# LAND CLASSIFICATIONS, SUSTAINABLE LAND MANAGEMENT, AND ECOSYSTEM HEALTH

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**Contents**



*"Environmental problems resulting from human activities have begun to threaten the sustainability of earth's life support system. Among the most critical challenges facing humanity are the conservation, restoration, and wise management of the earth's resources"*

*(Ecological Society of America (cited in Lubchenco, 1998)).*

Land classifications and land evaluation assist us to interpret whether we are degrading or enhancing land quality, and to develop better land use plans. Without good land quality, all forms of terrestrial life on this planet will cease. Land classifications range from simple, subjective evaluations based on field observations, to complex, computer generated evaluations using mathematical models and integrated data bases. This article describes different approaches to land classifications, starting with simple procedures of soil interpretations and progressing to the more complex applications. A few examples of the different approaches have been selected to illustrate the principles involved. Although land classifications originated as procedures for agricultural development, these procedures are increasingly being used to resolve issues of sustainable land management and ecosystem health.

## 1. Land Evaluation

### 1.1. Soil Interpretations

In the late nineteenth century and the early part of the twentieth Century, soil interpretations were simple, subjective assessments, such as “Good, Fair or Poor” for specific applications. Mostly, they were based on anecdotal experience and observations gained by land surveyors and development companies. The first “formal”, comprehensive soil interpretations, based on observable soil characteristics such as texture, stoniness, color (organic matter content), and soil depth, were conducted in Germany and in Russia in the late 1800s for purposes of land assessment and taxation.

Soil interpretations are extensions of soil classification systems and soil inventories. They are applied for a wide range of uses, primarily relating to plant growth and productivity. Agricultural, rangeland, and forestry interpretations have been the main focus, but interpretative schemes also have been developed for irrigation and drainage interpretations, engineering interpretations, and interpretations for wildlife habitat and outdoor recreation.

The principal uses for soil interpretations are for crop suitability, local land use zoning, agricultural policy assessment and agricultural land use planning, and municipal land assessment. More recently, soil interpretations are being developed for water quality issues and other environmental concerns such as surface water pollution (run-off), groundwater contamination (seepage), and land reclamation. Also, issues of soil quality for sustainable production are receiving attention, and new ratings are being developed that integrate soil and landscape components into predictive models for better environmental management.

Soil interpretations also include “indigenous soil classifications”, i.e. the accumulated knowledge, skill, understanding, and technology of local people derived from their direct interaction with the environment and passed on through generations. These classifications are often based on observable soil properties such as color, texture, and taste, but may also include refinements to evaluate properties such as soil nutrient status, soil moisture, and suitability classifications for important food crops. Indigenous soil classifications are found throughout the world. The study of these systems is called “ethnopedology”.

**The Storie Index.** By the late 1930s, soil interpretations became more structured with the introduction of the Storie Index. In this approach, the observational and anecdotal approaches used previously were replaced by measurable soil parameters which were assessed according to defined protocols, and mathematically combined to give a single number. The soils were then indexed and ranked. Because these procedures were more scientifically based and less biased by individual experience, the indexing approach was quickly adopted by other jurisdictions, although it was often modified for local applications with introduction of other, landscape related factors such as climate, slope, stoniness, soil moisture limitations, heat units for maturing corn and tender fruits, and so forth. With the addition of socioeconomic factors such as distance to markets, these modified Storie systems became the basis for many rural land assessments. The Storie system is highly structured but easy to understand by non-specialists, and it continues to be used, particularly for irrigation and specialty crop interpretations.

### 1.2. Land Capability and Land Suitability

The term "Land Capability" is used in many land classifications, but mostly in North America and Europe. Land capability is the "quality" of land to produce common cultivated crops and pasture plants without deterioration over a long period of time. Land suitability is the fitness of a given type of land for a specified kind of land use (FAO, 1983). In both classifications, land is considered in its present condition or after improvements. In some cases, the terms "capability" and "suitability" are used interchangeably.

#### 1.2.1. Development of the Land Capability Classification in USA

The first Land Capability Classification (LCC) was developed by the Soil Conservation Service (now called the Natural Resource Conservation Service) in the late 1930s and early 1940s. In time, it became the agency's main tool for evaluating appropriate uses of farmland and making recommendations on soil conservation practices, although it is only one of many possible interpretations that are made from a soil survey.

The LCC was a three level classification consisting of Capability Class, Capability Subclass, and Capability Unit. The system classified land into eight classes, designated by Roman numerals I through VIII, with increasing limitations on land use and the need for conservation measures and careful management. Land was placed in a Class based on landscape, slope of the field, and soil depth, texture and acidity. Only the first four classes of the LCC are considered as suitable for cropland, the remaining four classes, V through VIII, were suitable for pasture, range, woodland, wildlife, recreation, and esthetic purposes. Subclasses were identified for special limitations such as (e) erosion, (w) excess wetness, (s) problems in the rooting zone, and (c) climatic limitations. At the lowest level, Land Capability Units were identified as groupings of soils with similar levels of yield and common requirements for land management.

Procedures to classify soils according to the LCC first involved making a detailed soil survey, with additional information on slope, erosion, and land use. This information was then translated into the Land Capability Classes, with Subclasses to show particular limitations and problems, and Units to provide interpretive information for the farmer. These interpretations were often done by multidisciplinary teams consisting of agronomists, biologists, economists, engineers, foresters, range experts, soil scientists, and soil conservationists. Recommendations for farmers were often taken from standardized Capability tables and guides which were made available to all field offices.

The LCC has been eclipsed by other methods of interpreting soil surveys for planning conservation practices, although these systems are still used. The system was found lacking for forestry and rangeland management, and experts in these areas developed woodland site classifications and range land management plans.

### 1.2.2. The Canada Land Inventory (CLI) - A Modified Land Capability Classification

The CLI was one of the most successful adaptations of the land capability classification system. It was a major program to provide a comprehensive, standardized assessment of land capability to support defined land-based activities in the country (Canada Land Inventory, 1964). It was implemented to resolve emerging resource and land use conflicts, and to support regional land use planning, as the country was rapidly changing from a rural-agrarian society to an urban-industrial society. The program provided land capability assessments for agriculture, forestry, wildlife (waterfowl, ungulates) and outdoor recreation, for the 2.5 million $km^2$ which are the "settled" portion of Canada. In addition, there was a classification of present land use. The CLI approach differed from that of the USDA in that it was a seven rather than eight class system, it used only Class and Subclass, and the scale of presentation was selected as 1:250,000. It is noteworthy that the CLI gave rise to the Canada Geographic Information System (CGIS), which was the program of origin for computerized mapping and the foundation for geographic information systems (GIS) in the world.

*Soil Capability Classification for Agriculture*: Mineral soils were grouped into seven classes based on their capability for common field crops of the region. The Class reflected inferred productivity potentials based on soil, landform and climate. Three categories of Subclasses recognized the kinds and degrees of limitations, e.g. moisture (A), heat (H), topography (t), stoniness (p), inundation (i), soil moisture holding capacity (m), structure (d), salinity (n), low fertility (f), visible erosion (e), excess wetness (w) and shallowness to rock (r). Example of a rating symbol could be 3md, meaning Class 3, a moderately high capability, with moderate limitations of low moisture holding capacity and poor structure.

*Land Capability Classification for Forestry*: All mineral and organic soils were classified in one of seven classes based on an inherent productivity for commercial timber (mean annual increment, merchantable timber). Three categories were used, Class, Subclass and Indicator Species. An example of a rating symbol could be 2m wS, meaning Class 2 with a slight moisture holding capacity limitation; white spruce expected to yield from 91-110 cubic feet per acre per annum.

*Land Capability Classification for Wildlife (waterfowl; ungulates):* Wildlife capability was based on environmental factors that affected the quality and quantity of habitat that provide food, cover and space important to the wildlife species in question. Separate assessments were made for ungulates and waterfowl. Indicator species were used for ungulates (antelope, caribou, deer, elk, goat, moose, mountain sheep) to designate the major species in an area.

*Land Capability Classification for Outdoor Recreation*: Land areas were classified on the basis of the intensity of outdoor recreational use, or the quantity of outdoor recreation which could be generated and sustained per unit area of land. Quantity was measured by "visitor days" and both intensive and dispersed activities were recognized. Uses included activities such as beaches, ski slopes, and dispersed activities such as viewing or boating. Water bodies were not directly classified, their values accruing to the adjoining shoreline. Subclasses, in contrast to the previous systems, were used to indicate opportunities for recreation.

### 1.2.3. Land Capability Systems in Europe

Procedures of land classification and land capability in Europe developed according to defined needs. The earliest formal systems, based on scores for soil and land properties, were developed in Germany in the 1930s. In the 1950s, the Agricultural Land Classification was developed in the United Kingdom with the objective to protect the best agricultural land from non-agricultural development, and to ensure food security after the upheavals created by WW2. This was based on the USDA system, but consisted only of five classes. Only lands with agricultural potential were classified. This system was modified in the 1970s with procedures to assess land suitability for the main field crops. More quantitative approaches were developed later in the Netherlands, following the concept of “land qualities”, as used in the FAO Framework for Land Evaluation.

The latest developments encompass environmental protection as well as agricultural productivity. Vulnerability to a variety of “risks”, including contamination from agrichemicals, waste disposal, and land degradation, are assuming increasing importance. Also, computer models (pedo-transfer functions) and integrated land information systems are used more regularly to achieve better and more quantitative evaluations.



## 1.3. Physical and Integral Land Evaluation

Land evaluation includes all methods to explain or predict the use potential of land. It involves the study and interpretation of landforms, soils, vegetation, climate and other aspects of land, in order to identify and make a comparison of promising kinds of land use. The concept of land evaluation is similar to that of terrain analysis as used by engineers, and it has been used interchangeably with land classification and soil survey interpretations in the past. The purpose of land evaluation is to facilitate decision making in the optimal use of land resources. Land evaluation is not an end in itself, but rather, it is a means towards an end.

Procedures of land evaluation involve integrating physical characteristics of the soil, landscape, vegetation and climate in an area, with the economic and social management limitations of the region, to identify the potential and most beneficial uses of the land. Land evaluation provides input into the land use planning process by rationalising the nature and properties of the land being considered with the requirements of alternative land uses. In most cases, land evaluation is concerned with change in the use of land, and increasingly with changes in the land itself.

"Land evaluation" was introduced into the literature by W.C. Visser in 1950. It was adopted by Stewart (1968) in Australia and in a casual way by other authors, but it was not commonly accepted until 1976 when FAO published "A Framework for Land Evaluation". This publication, developed jointly with a Dutch working group, was profoundly influential in reshaping how information on land is organised and presented, and how alternate use possibilities are evaluated (see van Diepen et al., 1991).

Land evaluation originated through studies on land suitability, land capability, soil ratings and soil survey interpretations. These classifications (in various ways) contribute to what has commonly been called land classifications, which Vinck defined in 1960 as those groupings of soils that are made from the point of view of people that are using the soils in a practical way. Land evaluation includes parts of these procedures, but extends beyond all of them.

Land evaluation encompasses two basic concepts. The first is physical land evaluation, which provides assessments of the performance of specific land uses in terms of constraints imposed by the land, using indices such as capability, suitability, vulnerability and productivity. Physical land evaluations provide comparisons of potential land use alternatives for regional and local land use planning, such as in the LESA program in the USA, which integrates principles of land evaluation with site assessment for urban land use planning. However, the studies normally do not include assessments of risk, vulnerability, resilience, and sustainability, and by themselves they do not provide sufficient information for establishing land use policies and guidelines.

The second is integral land evaluation which assesses the nature and productivity of the land resource compared to goals and expectations of society, as expressed by economically acceptable production levels and requirements for goods, services and amenities.

Integral land evaluation is an extension of physical land evaluation, but it identifies land use options in economic terms and it indicates the feasibility and degree of flexibility of meeting specified socio-economic objectives (targets) given the availability and quality of the land resource base. Integral land evaluation is more dynamic than physical land evaluation, and the studies are normally achieved using various types of programming models or other computer models.

### 1.4. The International Framework for Land Evaluation

The FAO Framework for Land Evaluation, through widespread adoption and adaptation, has emerged as an international standard for land evaluation. The approach is rooted in the principles of earlier land classification systems, notably the work of Stewart in Australia and the United States Bureau of Reclamation, but modified considerably by experience gained from integrated resource surveys and the requirements of land use planning.

The FAO Framework is not a formal classification system, but rather a collection of concepts, principles and procedures on the basis of which local, regional and national evaluation systems can be developed. The concepts and principles are universal and scale neutral, and they can be used to construct systems at all levels of intensity and for all kinds of rural land uses. Recommended procedures for a suitability classification are provided, but these are optional. The value of the FAO Framework is not in the classifications that evolved from it, but in the evolution of a new paradigm for rationalising the wise use of land resources.

The basic concepts in the Framework include land (as defined by FAO in 1976), land mapping units, major kinds of land use and land utilization types, land characteristics and land qualities, diagnostic criteria, land use requirements and land improvement. These are employed within a framework bounded by six principles, namely:

- Land suitability is assessed and classified with respect to specified kinds of land use;
- The suitability classes are defined by economic criteria;
- A multidisciplinary approach is required;
- Evaluation should take into account the physical, economic, social and political context of the area considered;
- Suitability refers to land use on a sustained basis;
- Evaluation involves comparison of two or more alternative kinds of use.

The recommended procedures of conducting a land evaluation according to the FAO Framework are as follows:

- Development of the objective(s) of the evaluation;
- Selection of relevant kinds of land uses, and identification of their requirements and limitations for land;
- Description of land (mapping) units, and assessment of land qualities;
- Comparison of land use requirements for each land use with the adequacy of land qualities identified in each land (mapping) unit;
- Assessment of economic and social performance of each land use relative to the objective(s) of the evaluation;
- Final (suitability) classification and presentation of results.

The procedure of comparing (matching) land use requirements with the nature of the land resource is central to the application of the Framework (Figure 1). This is normally accomplished using subjective judgement and experience. It is an iterative process, with refinements developed through re-examination with economic and social objectives.

The FAO Framework for Land Evaluation has been applied in most countries of the world, but rarely in its complete form. This is entirely proper, since frameworks by their nature are rarely used in their entirety.

In using the Framework, it is important that the concepts and principles be applied systematically, but procedures and output should be moulded to meet the specific objectives of each evaluation study. McCormack, in 1987, proposed soil potential ratings as an alternative approach to ranking the performance of soils.

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