECOSITE:		
VEGETATION TYPE:		
INCLUSION		
COMPLEX		

Notes:

10. Data Cards

The following data sheets are provided as templates for use by those who undertake Ecological Land Classification. Please feel free to photocopy or scan these data sheets as often as required, and use the copies in field data collection, or share copies with colleagues who undertake ELC.

ELC COMMUNITY DESCRIPTION & CLASSIFICATION	SITE:		POLYGON:
	SURVEYOR(S):	DATE:	TIME: START FINISH
	UTMZ:	UTME:	UTMN:

POLYGON DESCRIPTION

SYSTEM	SUBSTRATE	TOPOGRAPHIC FEATURE	HISTORY	PLANT FORM	COMMUNITY
☐ TERRESTRIAL ☐ WETLAND ☐ AQUATIC	☐ ORGANIC ☐ MINERAL SOIL ☐ PARENT MIN. ☐ ACIDIC BEDRK. ☐ BASIC BEDRK. ☐ CARB. BEDK.	☐ LACUSTRINE ☐ RIVERINE ☐ BOTTOMLAND ☐ TERRACE ☐ VALLEY SLOPE ☐ TABLELAND ☐ ROLL. UPLAND ☐ CLIFF ☐ TALUS ☐ CREVICE / CAVE ☐ ALVAR ☐ ROCKLAND ☐ BEACH / BAR ☐ SAND DUNE ☐ BLUFF	☐ NATURAL ☐ CULTURAL	☐ PLANKTON ☐ SUBMERGED ☐ FLOATING-LVD. ☐ GRAMINOID ☐ FORB ☐ LICHEN ☐ BRYOPHYTE ☐ DECIDUOUS ☐ CONIFEROUS ☐ MIXED	☐ LAKE ☐ POND ☐ RIVER ☐ STREAM ☐ MARSH ☐ SWAMP ☐ FEN ☐ BOG ☐ BARREN ☐ MEADOW ☐ PRAIRIE ☐ THICKET ☐ SAVANNAH ☐ FOREST ☐ PLANTATION
SITE			COVER		
☐ OPEN WATER ☐ SHALLOW WATER ☐ SURFICIAL DEP. ☐ BEDROCK			☐ OPEN ☐ SHRUB ☐ TREED		

STAND DESCRIPTION

LAYER		HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (up to 4 sp) (>> MUCH GREATER THAN ; > GREATER THAN; = ABOUT EQUAL TO)
1	CANOPY			
2	SUB-CANOPY			
3	UNDERSTOREY			
4	GRD. LAYER			

HT CODES: **1**= >25m **2**= 10<HT≤25m **3**= 2<HT≤10m **4**= 1<HT≤2m **5**= 0.5<HT≤1 m **6**= 0.2<HT≤0.5m **7**= HT<0.2m

CVR CODES: **0**= NONE **1**= 0%<CVR≤10% **2**= 10%<CVR≤25% **3**= 25%<CVR≤60% **4**=CVR>60%

STAND COMPOSITION:								BA:
SIZE CLASS ANALYSIS:		< 10		10 - 24		25 - 50		>50
STANDING SNAGS:		< 10		10 - 24		25 - 50		>50
DEADFALL / LOGS:		< 10		10 - 24		25 - 50		>50

ABUNDANCE CODES: **N** = NONE **R** = RARE **O** = OCCASIONAL **A** = ABUNDANT

COMM. AGE		PIONEER		YOUNG		MID-AGE		MATURE		OLD GROWTH

SOIL ANALYSIS

TEXTURE:	DEPTH TO MOTTLES / GLEY (cm)	g=	G=
MOISTURE:	DEPTH TO ORGANICS (cm):		
HOMOGENEOUS / VARIABLE	DEPTH TO BEDROCK (cm):		

		COMMUNITY CLASSIFICATION:	ELC CODE:
COMMUNITY CLASS:			
COMMUNITY SERIES:			
ECOSITE:			
VEGETATION TYPE:			
	INCLUSION		
	COMPLEX		

Notes:

ELC PLANT SPECIES LIST	
	SITE:
	POLYGON:
	DATE:
	SURVEYOR(S):

LAYERS: **1** = CANOPY **2** = SUB-CANOPY **3** = UNDERSTOREY **4** = GROUND (GRD.) LAYER

ABUNDANCE CODES: **R** = RARE **O** = OCCASIONAL **A**= ABUNDANT **D** = DOMINANT

SPECIES CODE	LAYER				COL.	SPECIES CODE	LAYER				COL.
	1	2	3	4			1	2	3	4	

ELC STAND CHARACTERISTICS	
	SITE:
	POLYGON:
	DATE:
	SURVEYOR(S):

TREE TALLY BY SPECIES:

PRISM FACTOR ______

SPECIES	TALLY 1	TALLY 2	TALLY 3	TALLY 4	TALLY 5	TOTAL	REL. AVG
TOTAL							100
BASAL AREA (BA)							
DEAD							

STAND COMPOSITION:

COMMUNITY PROFILE DIAGRAM

Notes:

ELC

SOILS ONTARIO

SITE:	
POLYGON:	
DATE:	
SURVEYOR(S):	

P/A	PP	Dr	Position	Aspect	Slope %	Type	Class	UTM Z	UTM E	UTM N

SOIL	1	2	3	4	5
TEXTURE x HORIZON					

A TEXTURE					
COARSE FRAGMENTS					
B TEXTURE					
COARSE FRAGMENTS					
C TEXTURE					
COARSE FRAGMENTS					
EFFECTIVE TEXTURE					
SURFACE STONINESS					
SURFACE ROCKINESS					

DEPTH TO/OF

MOTTLES					
GLEY					
BEDROCK					
WATER TABLE					
CARBONATES					
DEPTH OF ORGANICS					
PORE SIZE DISC #1					
PORE SIZE DISC #2					
MOISTURE REGIME					

SOIL SURVEY MAP					
LEGEND CLASS					

ELC **MANAGEMENT / DISTURBANCE**	**SITE:**
	POLYGON:
	DATE:
	SURVEYOR(S):

DISTURBANCE / EXTENT	0	1	2	3	**SCORE †**
TIME SINCE LOGGING	>30 YEARS	15 – 30 YEARS	5 – 15 YEARS	0 -5 YEARS	
INTENSITY OF LOGGING	NONE	FUEL WOOD	SELECTIVE	DIAMETER LIMIT	
EXTENT OF LOGGING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
SUGAR BUSH OPERATIONS	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF OPERATIONS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
GAPS OF FOREST CANOPY	NONE	SMALL	INTERMEDIATE	LARGE	
EXTENT OF GAPS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
LIVESTOCK (GRAZING)	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF LIVESTOCK	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
ALIEN SPECIES	NONE	OCCASIONAL	ABUNDANT	DOMINANT	
EXTENT OF ALIEN SPECIES	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
PLANTING (PLANTATION)	NONE	OCCASIONAL	ABUNDANT	DOMINANT	
EXTENT OF PLANTING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
TRACKS AND TRAILS	NONE	FAINT TRAILS	WELL MARKED	TRACKS OR	
EXTENT OF TRACKS/TRAILS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
EARTH DISPLACEMENT	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF DISPLACEMENT	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
NOISE	NONE	SLIGHT	MODERATE	INTENSE	
EXTENT OF NOISE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
DISEASE/DEATH OF TREES	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF DISEASE/DEATH	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
WIND THROW (BLOW DOWN)	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF WIND THROW	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
BROWSE (e.g. DEER)	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF BROWSE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
BEAVER ACTIVITY	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF ACTIVITY	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
FLOODING (pools & puddling)	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF FLOODING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
FIRE	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF FIRE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
ICE DAMAGE	NONE	LIGHT	MODERATE	HEAVY	
EXTENT OF ICE DAMAGE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
OTHER	NONE	LIGHT	MODERATE	HEAVY	
EXTENT	NONE	LOCAL	WIDESPREAD	EXTENSIVE	

† INTENESITY X EXTENT = SCORE

ELC
WILDLIFE

SITE:	
POLYGON:	
DATE:	
SURVEYOR(S):	

TEMP (°C):	CLOUD (10TH):	WIND:	PRECIPITATION:
CONDITIONS:			

POTENTIAL WILDLIFE HABITAT:

	VERNAL POOLS		SNAGS
	HIBERNACULA		FALLEN LOGS

SPECIES LIST

TY	SP. CODE	EV	NOTES	#

TY	SP. CODE	EV	NOTES	#

FAUNAL TYPE CODES (TY):
B = BIRD M = MAMMAL H = HERPETOFAUNA L = LEPIDOPTERA F = FISH O = OTHER

EVIDENCE CODES (EV):

BREEDING BIRD - POSSIBLE:
SH = SUITABLE HABITAT
SM = SINGING MALE

BREEDING BIRD - PROBABLE:
T = TERRITORY
A = ANXIETY BEHAVIOUR
D = DISPLAY
N = NEST BUILDING
P = PAIR
V = VISITING NEST

BREEDING BIRD• CONFIRMED:
DD = DISTRACTION
NE = EGGS
AE = NEST ENTRY
NU = NEST USED
NY = YOUNG
FY = FLEDGED YOUNG
FS = FOOD / FAECAL SACK

OTHER WILDLIFE EVIDENCE:
OB = OBSERVED
DP = DISTINCTIVE PARTS
TK = TRACKS
SI = OTHER SIGNS (specify)
VO = VOCALIZATION
HO = HOUSE / DEN
FE = FEEDING EVIDENCE
CA = CARCASS
FY = EGGS OR YOUNG
SC = SCAT

11. Polygon Description and Classification

Up to now, we have observed and described various aspects of the environment, including site, soils, and vegetation. We have met the first two objectives listed in **Figure 58** (refer to section 4, How to Apply the ELC, and **FG,** page 109, for further details). Our information now includes:

- Interpreted Air Photos: interpreted air photos for polygon boundaries
- Field Survey: physiographic, site, soil, and vegetation data collected according to field survey methods and data cards.

The next steps to meeting our objectives (i.e., **Figure 58)** include:

- Description of Polygon: standardized description of polygon attributes to facilitate keys, classification, and database design and management
- Classification: consistent keying and naming of communities

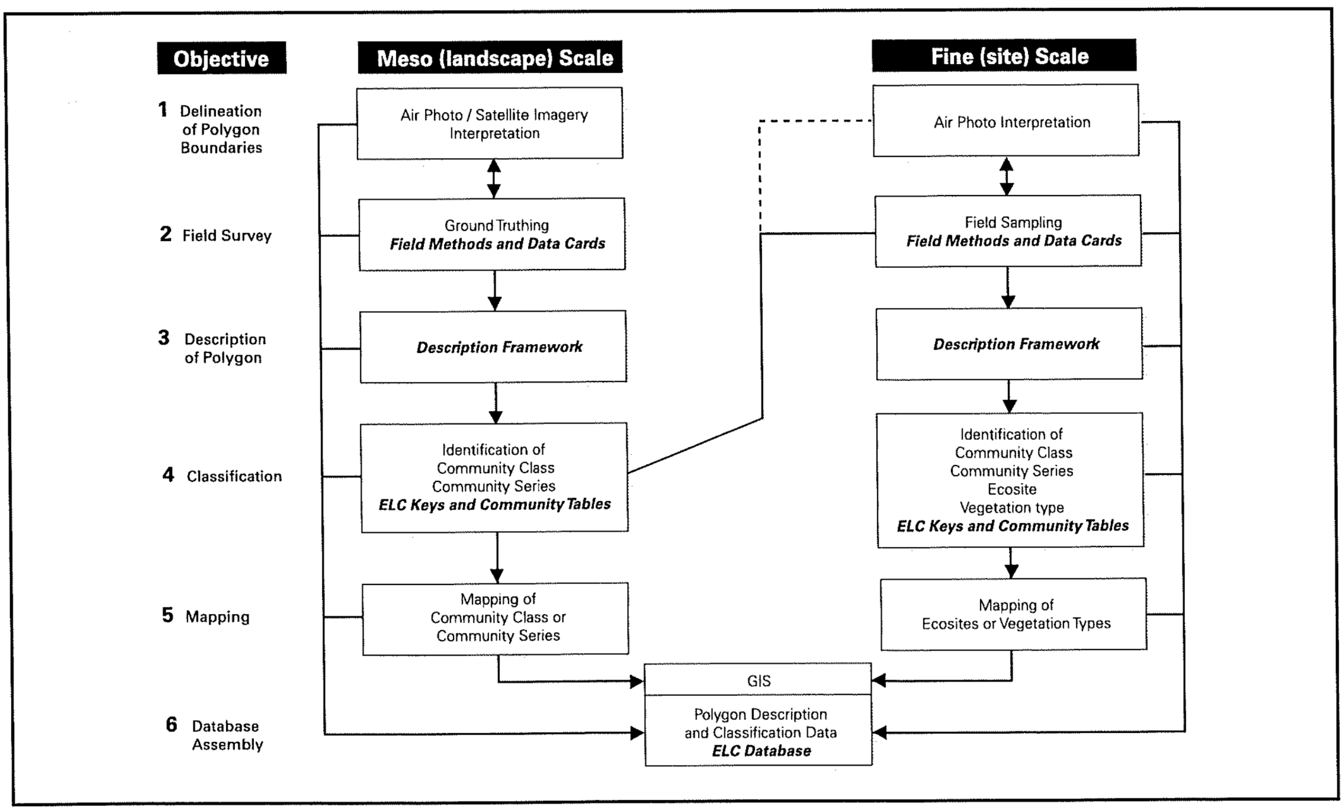


Figure 58

Schematic representation of how the ELC tools and techniques are applied at different scales of resolution (refer to Table 3, page 31 for more details). At this stage, we have accomplished the first two objectives, and are proceeding with Description and Classification of communities and polygons.

What follows is the process for using this information to describe and classify polygons in a consistent and standardized way.

There are two approaches to applying the ELC:

a. Informal

The informal approach uses only the ELC Keys **(FG,** pages 28 to 35), and Community Tables. This on-the-spot field assessment is based on observable features throughout the community or polygon. It is an approach similar to using a generic field plant or bird guide.

b. Formal

The formal approach is a rigorous and documented method using the ELC data cards, Description Framework, Diagrammatic Keys, and Community Tables. It is appropriate for land-use planning and ecosystem management as carried out by Conservation Authorities, municipalities, and consultants.

The following components of the ELC Field Guide are used to describe and classify communities and polygons. They are interrelated tools that make data consistent, taking you through a process that ends in classification using the Community Tables **(Figure 58).**

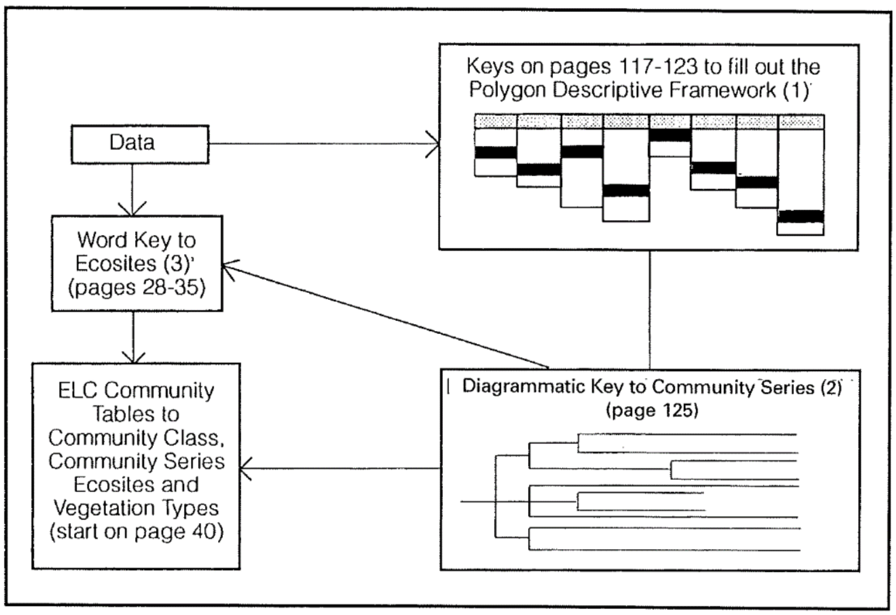


Figure 59
The relationship among the components of the ELC Field Guide used to describe and classify communities and polygons.

1. Word Keys to the Description Framework

On **FG** pages 117 to 123, there is a set of keys used primarily in the formal approach to classification. These keys categorize information from the data cards according to consistent attributes in eight fields of the Description Framework **(FG,** page 115). These are the attributes used to standardize the description of the community in the polygon. They are also the attributes used in the Diagrammatic Keys, which in turn lead you to the Community Tables.

2. Diagrammatic Keys

On **FG** pages 125 to 133, there is a set of diagrammatic keys which use only the eight attributes of the polygon documented in the Description Framework. The choices of attributes in the Diagrammatic Keys and Description Framework are more technical, limiting the language used to describe a community, making it easier to consistently categorize and classify a community.

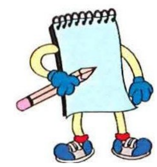
3. ELC Keys

On **FG** pages 28 to 35, there is a set of keys used primarily in the informal approach to classification. More detailed, less rigorously defined language is available here to describe the community, as opposed to the formal approach.

4. Community Tables

On FG pages 40 to 88, there is a set of Community Tables which organizes community units into a linear and nested framework. Currently, the keys are useful to direct you to a particular table or suite of tables. In order to fully apply the classification to the communities, use the Vegetation and Environmental Characteristics columns within the Community Tables. These columns provide additional criteria and attributes to distinguish communities at the finer level.

There is no single pathway to describe and classifying polygons, and the Keys and Tables can be used in sequence or independently. The preferred pathway will depend on the objectives of the study - whether a formal or informal approach is necessary - and the level of classification required to support the application (Community Series, Ecosite, or Vegetation Type are the most common endpoints).



A key is a tool that aids in obtaining an identification or classification of an unknown object or idea. It presents a sequence of choices (usually two, but sometimes more). At each set of choices, a decision must be made between them, which leads to the next pair of choices. If the correct choice is consistently made, the key will terminate at the correct identification or classification. The statements in the choices are based on the differing attributes for each category in the classification. In the ELC, statements refer to attributes concerning soils, moisture regimes, topography, plant form (physiognomy), plant cover, and community.

Polygon Description

The ecological function of a vegetation community is influenced by abiotic factors (soils, water, aspect), biotic factors (plant physiognomy, density, and associations), and the degree and source of disturbance (fire, agriculture, logging). Angus Hills (1960) was the first to provide an approach to organizing these factors and relate them to the expression of vegetation patterns on the Ontario landscape.

Hills recognized that landform had a profound effect on the climatic factors to which vegetation responds **(Figure 60).** Topography alone is capable of creating significant differences in temperature, air movement (which affects relative humidity which affects evapotranspiration rates), isolation and drainage patterns. These effects are then further modified by the underlying soil characteristics **(Figure 61**).

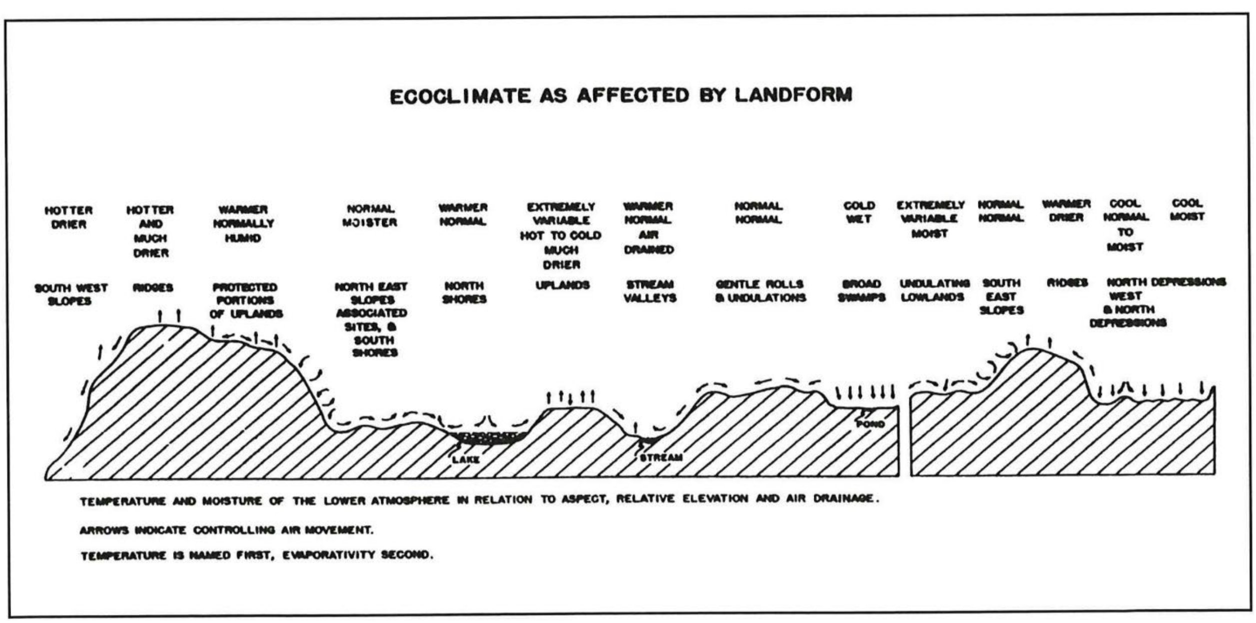


Figure 60
The influence of relief and topography on site-level climate; from Hills 1961.

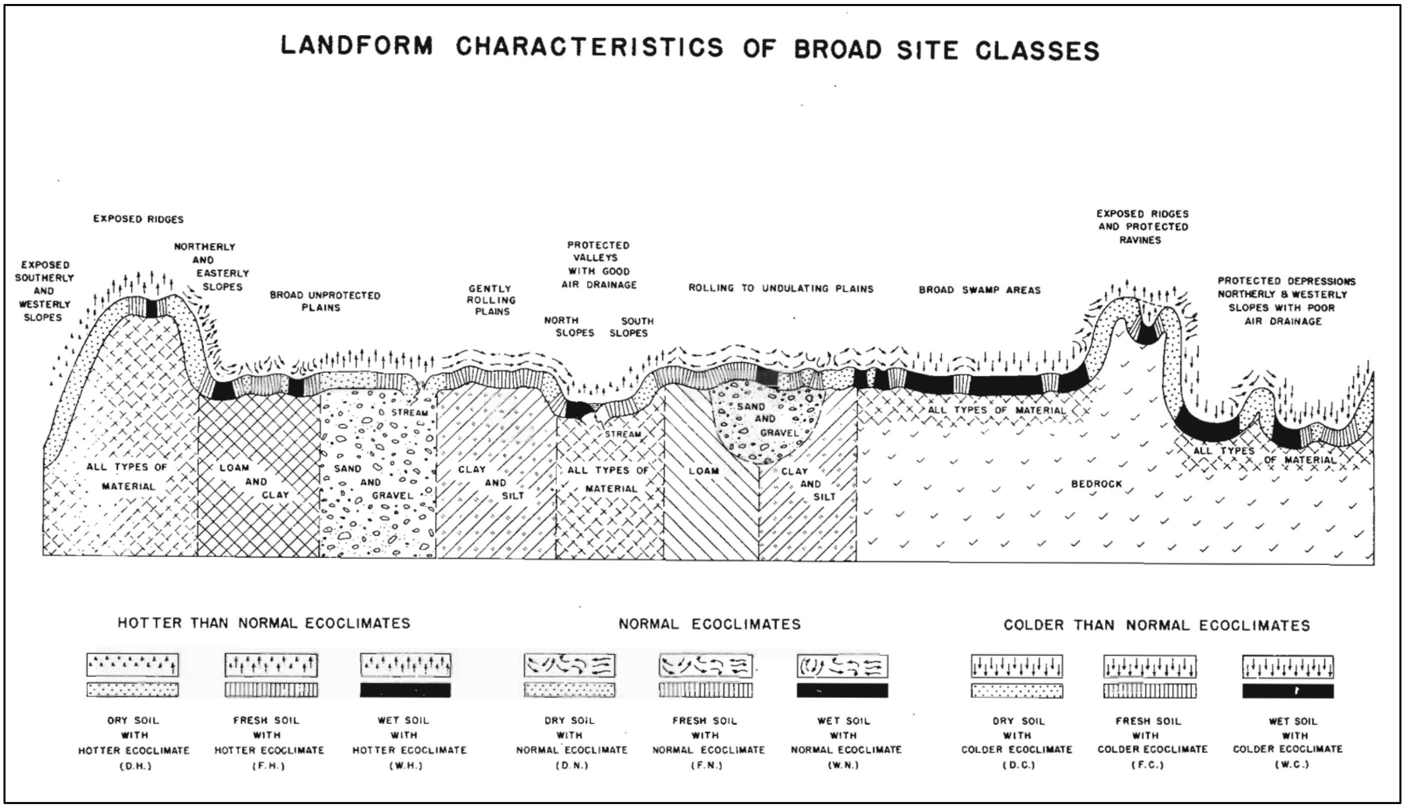


Figure 61
The effect of topography and soil type on site climate and hydrology characteristics; from Hills 1961.

Hills characterized the relationship among abiotic factors in a map that identified what he called Site Regions and Site Districts. The concept has been further refined by the ELC program, and **Figure 4** (page 22) illustrates the Ecoregions and Ecodistricts of Ontario. This is the basic framework on which the ecological land classification is built.

In order to provide a consistent method for the classification of vegetation communities, a method to describe the factors that act to modify plant communities was developed. These factors and characteristics not only help to identify ecological function, but they can be used as key words with which to key out communities, or as query and search capabilities when these data are entered into an ELC database.

ELC Description Framework

The first step in describing a polygon according to ELC involves sorting the data collected on the data sheets into standardized attributes. This entails processing your data through the ELC Keys **(FG,** pages 117 to 123). The Keys help you make decisions that describe the polygon and assign specific attributes to a particular field in the description system. Certain sections of the ELC Keys appear more than once in the Field Guide, building cross-referencing and relatedness among the tools.

The eight fields of the Polygon Description Framework **(Figure 62)** describe some of the abiotic and biotic characteristics of the polygon delineated through air photo interpretation. System, Site, Substrate, and Topographic Feature are controlled by abiotic factors. Cover, Plant Form, and Community are biotic factors. History deals with the nature of disturbance that controls the community - whether it is naturally occurring, or a consequence of human activity (cultural).

1. System	2. Site	3. Substrate	4. Topographic Feature	5. History	6. Cover	7. Plant Form	8. Community
Terrestrial	Open Water	Organic	Lacustrine	Natural	Open	Plankton	Lake
Wetland	Shallow Water	Mineral Soil	Riverine	Cultural	Shrub	Submerged	Pond
Aquatic	Surficial Deposits	Parent Mineral Soil	Bottomland		Treed	Floating Leaved	River
	Bedrock	Carbonate Bedrock	Terrace			Graminoid	Stream
		Basic Bedrock	Valley Slope			Forb	Marsh
		Acidic Bedrock	Tableland			Lichen	Swamp
			Rolling Upland			Bryophyte	Fen
			Cliff			Deciduous	Bog
			Talus			Coniferous	Barren
			Crevice / Cave			Mixed	Meadow
			Alvar				Prairie
			Rockland				Thicket
			Beach / Bar				Savannah
			Sand Dune				Woodland
			Bluff				Forest
							Plantation

Figure 62
The eight field that make up the ELC Polygon Description Framework, along with their associated attributes.

The following tables **(Tables 14 to 22)** define the attributes of each condition that describe the eight fields of the Polygon Description. The attributes are not definitive. Vegetation communities often gradually change from one ecological condition that can be clearly identified, through an ecotone, to another well-defined condition. The polygon should be described with the condition that exhibits the highest number of common characteristics.

The Word Keys to the Description Framework provide guidance in determining the correct condition for each field. The ultimate goal of this exercise is to assign a community classification at the level appropriate to the study (Community Class, Community Series, Ecosite, or Vegetation Type) using the ELC Community Tables that begin on page 40 of the Field Guide.

Table 14. System: What system applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 118 of the Field Guide)
Terrestrial	• Water table rarely or briefly above the substrate surface; • Substrate of parent mineral material, mineral soil or bedrock, depth of accumulated organics < 40 cm; • Standing pools of water (vernal pools) ≤ 20% of ground coverage • Wetland plant species[1] cover ≤ 50% of total plant species cover and/or mean wetness of a site for native species > O; • Moisture regime typically < 5.
Wetland	• Water table fluctuating, seasonally or permanently at or above the substrate surface • Standing water, pools or vernal pooling ≥ 20% of the ground coverage; • Wetland plant species[1] >50% of total plant species cover and/or mean wetness of a site for native species < O; • Moisture regime typically ≥ 5; • Water depth ≤2 m; • Emergent herbaceous or woody vegetation cover > 25%.
Aquatic [2]	• Water table permanently above surface, water depth various; • Emergent herbaceous or woody vegetation cover ≤ 25%; • Vegetation cover absent or of submerged or floating-leaved plant species.

1. Wetland plant species are those defined as such by the Ontario Wetland Evaluation System (OWES).
2. Note that some of these communities are defined as wetlands by the Ontario Wetland Evaluation System.

Table 15. Site: What site applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 118 of the Field Guide)
Open Water	• Permanent standing or running water; • Water level usually > 2 m; • Vascular vegetation cover ≤ 25%; • Community dominated by plankton.
Shallow Water	• Permanent standing or running water; • Water level usually ≤ 2 m; • Vegetation cover typically > 25%, except in active or disturbed sites; • Dominant vegetation submerged or floating-leaved species.
Surficial Deposits	• Bedrock outcrops few or not present; • Deposits of unconsolidated organic or mineral material > 15 cm over bedrock (i.e., soils or granular parent material is at least 15 cm deep); • Water table normally drops below the substrate surface for at least part of the year.
Bedrock	• Bedrock-controlled topography (i.e., large exposures of bedrock); • Average substrate depth ≤ 15 cm over bedrock; • Water table normally drops below the substrate surface for at least part of the year; • Variable accumulations of unconsolidated mineral substrates.

Table 16. Substrate: What substrate applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 118 of the Field Guide)
Organic	• Composed mainly of mosses, sedges, or other hydrophytic vegetation, containing ≥ 30% organic matter (≥ 17% organic carbon); • Commonly saturated with water; • Deposits ≥ 40 cm deep if humic or mesic organic materials, or ≥ 60 cm if fibric organic material.
Mineral Soil	• Unconsolidated inorganic material, < 30% organic matter; • Chemically weathered (comprises the solum; A and B horizons); • Evidence of horizon development to at least 15 cm.
Parent Material	• Unconsolidated; • Chemically unweathered mineral or organic material (comprises the C horizon); • No obvious horizon development.
Carbonate Bedrock	• Sedimentary, composed of carbonate minerals; • Effervesces on exposure to acid; • Weathers easily, pH > 7.
Basic Bedrock	• Igneous, composed of minerals with ≤ 66% silica; • Intermediate in weatherabilty, circumneutral pH.
Acidic Bedrock	• Igneous, composed of minerals with > 66% silica; • Resists weathering, pH < 7.

Table 17. Topographic Feature: What topographic feature applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 119 of the Field Guide)
Lacustrine	• Aquatic or wetland site associated with the waters of a lake or pond.
Riverine	• Aquatic or wetland site associated with the waters of a river or stream.
Bottomland	• Lower elevation of river valley that includes the floodplain and may extend beyond the limit of flooding to the base of the valley slopes.
Terrace	• A level bench in a valley elevated above the bottomland; • A glacio-fluvial landform formed when a modern river cuts through ancient river deposits.
Valley Slope	• Sloping walls of a distinct valley, which rise to the surrounding tableland.
Tableland	• An upland area that is essentially flat; • Does not have to be associated with a valley.
Rolling Upland	• Sites that are higher in elevation than the surrounding landscape that exhibit complex or repeated patterns of ridges, slopes and hollows, but without abrupt peaks, cliffs and other severe changes in topography.
Cliff	• Bedrock-controlled topography; • Site on *or near* the rim of a steep or vertical exposed rock face> 3 m high.
Talus	• Bedrock-controlled topography; • Site on fragmented rock or boulders accumulated at the base of a cliff.
Crevice/Cave	• Bedrock-controlled topography; • Deep, very shaded cavities and crevices in bedrock.
Alvar	• Bedrock-controlled topography, level, carbonate; • Mosaic of exposed limestone pavement and shallow substrate accumulation.; • Cracks or grykes in which soil accumulates; • Seasonal inundation of water and extreme summer drought.
Rockland	• Bedrock-controlled topography; • Block and fissure or rolling, knob and hollow (whale-back); • Mosaic of exposed rock and shallow substrate accumulation; • Unconsolidated substrates< 15 cm deep.
Beach/Bar	• Shoreline area of lake or river; • High disturbance from periodic high water levels and related physical effects such as ice scour, erosion, deposition, and long-shore drift.
Sand Dune	• Low ridge or hill of sand that has been sorted and deposited by wind.
Bluff	• Shoreline area of a river or lake; • Steep to vertical slopes of unconsolidated surficial deposits; • Subject to active erosion; slumping, mass wasting, or toe erosion.

Table 18. History: What history applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 120 of the Field Guide)
Natural	• Plant community that occurs spontaneously without regular human management, maintenance, or planting. May be dominated by either native or exotic species. • Any past disturbance has been terminated and biotic and abioticprocesses have taken over.
Cultural	• Plant community that is maintained by anthropogenic influencesand human based disturbances; • Non-native plant species oftencomprise a large proportion ofthe species richness and/or thebiomass of the community.

Table 19. Cover: What cover applies to the Polygon?

Condition	Attributes of Each Condition (See Key on page 120 of the Field Guide)
Open	• Shrub and tree cover 25%
Shrub	• Shrub cover> 25%, tree[1] cover < 25% (from key)
Treed (includes savannah, woodland and forest)	• Tree cover 25% • A community with tree cover of> 10% for fens and bogs: 25 to 100% for all others.

1. Definition of a tree: single stemmed, ≥ 6 m tall, and greater than 9.5 cm diameter at breast height (DBH).

Table 20. Plant Form: What plant form dominates the Community[1]?

Condition	Attributes of Each Condition (See Key on page 121 of the Field Guide)
Plankton	• Community dominated by free-floating microscopic organisms.
Submerged	• Community with > 75% of the total vegetation cover[2] comprised of submergent aquatic plants, (rooted and primarily growing underwater except for flowering parts that may break the surface); • Includes species of pondweed *(Potamogeton),* which have both submerged and floating leaves.
Floating-leaved	• Community with> 75% of the total vegetation cover[3] comprised of aquatic plants with leaves floating on the surface; • Includes both free floating plants and rooted floating-leaved plants as defined by Ontario Wetland Evaluation System.
Graminoid	• Community with > 75% of the total vegetation cover comprised of grasses, rushes, or other narrow-leaved, grass-like, non-woody plants; • Includes both narrow-leaved emergents and robust emergents as defined by Ontario Wetland Evaluation System.
Forb = herbaceous plants not included in above categories.	• Community with > 75% of the total vegetation cover comprised of broad-leaved plant species, both monocots and dicots.
Lichen	• Community with> 75 % of the vegetation cover comprised of non-vascular plants; > 50% of the total vegetation cover comprised of lichens.
Bryophyte	• Community with> 75 % of the vegetation cover comprised of non-vascular plants; > 50% of the total vegetation cover comprised of bryophytes: mosses and liverworts.
Deciduous	• Community with> 75 % of the canopy[4] cover comprised of deciduous, broad-leaved species.
Coniferous	• Community with> 75 % of the canopy cover comprised of coniferous species (includes Larch and Tamarack *[Larix* sp.]).
Mixed	• Community with a mixture of deciduous and coniferous species, each of which comprises > 25 % of the canopy cover.

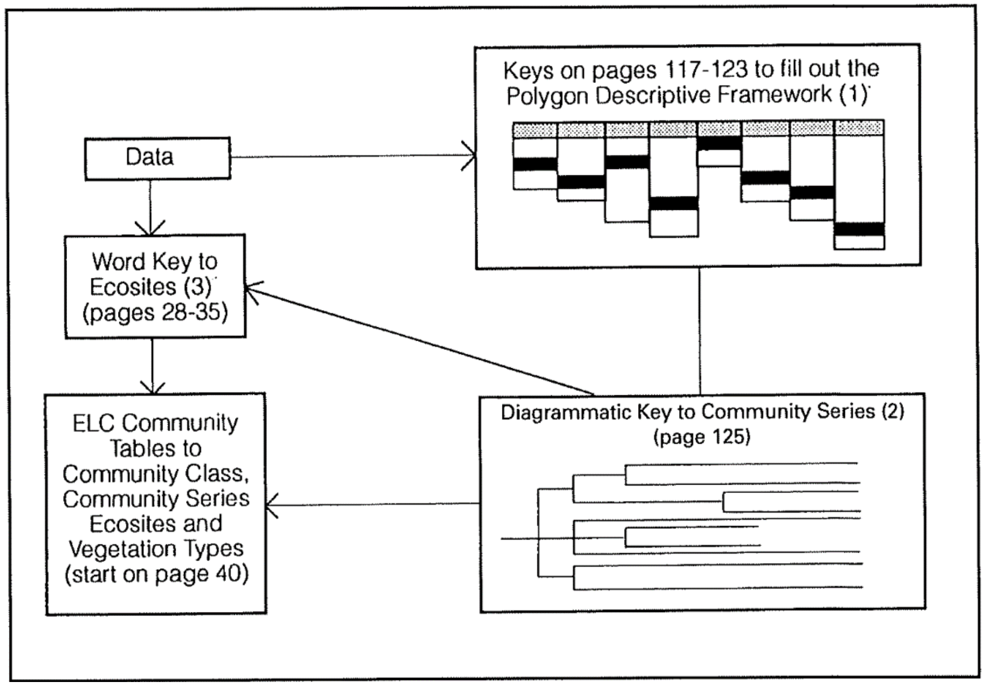
1. A community must be dominated by at least 10% ground cover, or 35% cover in at least one of the understorey, sub- canopy or canopy to be considered a vegetation community.
2. Note that under the OWES, percent cover of a submerged plant community may be as little as 10% in communities in water < 2 m deep.
3. Note that under the OWES, percent cover of a floating-leaved plant community must reach at least 25%
4. Canopy is defined as the highest vegetation layer in the community that intercepts incident light. In an open community, the canopy may be formed by asters or cattails; in a shrub community, the canopy may be formed by dogwood. The canopy does not have to be > 10 m as the "layers" codes may imply on the Plant Species List Data Card.

Table 21. Community: What is the Community?

Condition	Attributes of Each Condition (See Key on page 122 of the Field Guide)
Lake	• Aquatic community, standing water, usually > 2 ha, subject to wave action.
Pond	• Aquatic community, standing water, usually ≤ 2 ha, too small for wave action.
River	• Aquatic site in flowing watercourse; 4th order stream or greater.
Stream	• Aquatic site in flowing watercourse; 3rd order stream or less.
Marsh	• Wetland community with ≤ 25% tree or shrub cover; • Vegetation dominated by emergent herbaceous species (graminoid or forbs)[1]; • Includes Mineral Fen Ecosites [2] often with brown moss and/or marl substrate.
Swamp	• Wetland community with ≥ 25% tree or shrub cover; • Vegetation dominated by woody species (deciduous, coniferous, or mixed).
Fen	• Wetland community withs ≤ 25% tree cover; • Peat accumulating; • Vegetation dominated by shrubs and graminoids with characteristic indicator plant species; • Water source minerotrophic[3]; pH ranges between 5 and 7.6.
Bog	• Wetland community with ≤ 25% tree cover; • Peat accumulating, usually *Sphagnum;*> 40 cm deep; • Vegetation dominated by *Sphagnum* moss, shrubs, and graminoids with characteristic indicator plant species; • Water source ombrotrophic[4]; pH ranges between 3.2 to 5.
Barren	• Open sites on bedrock or unconsolidated material where the major limiting factor is drought; • Stunted trees and tall shrubs (1 to 6 min height) may be present but not tallgrass prairie species.
Meadow	• Open communities dominated by herbaceous graminoid or forb species; • Vegetation cover relatively continuous and closed; • Tallgrass prairie species absent.
Prairie	• Open communities dominated by herbaceous graminoid or forb species; • Vegetation cover relatively continuous and closed; • Tallgrass prairie species present (i.e., Indian Grass, Little Bluestem, Big Bluestem)
Thicket	• Shrub cover > 25 %; • Shrubs typically> 2 m high; • Vegetation cover (ground cover and shrub layer) relatively continuous and closed.
Savannah	• Community with > 25% but ≤ 35% tree cover.
Woodland	• Community with tree cover between 35% and ≤ 60%.
Forest	• Tree cover > 60%, trees originating from natural regeneration.
Plantation	• Woodland with a tree crop of one or a few species, usually planted and managed intensively for industrial wood production, whether timber or fibre, but also planted for shelter, landscape, or reclamation. May often include naturally regenerating trees. Includes former semi-natural woodlands restocked by planting.
Cultivated [5]	• Agricultural communities that are actively being harvested or used as pasture; • High proportion of biomass is non-native.
Constructed [5]	• Communities created by human industry, including recreational lands (golf courses, groomed parkland), residential development, industrial/commercial development, infrastructure, extraction operations, and landfills.

1. Note that OWES includes communities dominated by submergents and floating-leaved plants as within their definition of *marsh.*
2. OWES includes Mineral Fen Ecosites in their definition of *fen.* It is a broader definition based on indicator plant species, not substrates and physiognomy. Shrubby Cinquefoil Coastal Meadow Marsh Type is problematic in the ELC context as it can have >25% low shrub, and therefore should be a thicket swamp ecosite.
3. Minerotrophic refers to a water source that as passed through mineral soil (groundwater).
4. Ombrotrophic refers to a water source confined to precipitation with no connection to groundwater, and very low in nutrients.
5. Not yet on the Data Cards but provided in order to generate seamless mapping fabric.

Polygon Classification



With a completed Polygon Description, use the Diagramatic Key to Linking the Description and Classification Frameworks to classify a community to Community Series or Ecosite. This graphic key places the factors described for a specific polygon into a "tree", and by choosing the correct "branch" at each decision point, you will find the key leads to a specific ELC community unit. The Key refers to a specific line in the ELC Community Tables which, when consulted, provides additional information regarding vegetation and environmental characteristics of the community. Using the ELC Community Tables, a Vegetation Type and Ecosite can be assigned to a particular community.

Alternatively, the Word Key to Ecosites first provides a key to the correct System: terrestrial, wetland, or aquatic. This is a critical point in the classification, because failure to recognize a wetland system is the most common mistake made in land classification. This error is due in part to variable water level fluctuations which leave many swamps dry in summer and fall. Vegetation patterns and soil moisture regimes can resolve the confusion even without the presence of standing water. After the Key to Systems are three keys that provide more detailed data than in the other keys, including data on plant species, cover, vegetation characteristics, environmental characteristics, and indications of disturbance factors. They are:

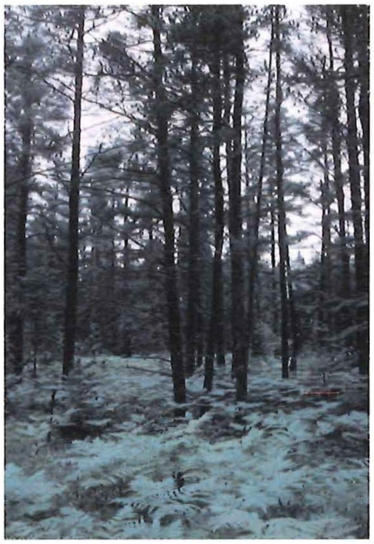
- Key to Terrestrial Ecosites (FG page 29)
- Key to Wetland Ecosites (FG page 32)
- Key to Aquatic Ecosites (FG page 35).

Similar to the Diagrammatic Key, the Word Keys lead to a specific location in the ELC Community Tables which should be consulted for further information.

There are still some anomalies within the ELC system. This is the First Approximation, and data collection is not complete for all communities. Some ecosites are problematic and, therefore, the classification may only go to Community Series. New ecosites and vegetation types have been described since the publication of the Field Guide and will be incorporated into the next edition. This research is ongoing. The section that deals with Cultural sites is being reorganized and expanded, and ultimately the ELC system will provide a mechanism for seamless landscape mapping.

Introduction to Community Keys

Two different community types are presented in the photographs below. In the table provided, use the Description Framework and other clues to vegetation and environmental factors that characterize these two communities.



Community 1

Community 2

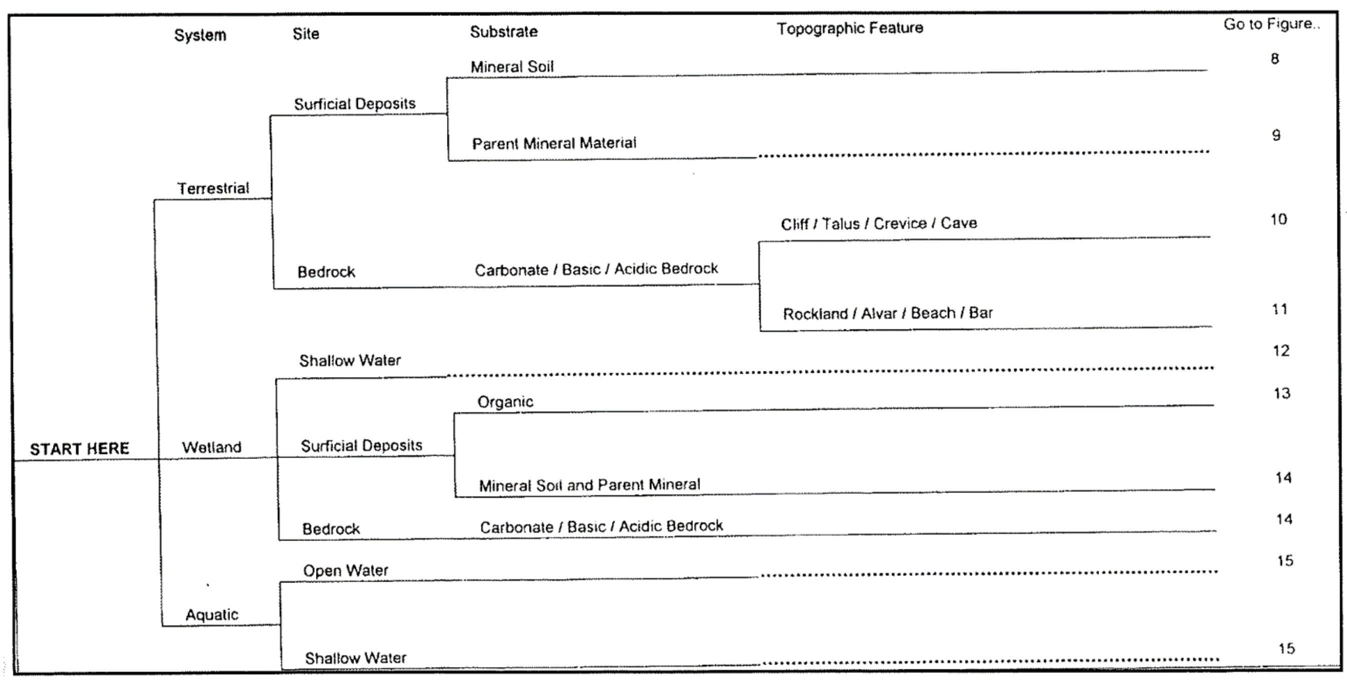
What characteristics are the same?
What makes these communities different?
What is the most important difference?
How can these communities be classified?

Fill in the Polygon Description below for Community 2.

1. System	2. Site	3. Substrate	4. Topographic Feature	5. History	6. Cover	7. Plant Form	8. Community
Terrestrial	Open Water	Organic	Lacustrine	Natural	Open	Plankton	Lake
Wetland	Shallow Water	Mineral Soil	Riverine	Cultural	Shrub	Submerged	Pond
Aquatic	Surficial Deposits	Parent Mineral Soil	Bottomland		Treed	Floating Leaved	River
	Bedrock	Carbonate Bedrock	Terrace			Graminoid	Stream
		Basic Bedrock	Valley Slope			Forb	Marsh
		Acidic Bedrock	Tableland			Lichen	Swamp
			Rolling Upland			Bryophyte	Fen
			Cliff			Deciduous	Bog
			Talus			Coniferous	Barren
			Crevice / Cave			Mixed	Meadow
			Alvar				Prairie
			Rockland				Thicket
			Beach / Bar				Savannah
			Sand Dune				Woodland
			Bluff				Forest
							Plantation

The eight fields that make up the ELC Polygon Description Framework, along with their associated defined range of conditions.

Refer to the Diagrammatic Keys below, and key out the ELC Community Unit into which Community 2 should be classified.



Diagrammatic Key, using the Description Framework fields and their attributes, leading to ELC Community Tables. Follow the Figure number to the next key.

Topographic Feature	History	Cover	Vegetation	Community	ELC Community Unit	Table #
Wetlands on Mineral Soil / Parent Mineral Material		Open		Marsh	Mineral Meadow Marsh	44, 46
		Shrub		Swamp	Mineral Thicket Swamp	40
		Treed	Deciduous	Swamp	Mineral Deciduous Swamp	37 - 38
			Coniferous	Swamp	Mineral Coniferous Swamp	31
			Mixed	Swamp	Mineral Mixed Swamp	34
Wetlands on Acidic / Basic / Carbonate Bedrock		Open		Marsh	Bedrock Meadow Marsh	44
		Shrub		Swamp	Bedrock Thicket Swamp	40
		Treed	Deciduous	Swamp	Mineral Deciduous Swamp	37 - 38
			Coniferous	Swamp	Mineral Coniferous Swamp	31
			Mixed	Swamp	Mineral Mixed Swamp	34

Diagrammatic Key for Wetland Communities on Mineral Soil, Parent Mineral Material, and Bedrock Substrates.

Refer to the ELC Community Tables below and read through the potential ecosites into which Community 2 may be classified. To what vegetation type does it belong?

38 Nested ELC Community Units	Code	6E	7E	Vegetation Characteristics	Environmental Characteristics
Swamp	SW			- tree or shrub cover > 25% - dominated by hydrophytic shrub and tree species	- variable flooding regimes - water depth < 2 m - standing water or vernal pooling > 20% of ground coverage
Deciduous Swamp	SWD			- tree cover > 25%; trees > 5 m in height - deciduous tree species > 75% of canopy cover - common species include Fowl Manna Grass, Spotted Touch-me-not, Bugleweed, Skunk Cabbage, Marsh Marigold, Bedstraws and Stinging Nettles - typically fern and sedge rich	
Maple Mineral Deciduous Swamp Ecosite	SWD3			- Red Maple, Silver Maple, Swamp Maple and Manitoba Maple	- mineral and peaty phase mineral (organic accumulations 20 to 40 cm) substrates - areas where flooding duration is short – substrate aerated by early to mid-summer
Red Maple Mineral Deciduous Swamp Type	SWD3-1	X	X		
Silver Maple Mineral Deciduous Swamp Type	SWD3-2	X	X		
Swamp Maple Mineral Deciduous Swamp Type	SWD3-3	X	X		
Manitoba Maple Mineral Deciduous Swamp Type	SWD3-4	X	X		
Mineral Deciduous Swamp Ecosite	SWD4			- less common associations of Willow, White Elm, White Birch, Aspen and Yellow Birch	- mineral and peaty phase mineral (organic accumulations 20 to 40 cm) substrates - areas where flooding duration is short – substrate aerated by early to mid-summer - common on floodplains
Willow Mineral Deciduous Swamp Type	SWD4-1	X	X		
White Elm Mineral Deciduous Swamp Type	SWD4-2	X	X		
White Birch – Poplar Mineral Deciduous Swamp Type	SWD4-3	X	X		
Yellow Birch Mineral Deciduous Swamp Type	SWD4-4	X	X		

Repeat the keying exercise with the Word Keys to the Ecosites starting on page 28 of the Field Guide. Does this pathway lead to the same ecosite?

Repeat the exercise for Community 1.

12.Polygon Sampling and Helpful Hints

The steps involved in polygon sampling are divided into preparation tasks and field data collection.

Preparation Tasks

- establish the sampling requirements based on the goals and objectives of the study
- plan the number of sample points, the location of the points, and the sequence of sampling
- prepare the equipment required to complete the sampling, which will include the data cards for each polygon that have site location, date, and surveyor information filled out
- have conducted a review of the area using secondary sources of information, such as bedrock and surficial geology, physiography, and soils maps
- review any biological or life science inventories of the area.

Sampling Protocols

Before going out in the field, the sampling protocol has to be decided. However, it is beyond the scope of this introductory course to discuss how to design a sampling protocol. Many textbooks have been written on the subject (see Bibliography). It is important to recognize that what is sampled, and the number and distribution of sampling points, will be determined by the goals and objectives of the study. A statistical study will require more data than a survey-level investigation, often requiring plots rather than a walk-about.

Furthermore, the scale of the project being undertaken will affect the sampling protocol. If the project is a landscape-level investigation (of a scale approximately 1:50,000 or more), the field investigation may only confirm polygons to the Community Class or Community Series level. This is an appropriate scale for large watershed studies. More detailed investigations at finer scales will require more sampling points and more detailed data collection. At all scales, ELC methods can be applied.

For a survey level of investigation, a walk about with sampling points (prism sweeps and soil samples) placed subjectively in representative portions of the polygons can provide a characterization of the site. Data that are to be used in a statistical analysis should sample at least 1%, or up to 10%, of the vegetation community. The ELC system recommends using multiple sample points within each polygon to record community variation. The Stand and Soil Characteristics data card is designed to accommodate multiple sampling points.

IN THE FIELD

Field Data Collection

- conduct a reconnaissance of the polygon, paying attention to trends, patterns, and anomalies in site, soils, and vegetation
- use this information to verify and adjust sample points
- verify the interpreted polygon boundaries and make changes on the air photo as necessary
- at each sample point, collect tree tally data (with prism sweeps), soils data (describe soil sample and sketch profile)
- record plant species at sample points and as new species are encountered
- when all points have been sampled, complete the Plant Species List and summarize this into the Stand Description
- optional data cards are provided to record evidence of wildlife and disturbance or management regimes.

Orientation (...Location, Location, Location)

Using air photos, identify landmarks to locate yourself on the map. Once in the study area, you may have difficulty locating yourself on the map in relation to the delineated polygons. New advances have made Geographical Positioning Systems (GPS) an inexpensive and reliable tool for establishing coordinates.

To maintain bearings in the field:

- refer to air photos frequently
- carry the topographic map for the site at the finest scale available
- look for drainage patterns and landmarks (such as topographic breaks, large trees, conifers, canopy openings, boulders, trails, or fallen trees)
- carry and use a compass and tape measure, or a GPS unit.

Recognizing Polygon Boundaries in the Field

You can expect to encounter some degree of variation in vegetation and soils within individual polygon units (e.g., species patchiness, depth to mottles). Identifying polygon boundaries can represent a significant challenge, particularly in large polygons.

The following guidelines can help to recognize polygon boundaries on the ground:

- often in polygons, there are reasonably clear demarcations that can be used to find the polygon boundary:
    - first, use site and soil features such as creeks, drainage patterns, and slopes

  - second, use obvious vegetation patterns such as the contrast between treed and shrub and open communities
- less obvious than these features are the more subtle changes in the vegetation canopy (species, cover, and age)
- finally, use understorey and ground cover as indicators
- be sensitive to changes in Systems even when the canopy cover does not significantly change (e.g., Eastern White Cedar may be dominant in a valley swamp and continue up the slopes of the valley onto the tableland forming a coniferous forest).

Only the core of the polygon should be sampled. Therefore, the outer 10 m should be considered a transitional buffer strip. When compiling the Plant Species List, stay within the core area. Due to the radius of the prism sweeps, sampling points should be located at least 50 m inside the polygon, and at least 100 m from each other to avoid sampling the same trees twice. At each sampling point, record the coordinates from the GPS unit, or pierce the reference map and label the back with the polygon number and sampling point number.

The following details should be confirmed before leaving the polygon:

- make sure all data cards are filled out; especially ensure that all polygons are numbered on the data cards
- double check the System attribute in the Description Framework because this is the most problematic attribute: review the criteria used in the Key while on site to verify this determination
- sketch the Community Profile
- summarize the data:
  - characterize the stand, slope, and soil conditions for the entire polygon, even if there is some variation
  - average the tree tallies and create the Stand Composition
  - average the "Depth to" data of the Soil Assessment
  - determine the prevailing soil texture for the polygon by synthesizing soil samples; typically, this is the most commonly occurring texture; if soil samples vary widely, reconsider sampling points and polygon boundaries
  - average the slope data across the polygon.

Vegetation Sampling Exercise

Purpose:

To verify the polygon boundaries and descriptions interpreted from air photography on the site, and to collect additional data required to classify the community to levels of Ecosite or Vegetation Type.

Assume:

Vegetation distinctions will be visible to the unaided eye.

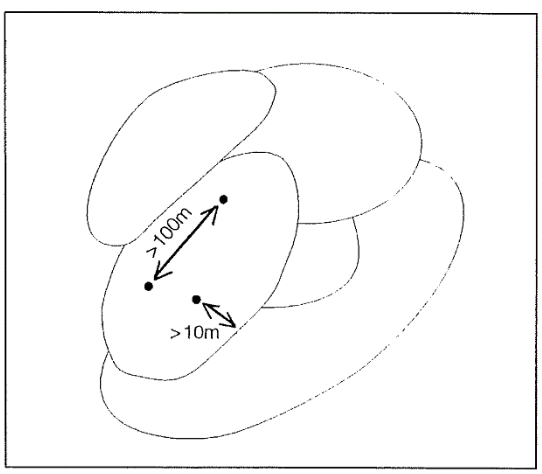
Method:

1. Walk polygon boundaries to confirm the air photo interpretation and adjust any that do not reflect real distinctions between ecosite units. Add in any additional boundaries that you detect.

2. Sample (prism sweep, soil types) at least three representative points. Points must be at least 10 m from the boundary and prism sweeps should not overlap. Keep them at least 50 m apart to avoid sampling the same tree in two successive sweeps.

3 Complete data records. Community Description and Classification, Stand and Soil Characteristic, And Plant Species List are mandatory for this exercise. Complete the management or disturbance and wildlife records if time permits.

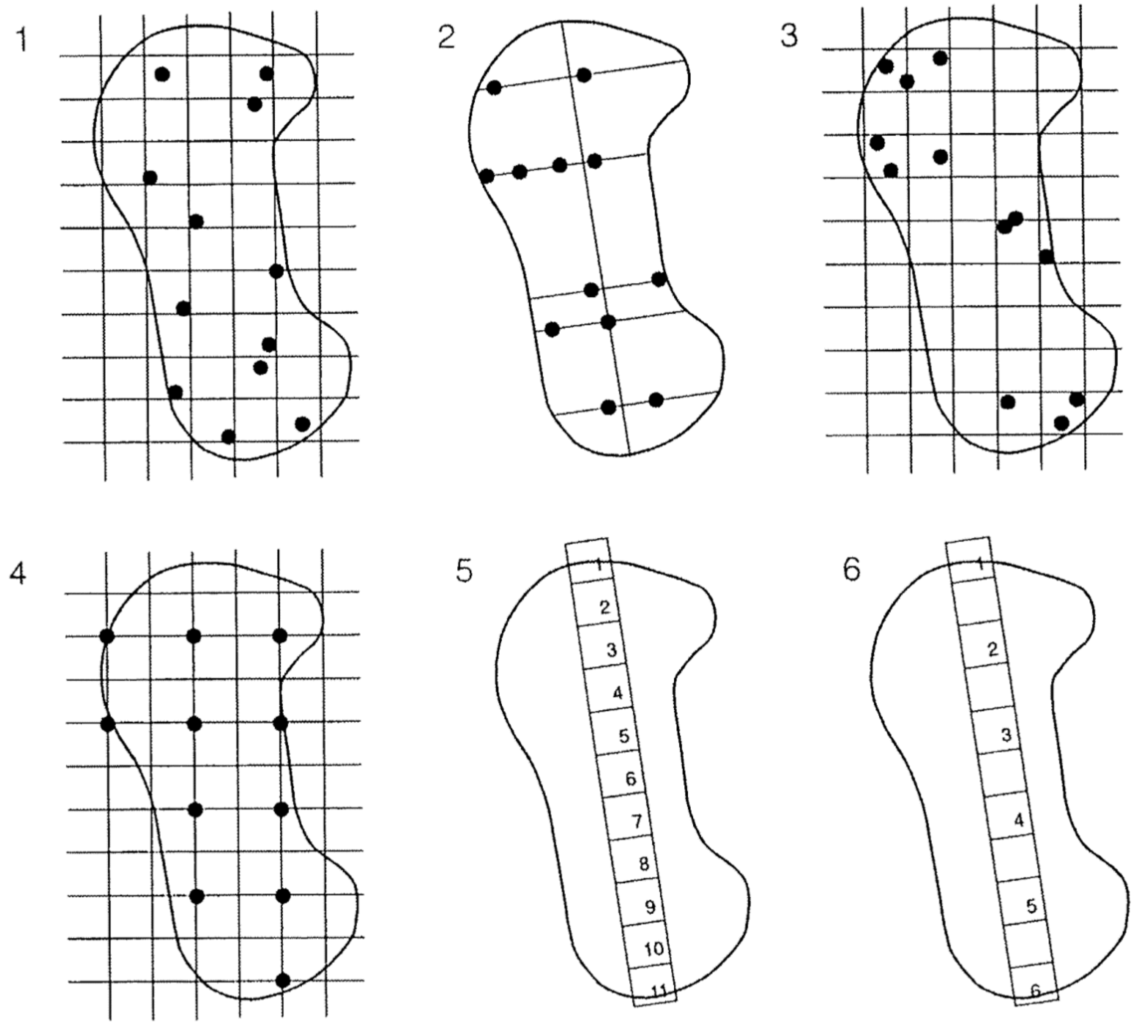
4. Check results of tallies. If they are somewhat similar, proceed with sampling the next polygon. If they are very different (different species or extremely different ratios), sample additional points until:
   (a) 1% of the polygon has been sampled, or;
   (b) the ratios and species composition stabilize.



Note: This method is designed to demonstrate ELC methods and provide the minimum information to qualitatively characterize a polygon. The sampling protocol should be designed to answer the question that has triggered the investigation. See additional notes on sampling protocol.

Figure 63

• = sampling points for sweeps and soil samples.



Different methods for placement of sample plots applied to a hypothetic investigation area.

Fig. 1 Random sampling (12 sample plots); random numbers are taken as coordinates for points relative to a grid.

Fig. 2 Stratified random sampling (12 sample plots); a baseline is placed along the long axis of the investigation area, transverse lines are randomly placed along the baseline, and sample plots are located on the transverse lines by random numbers, the number of sample plots along each transverse line proportional to the length of the line.

Fig. 3 Stratified random sampling (12 sample plots); four blocks of fixed size are randomly placed within the investiation area, within each block three sample plots are randomly distributed.

Fig. 4 Systematic sampling (11 sample plots) in a two-dimensional grid.

Fig. 5 Systematic sampling (11 sample plots) in a closed transect (one-dimensional grid).

Fig. 6 Systematic sampling (6 sample plots) in an open transect (one-dimensional grid).

Adapted from: Okland, R.H. 1990. Sommerfeltia Supplement 1. Vegetation Ecology; Theory, Methods and Applications with Reference to Fennoscandia. 233 pgs.

Figure 64

Examples of sample plot distribution.

Field Equipment Checklist

Personal Items:

- Sunscreen
- Bug repellant
- Hat
- Boots
- Water or juice
- Lunch (if necessary)
- Tissue paper
- Umbrella

Recording supplies:

- Clipboard
- Pencils and eraser
- Notebook

Soil Investigation Equipment:

- Augers and graduated sample box
- Suunto clinometer
- Soil sieves
- Spatula
- Soils manual
- Groundsheet for soil digging
- Munsell Soils Chart (optional)
- Soil Classification Manual
- Tape measure (3 metres)
- 10% hydrochloric acid or muriatic acid (dilute 1:3) in a squeeze bottle (Caution: acid will eat into your skin!)
- Shovels
- Knife
- ELC data sheets

Vegetation mapping and inventory:

- Air photo with mylar or acetate
- Wax pencil
- Prism
- Compass
- Hand lens
- ELC Field Guide
- Ziplock bags
- Binoculars
- Cheat sheet
- Plant code list

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