INTERNATIONAL STANDARD

ISO 19144-1

First edition
2009-08-15

Geographic information — Classification systems —

Part 1: Classification system structure

Information géographique — Systèmes de classification —

Partie 1: Structure de système de classification

Reference number
ISO 19144-1:2009(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19144-1 was prepared jointly by the Food and Agriculture Organization (FAO) of the United Nations and Technical Committee ISO/TC 211, *Geographic information/Geomatics* under a cooperative agreement between the two organizations.

ISO 19144 consists of the following parts, under the general title *Geographic information — Classification systems*:

— *Part 1: Classification system structure*

The following part is under preparation:

— *Part 2: Land cover classification system (LCCS)*

Introduction

This part of ISO 19144 is based on publications of the Food and Agriculture Organization (FAO) of the United Nations [1][2]. The first in a series of International Standards related to geographic classification systems, it defines the structure of such systems, together with the mechanism for defining and registering classifiers.

Since there are many different possible application areas, there is no single classification system that will serve all needs. The method by which classifiers are defined depends upon the application area. In addition, the classifiers used within a particular application area might not be adequate for all situations encountered within that application area and could need to be augmented over time. To facilitate extension of the set of classifiers in a particular application area, classifiers are registered in a register structure compliant with ISO 19135. This allows the set of classifiers to be maintained. The use of the ISO 19135 registration mechanism allows for separate registers to be defined for different sets of classifiers within multiple information communities, thereby satisfying application needs. This approach allows for independence between information communities, but also allows relationships to be developed between different classification systems that potentially allow the conversion, or partial conversion, of data from one classification system to another, or the fusion of data from two separate sources.

The concept of classification systems is well known in the geographic information community. A classification system can be used to subdivide any geographic area into small units, each of which carries an identifier that describes its type. The results can then be represented as a discrete coverage as described in ISO 19123. Many such classification systems can be defined to address any geographic area. Different application areas and different information communities can define their own classification systems. However, if the classification system is defined in a compatible way, interaction between different information communities becomes possible. In addition, in a particular application area, it is desirable that there be a few well-established classification systems, and that these themselves be standardized within information communities.

This part of ISO 19144 describes the common structure, while subsequent parts will allow for the standardization of specific classification systems.

A *coverage* is a function that returns values from its range for any direct position within its spatial, temporal or spatiotemporal domain. A *discrete coverage* is a function that returns the same feature attribute values for every direct position within any single spatial object, temporal object or spatiotemporal object in its domain. The domain is an area covered by the coverage function, and the discrete coverage breaks that area down into a set of spatial, temporal or spatiotemporal objects. The geometry of the discrete coverage used to represent the results of applying a classification system can be any type of discrete coverage — for example, a set of polygons fitted together like a jig-saw puzzle, a set of grid cells, or a set of points or curves.

A classification system consists of a set of classifiers. These classifiers may be algorithmically defined, or established according to a set of classification system definitions. The classifiers are application-area-dependent and are or will be defined in the other parts of ISO 19144 or other standards or publications. A register allows for the maintenance of a set of classifiers for a particular application area. A spatial, temporal or spatiotemporal object defined in terms of a set of classifiers is a *classified* object.

There is a commonality between conventional geographic features and classified objects. A *feature* is defined in ISO 19101 as an abstraction of real world phenomena. An example of a class of feature is a *building*, and a particular building, e.g. the UN building in New York, is an instance of a *feature class*. Conventional geographic features are *atomic units* that are assembled to build one type of geographic information data set.

A classification system works in the opposite manner, from the top down, by successively decomposing the whole within a coverage area. Classified objects are features, in that they are an abstraction of a real world phenomena, but classified objects are *not* atomic, because they are necessarily related to each other by the classifiers that decompose the whole. In a simple example of a classification system, the earth as a whole can be covered by either “land” or “water”, and two classifiers can be defined partitioning the attribute range into two, identifying objects as being either land or water. Any particular area on the earth, corresponding to a classified object, would be of type “land” or “water”.

ISO 19135 specifies that a *technical standard* be required to define the item classes in any conformant register. This part of ISO 19144 defines schemas for registers conformant to ISO 19135 and serves as the technical standard that defines the item classes required for the registration of classifiers. It establishes a set of rules for specifying definitions that can be used in a particular context to establish classified objects.

Registers of classifiers can serve as sources of reference for similar registers established by other geographic information communities as part of a system of cross-referencing. Cross-referencing between respective items in registers of classifiers might be difficult in cases where the structure of registers differs between information communities. This part of ISO 19144 can serve as a guide for different information communities for the development of compatible registers that can support a system of classifier cross-referencing.

The structure of a classification system together with the mechanism of defining and registering classifiers defined in this part of ISO 19144 is general and can be applied to many different information-community-defined classification systems, including soil, landform, vegetation, urbanization and systems for understanding biodiversity and climate change. The use of this document will allow the relationship between different classification systems to be described.

Geographic information — Classification systems —

Part 1:
Classification system structure

1 Scope

This part of ISO 19144 establishes the structure of a geographic information classification system, together with the mechanism for defining and registering the classifiers for such a system. It specifies the use of discrete coverages to represent the result of applying the classification system to a particular area and defines the technical structure of a register of classifiers in accordance with ISO 19135.

The structure can be used to develop specific classification systems that address particular application areas, specified in other parts of ISO 19144.

2 Conformance

2.1 Classes

Three conformance classes are identified in this part of ISO 19144.

2.2 Conformance of a classification system

Any classification system for which conformance to this part of ISO 19144 is claimed shall be in accordance with Annex A (see A.2).

2.3 Conformance of a register of classifiers

Any register of classifiers for which conformance to this part of ISO 19144 is claimed shall be in accordance with Annex A (see A.3) and ISO 19135:2005, A.1.

2.4 Representation of classification results

Any legend of classifiers for which conformance to this part of ISO 19144 is claimed shall be in accordance with Annex A (see A.4).

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 19103:2005, *Geographic information — Conceptual schema language*

ISO 19110:2005, *Geographic information — Methodology for feature cataloguing*

ISO 19115, *Geographic information — Metadata*

ISO 19123, *Geographic information — Schema for coverage geometry and functions*

ISO 19135:2005, *Geographic information — Procedures for item registration*

4 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

4.1 Terms and definitions

4.1.1
***a posteriori* classification**
classification (4.1.4) scheme based upon definition of classes after clustering the field samples collected

NOTE 1 Taken from FAO LCCS version 2 (see Reference [2]).

NOTE 2 See Annex B for an examination of this and ***a priori* classification** (4.1.2).

4.1.2
***a priori* classification**
classification (4.1.4) scheme structured so that the classes are abstract conceptualizations of the types actually occurring

NOTE 1 Taken from FAO LCCS version 2 (see Reference [2]).

NOTE 2 The approach is based upon the definition of classes before any data collection actually takes place.

NOTE 3 See Annex B for an examination of this and ***a posteriori* classification** (4.1.1).

4.1.3
classified object
spatial object, temporal object or spatiotemporal object assigned to a specific **legend class** (4.1.16)

4.1.4
classification
abstract representation of real world phenomena using **classifiers** (4.1.6)

4.1.5
classification system
system for assigning objects to classes

4.1.6
classifier
definition used to assign objects to **legend classes** (4.1.16)

NOTE Classifiers can be defined algorithmically or according to a set of **classification system** (4.1.5) specific rules.

4.1.7
coverage
feature (4.1.10) that acts as a function to return values from its **range** (4.1.17) for any direct position within its spatial, temporal or spatiotemporal **domain** (4.1.9)

[ISO 19123:2005]

EXAMPLE Raster image, polygon overlay, digital elevation matrix.

NOTE A coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.

4.1.8
discrete coverage
coverage (4.1.7) that returns the same **feature attribute** (4.1.11) values for every direct position within any single spatial object, temporal object, or spatiotemporal object in its **domain** (4.1.9)

[ISO 19123:2005]

NOTE The domain of a discrete coverage consists of a finite set of spatial, temporal, or spatiotemporal objects.

4.1.9
domain
well-defined set

[ISO/TS 19103:2005]

NOTE Domains are used to define the domain and **range** (4.1.17) of operators and functions.

4.1.10
feature
abstraction of real world phenomena

[ISO 19101:2002]

EXAMPLE The phenomenon "Eiffel Tower" can be classified with other similar phenomena into a feature type "tower".

NOTE A feature can occur as a type or an instance. In this part of ISO 19144, *type* is meant unless otherwise specified.

4.1.11
feature attribute
characteristic of a **feature** (4.1.10)

[ISO 19101:2002]

4.1.12
feature concept dictionary
dictionary that contains definitions of, and related descriptive information about concepts that may be specified in detail in a **feature** (4.1.10) catalogue

[ISO 19126:—[1)]]

4.1.13
identifier
linguistically independent sequence of characters capable of uniquely and permanently identifying that with which it is associated

[ISO 19135:2005]

4.1.14
item class
set of items with common properties

[ISO 19135:2005]

NOTE "Class" is used in this context to refer to a set of instances, not the concept abstracted from that set of instances.

---

1) To be published.

4.1.15
legend
application of a **classification** (4.1.4) in a specific area using a defined mapping scale and specific data set

NOTE Taken from FAO LCCS version 2 (see Reference [2]).

4.1.16
legend class
class resultant from the application of a **classification** (4.1.4) process

NOTE The result of a classification process is termed *legend class* in this part of ISO 19144 in order to avoid confusion with the term "class" as used in UML modelling.

4.1.17
range
⟨coverage⟩ set of **feature attribute** (4.1.11) values associated by a function with the elements of the **domain** (4.1.9) of a **coverage** (4.1.7)

[ISO 19123:2005]

4.1.18
register
set of files containing **identifiers** (4.1.13) assigned to items with descriptions of the associated items

[ISO 19135:2005]

4.1.19
registry
information system on which a **register** (4.1.18) is maintained

[ISO 19135:2005]

4.1.20
technical standard
standard containing the definitions of **item classes** (4.1.14) requiring registration

[ISO 19135:2005]

4.1.21
vector geometry
representation of geometry through the use of constructive geometric primitives

[ISO 19107:2003]

4.2 Abbreviated terms

4.2.1 General

CRS Coordinate Reference System

LCCS Land Cover Classification System

UML Unified Modelling Language

4.2.2 Notation

The conceptual schema specified in this part of ISO 19144 is described using the Unified Modelling Language (UML), following the guidance of ISO/TS 19103.

Several model elements used in this schema are defined in other standards in the ISO 19100 series. By convention within this suite of International Standards, names of UML classes[2], with the exception of basic data type classes, include a two-letter prefix that identifies the International Standard and the UML package in which the class is defined.

UML classes defined in this part of ISO 19144 have the two-letter prefix “CL”.

Table 1 lists the other International Standards and the packages in which UML classes used in this part of ISO 19144 have been defined.

Table 1 — Sources of externally defined UML classes

Prefix	International Standard	Package
CV	ISO 19123	Coverage core and discrete coverages
DS	ISO 19115	Metadata application information
GF	ISO 19109	General feature model
GM	ISO 19107	Geometry root
MD	ISO 19115	Metadata entity set information
MI	ISO 19115-2	Metadata entity set imagery
RE	ISO 19135	Procedures for registration
SC	ISO 19111	Spatial referencing by coordinates
TM	ISO 19108	Temporal objects

5 Classification systems

5.1 Concept

A discrete coverage returns the same feature attribute for every direct position within any single geometric object in its spatiotemporal domain. The spatiotemporal domain consists of a set of geometric objects that together form the coverage.

EXAMPLE 1 The discrete coverage of postal zones within a country: each zone has a different code and it is not possible to interpolate between these codes. Nevertheless, there could be a high level relationship between the codes. The small country of Monaco is divided into five *quartiers*: “Moneghetti”, “La Condamine”, “Fontvieille”, “Monaco-Ville” and “Monte-Carlo”. These political jurisdictions completely cover the area of the country. The area of Monaco can be represented as a discrete coverage with five spatial objects where each object has the geometry of a polygon. The attribute value for each spatial object is the name of the political jurisdiction. See Figure 1.

2) There is potential confusion between the use of the term “class” as used in UML, “class” as used in a classification scheme and “item class” as used in the procedures for registration. Class as used in a classification scheme is termed legend class in this part of ISO 19144.

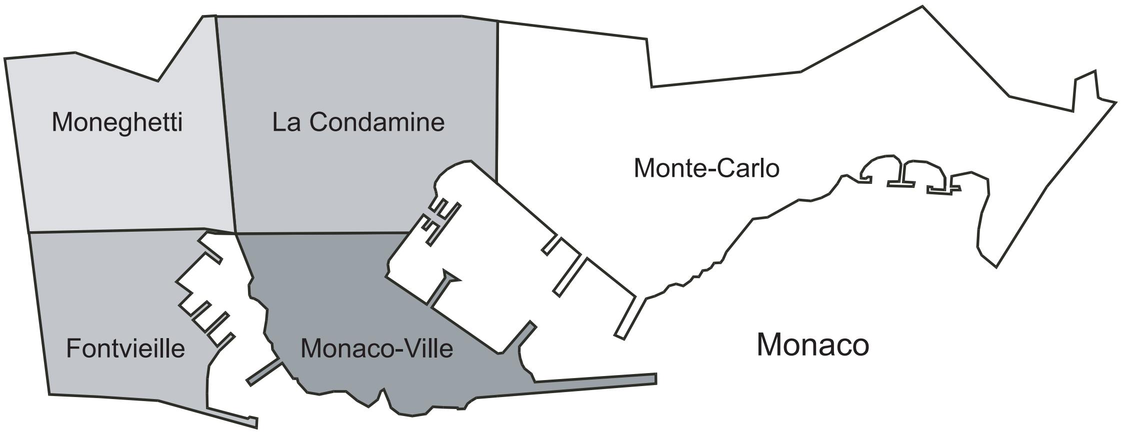

Figure 1 — Example of discrete coverage with polygon geometry

The geometry of the spatial objects associated with a discrete coverage can also be grid cells within a grid structure. Each of the grid cells may carry an attribute.

EXAMPLE 2 A discrete coverage with grid geometry of the same area as used in the previous example. See Figure 2. The figure legend identifies the instances of the attribute values that actually exist in the data.

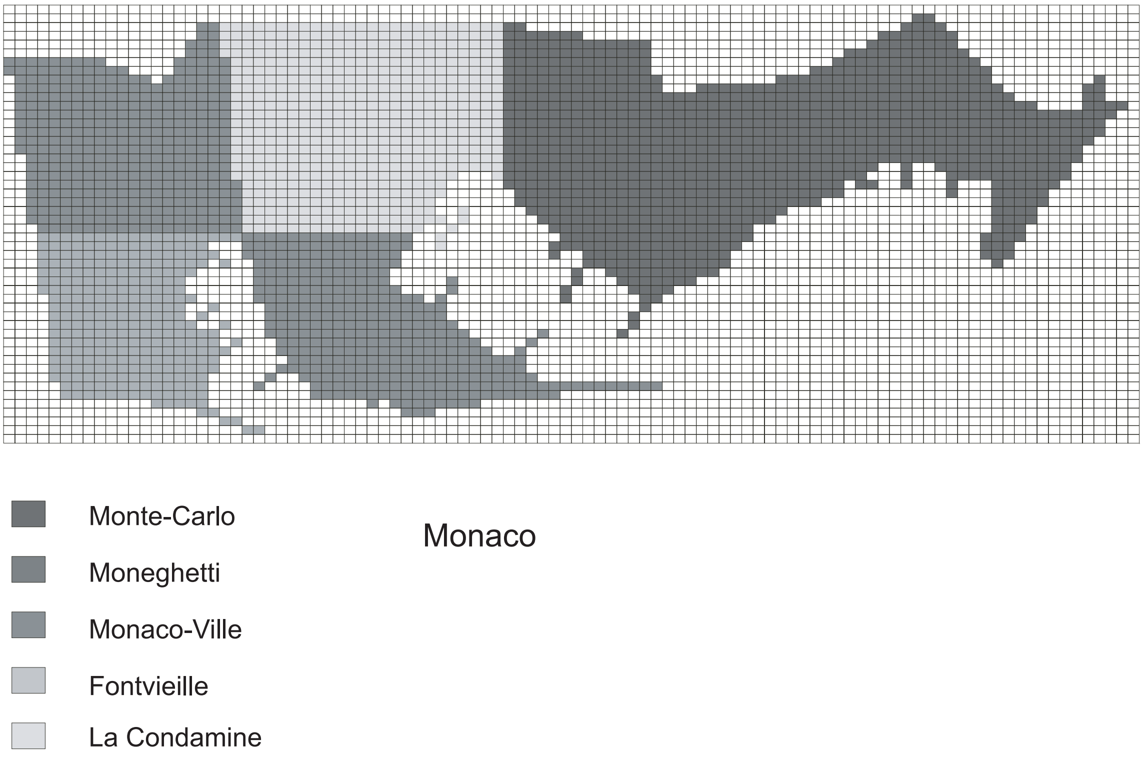

Figure 2 — Example of discrete coverage with grid geometry

NOTE The discrete coverages illustrated by the above examples are simple because only one relatively simple attribute has been used. However, in reality the attributes for each of the coverage spatial objects can be very complex. In order to describe land cover it is necessary to integrate a large number of descriptive parameters related to soil, biology and density into a comprehensive land cover classification system. Such a classification system is of course application-area-dependent. An oceanographer will have a different classification system than that of a meteorologist. Classification systems can vary widely in different application areas, but for similar application areas there needs to be some commonality in order for data from different sources to be used together.

A classification system allows one to define *classifiers* in order to partition the attribute range of a discrete coverage to establish classified objects.

5.2 Classification and legend

Classification is an abstract representation of real world phenomena (i.e. the situation in the field) using classifiers. A classification is a systematic framework with the names of the classes and the definitions used to distinguish them, and the relation between classes. Classification thus necessarily involves definition of class boundaries that must be clear and based upon objective criteria.

A classification system shall be

— *scale independent,* meaning that the classes at all levels of the system shall be applicable at any scale or level of detail, and

— *source independent,* implying that it is independent of the means used to collect information.

NOTE 1 Scale independence and source independence exist in the general case of a classification system. When the system is applied to real data, i.e. when a legend is created, the scale and source limitations of the data can create restrictions on the legend.

A *legend* is the application of a classification in a specific area using a defined mapping scale and specific data set. Therefore, a legend may contain only a proportion, or subset, of all possible classes of the classification.

A legend shall be

— *scale dependent*, and

— *source dependent*.

EXAMPLE 1 Scale dependence: some elements might be too small to be delineated independently when collected at a particular scale.

EXAMPLE 2 Source dependence: elements collected from different sources, such as an aerial photograph and a satellite false colour composite image, could be different.

A legend is a selection of a set of the classifiers from all of the possible classifiers within a classification system. A legend could correspond to the classifiers that apply to a single data set or it could be applicable to a number of related data sets.

NOTE 2 A legend is analogous to the set of features within a feature catalogue, which is a subset of all of the possible features within a feature concept dictionary.

EXAMPLE 3 The derivation of legend classes from a classification system: when applying the reference classification system to a given geographic area with a specific data type, only a subset of the classes from the reference system will occur in the real data. This set of classes is the legend with which the mapping system will be carried out. The reference system in Figure 3 is shown as a matrix with two parameters: the height of plants, ranging from 5 m to greater than 50 m, and the percentage crown cover, ranging from less than 10 % to 100 %. The classes are numbered with a code number from 1 to 100. In this specific case, the legend will have only four reference classification classes, numbers 33, 47, 78 and 83.

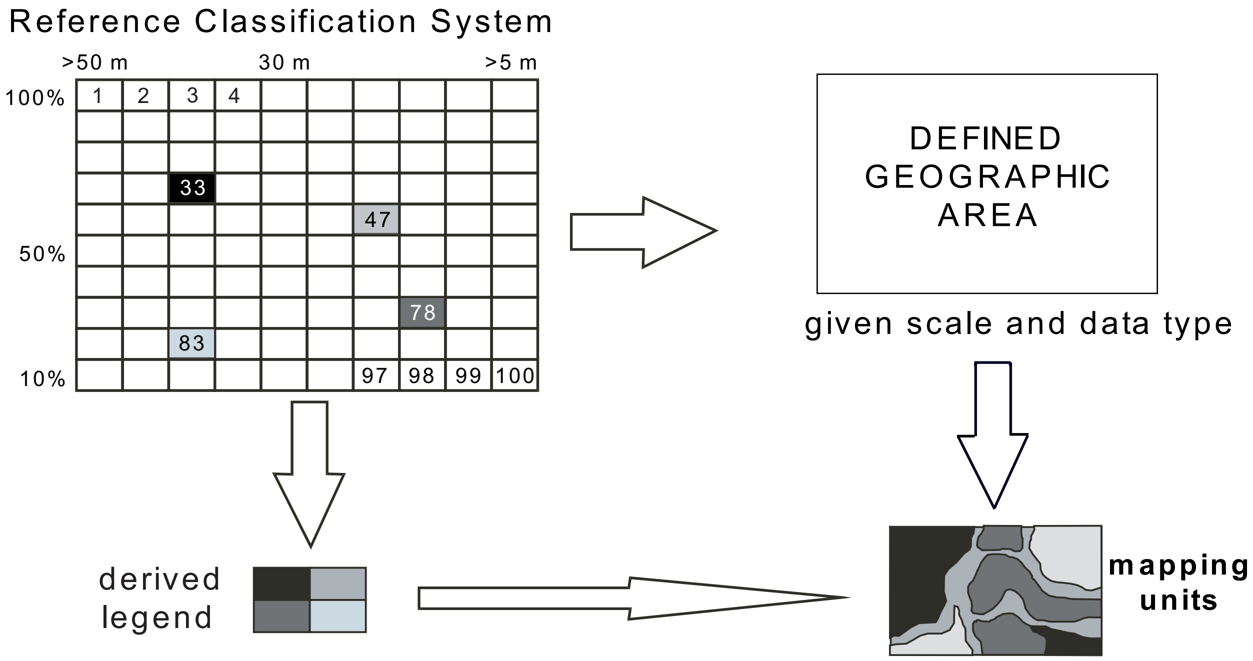

Figure 3 — Legend as application of classification in a particular area[2]

5.3 Hierarchical versus non-hierarchical systems

There are two basic forms of classification system: hierarchical and non-hierarchical.

a) **Hierarchical classification systems**

— Classifiers shall be defined so that all classes at a specific level of the hierarchy are mutually exclusive.

— Criteria used to define a classifier at one level of a hierarchical classification shall not be repeated at another level (e.g. criteria used to define a classifier at a lower level shall not be duplicated to a higher level of the hierarchy).

NOTE 1 Most classification systems are hierarchically structured. Such a classification offers greater consistency, owing to its ability to accommodate different levels of information — starting with structured broad-level classes — which allow further systematic subdivision into more detailed subclasses. At the higher levels of the classification system, few diagnostic criteria are used; whereas at lower levels, the number of diagnostic criteria increases.

b) **Non-hierarchical classification systems**

Classifiers shall be defined so that all classes are mutually exclusive.

NOTE 2 Non-hierarchical classification systems apply to only a single level of information, e.g. a single scale or type of information.

5.4 *A priori* and *a posteriori* classification systems

Two approaches are defined for establishing classification systems: *a priori* and *a posteriori* classifications. The first is based on the establishment of a classification scheme before the collection of the data to which it is applied, whereas the second is based on the establishment of classes based on the common properties identified in the data collected.

NOTE Both approaches have applications. An *a posteriori* approach to classification provides additional flexibility that allows the classification scheme to more closely match the data. However, it can make it more difficult to compare data collected and classified separately. If standardized rules are used to establish classes in an *a posteriori* classification system, then these rules can be used to generate broader sets of classes that encompass multiple separate classifications. The *a priori* and *a posteriori* classification system approaches are discussed in Annex B.

5.5 Structure of classified data

5.5.1 Systematic arrangement

Classification is the process of systematic arrangement of objects into groups on the basis of their attributes. The set of classes established in a classification system allows one to organize the attributes of geographic features so that the attribute value for a feature instance is the name of a class from the classification system. The groups can be directly defined or parametric rules can be used to generate the groups. A subset of the set of groups in a specific area becomes a legend.

NOTE The concept of classification is very general and is widely used in many scientific and other disciplines.

Most geographic attributes are distributed spatially. That is, instances of geographic attributes normally have different values at different spatial locations. Geographic information with discrete attributes can be represented as a discrete coverage or with vector geometry describing a boundary-defined spatial data set (vector data). Since the same real-world phenomenon may be represented using either coverage or vector data, the systematic arrangement of objects into groups forming the classification can be applied to both coverage and boundary-defined spatial vector data.

5.5.2 Representation using discrete coverages

The result of classifying an area is a legend that may be represented as a type of discrete coverage, as specified in ISO 19123. The range of a discrete coverage is a set of feature attribute values represented as a set of records with a common schema defined by the classification system. The domain consists of a finite collection of classified objects together with their direct positions. The geometric object and its associated record form a geometry value pair.

The class CV_Coverage (see ISO 19123) represents a feature type in accordance with the general feature model from ISO 19109:2005, Figure 4. Class CV_Coverage has three attributes: the *domainExtent*, the *rangeType* and the *commonPointRule*. In discrete coverages, there is a direct one-to-one relationship where each CV_GeometryValuePair links to corresponding attributes. Attribute *domainExtent* describes the extent of the domain coverage. The data type EX_Extent is defined in ISO 19115. Attribute *rangeType* describes the structure and composition of the attribute data record. Attribute *rangeType* makes use of the data type RecordType, which is defined in ISO/TS 19103. A RecordType is a metaclass that describes the structure of a set of records. A RecordType consists of a list of attribute name/data type pairs. A simple list is the most common form of *rangeType*. Attribute *commonPointRule* identifies the procedure to be used for evaluating the CV_Coverage at a position that falls either on a boundary between geometric objects or within the boundaries of two or more overlapping geometric objects, where the geometric objects are either CV_DomainObjects or CV_ValueObjects. The data type CV_CommonPointRule is defined ISO 19123.

Associated with a CV_Coverage is a specification of the coordinate reference system (CRS) to which the objects in the domain are referenced. The coordinate reference system is defined in ISO 19111.

Also associated with the CV_Coverage class are the CV_Domain and the CV_AttributeValues classes. The CV_Coverage links the set of domain objects to the set of records containing the attribute values. A CV_DomainObject can be any spatial or temporal or spatiotemporal object. The domain objects of a CV_DiscreteSurfaceCoverage are constrained to be instances of GM_Surface. There is one instance of CV_AttributeValues (i.e. one data record) for each instance of CV_DomainObject (i.e. each grid cell or polygon area).

See Figure 4.

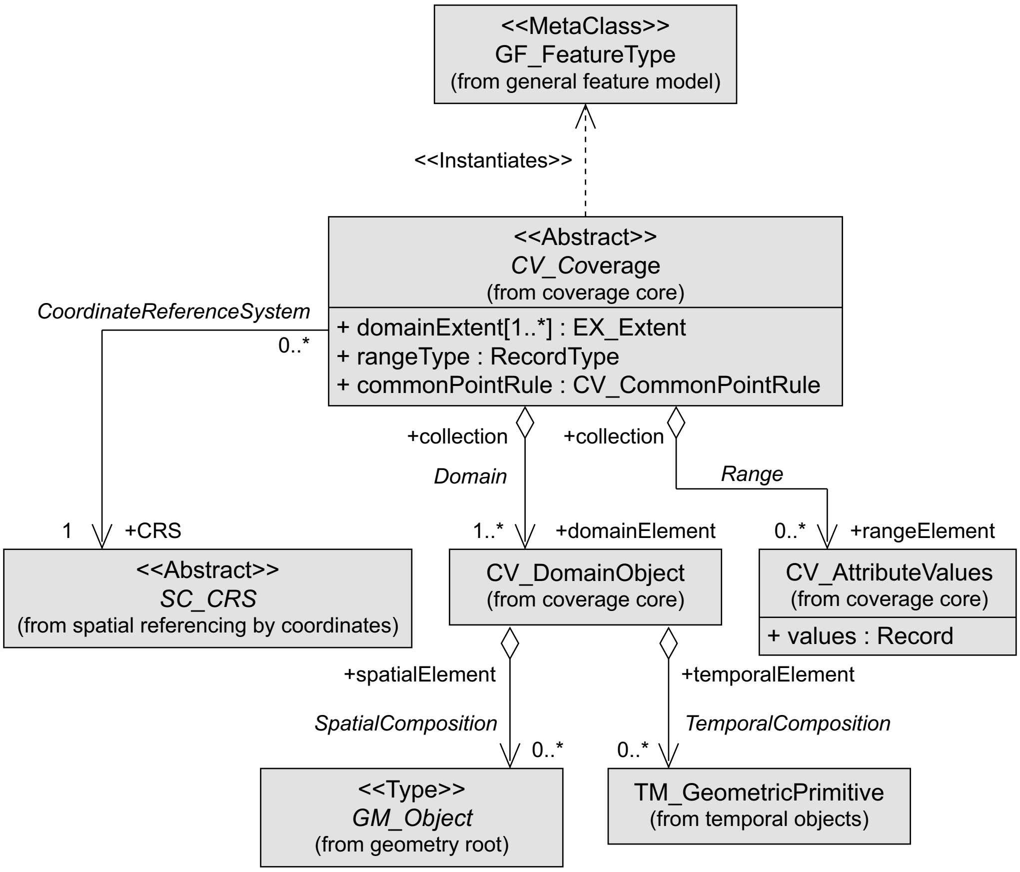

Figure 4 — Elements of a coverage

CV_DiscreteCoverage is the subclass that returns the same record of feature attribute values for any direct position within a single CV_DomainObject in its domain. Each geometry value pair consists of a domain object (e.g. a grid cell or a polygon) and a record of feature attribute values. See Figure 5. In discrete coverages there is a direct one-to-one relationship where each CV_GeometryValuePair is composed of a CV_DomainObject such as a GM_Object and a CV_AttributeValues value.

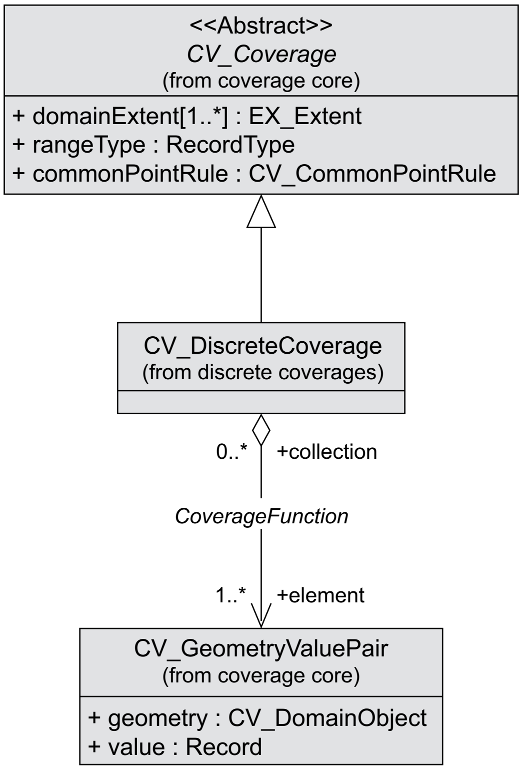

Figure 5 — Elements of a discrete coverage

The type of discrete coverage is based on the type of geometric object in the spatial domain. ISO 19123:2005, Clause 6, identifies five types of discrete coverage with different geometries:

- a discrete point coverage, consisting of a set of independent points;
- a grid point coverage, consisting of a set of grid points;
- a discrete curve coverage, consisting of a set of curves;
- a discrete surface coverage, consisting of a set of surfaces, typically GM_Surface objects (polygons) or congruent rectangles (grid cells) or regular hexagons, but possibly TIN objects or Thiessen Polygon objects;
- a discrete solid coverage, consisting of a set of solid volumes.

A classification system can make use of any type of geometric object in its spatial domain. It is possible to establish classifiers to identify the range values for any type of discrete coverage. Discrete coverages that partition an area are addressed by discrete surface coverage.

5.5.3 Discrete surface coverage

A classification system that makes use of a coverage whose range partitions an area shall make use of the CV_Discrete surface coverage in accordance with ISO 19123:2005, 6.8. The use of GM_Surface as the geometry element is illustrated in Figure 6.

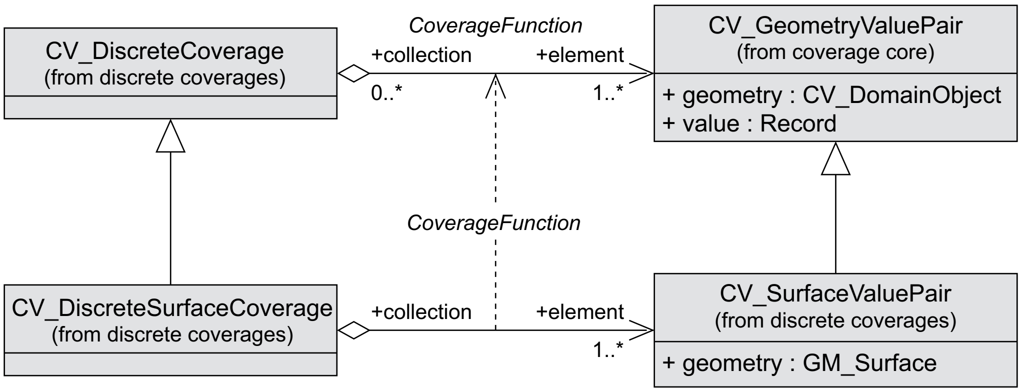

Figure 6 — Discrete surface coverage

The surfaces that constitute the domain of a discrete surface coverage can be mutually exclusive and exhaustively partition an area or can be independent sub-areas. The type of coverage geometry used often depends upon the method by which data was collected. Natural phenomena tend to have irregular boundaries and are often represented as a set of congruent polygons. Some phenomena, types of sensor data or the results of calculations tend to be organized in terms of a grid tessellation where the domain is a set of congruent rectangles. Subtypes of CV_DiscreteSurfaceCoverage that may be used in classification systems are illustrated in Figure 7. Different grid tessellations may be used. One type of quadrilateral grid is an equal-cell-size regular grid with a linear traversal sequence order; however, other grid organizations may be used, such as a variable cell size "QuadTree" grid with a Morton traversal sequence order.

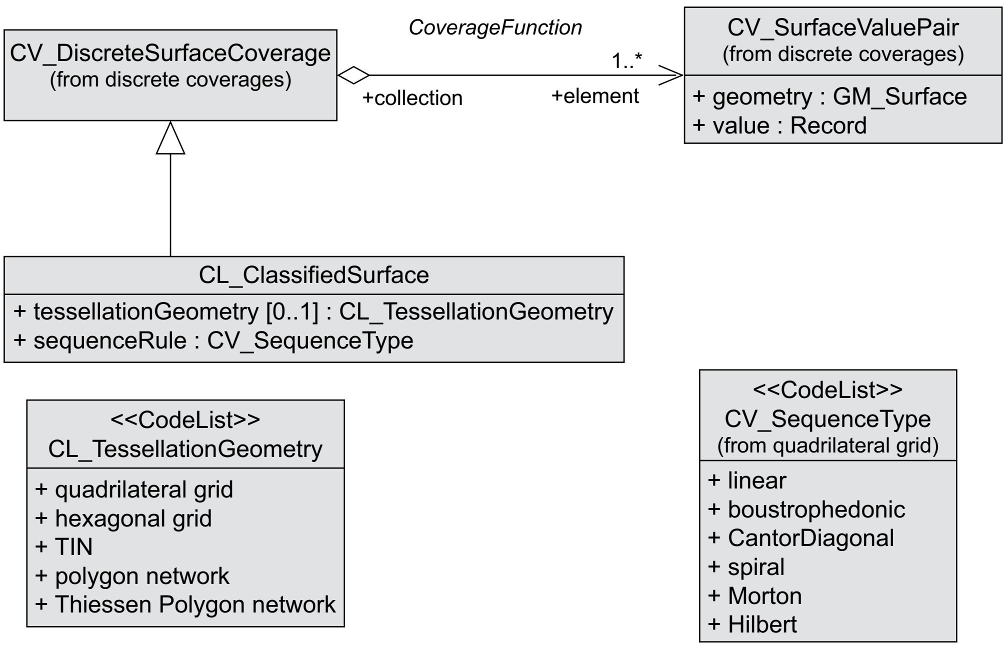

Figure 7 — Discrete surface coverage types

5.5.4 Attributes

A geometry value pair consists of a spatial, temporal or spatiotemporal object together with a record of feature attribute values. The value set for a classified data discrete coverage is represented as a collection of records with a common schema. The attribute *rangeType* of the object CV_Coverage describes the range of the coverage. The application schema for a particular classification system defines the record structure used to contain attribute values for that application system.

Attributes may be references to coded values in a catalogue of legend classes. A legend class corresponds to a feature type that is defined as part of a classification scheme. That is, the feature type is constrained to be part of the classification system that imposes some overall structure on the set of legend classes. The structure can be organized in either *a priori* or *a posteriori* manner, as described in Annex B. Figure 8 shows the relationship of a legend class to a feature type. The catalogue of legend classes may be held in a register as described in Clause 6.

A CL_LegendClass is a metaclass that is a subtype of the general GF_AttributeType metaclass from the GeneralFeatureModel of ISO 19109. It is implemented by a reference to a catalogue of legend classes through a CL_FeatureTypeReference. Feature attribute metadata can be associated with a legend class.

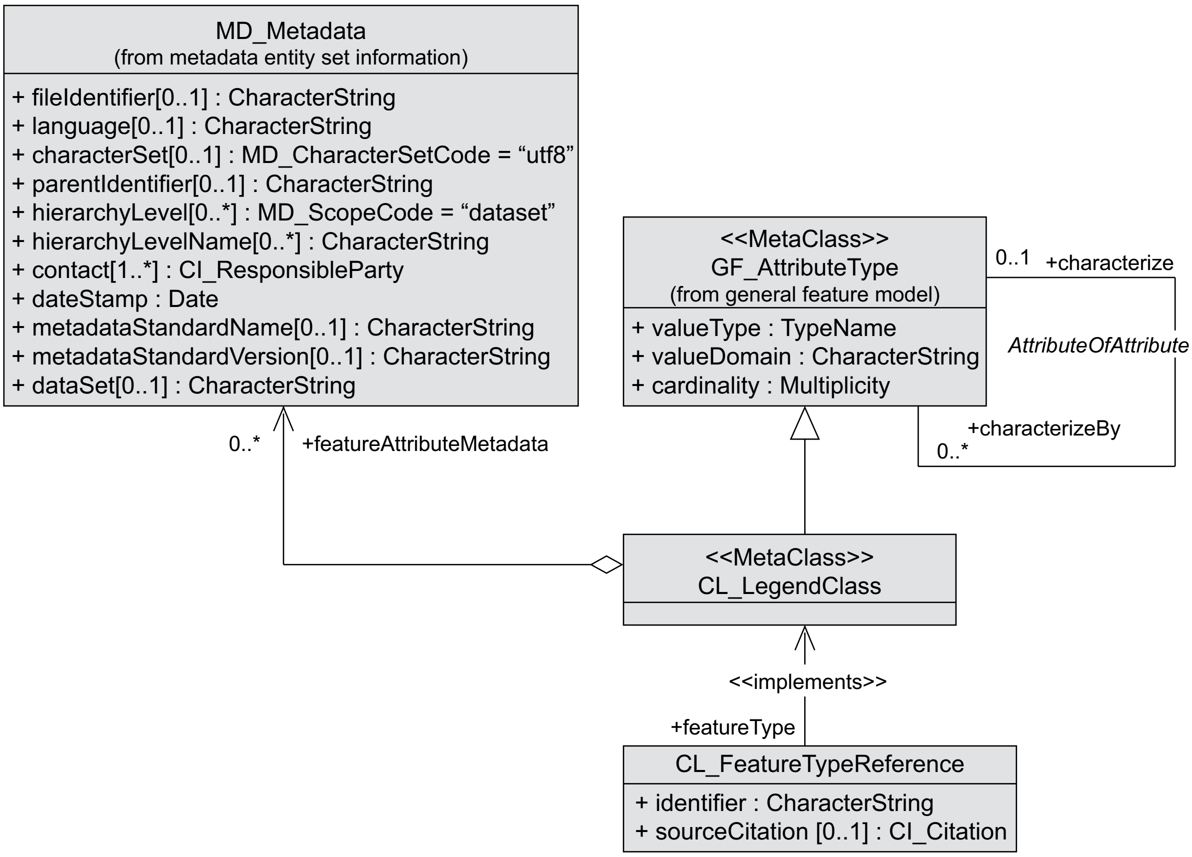

Figure 8 — Relationship of legend class to feature type

5.6 A classification data set

A classification data set can include a discrete coverage, together with associated metadata. Figure 9 illustrates an overview of a content model for classified discrete coverage data. This is a specialization of a corresponding illustration from ISO/TS 19129. Metadata elements consist of two types — those that describe the context of the data and those that describe the content of the data. Both context and content metadata are defined in ISO 19115. Imagery metadata from ISO 19115-2 can be used in some cases to describe the method by which classification data has been acquired. The geometric structure and attribute data consists of spatial referencing and a value set of data elements.

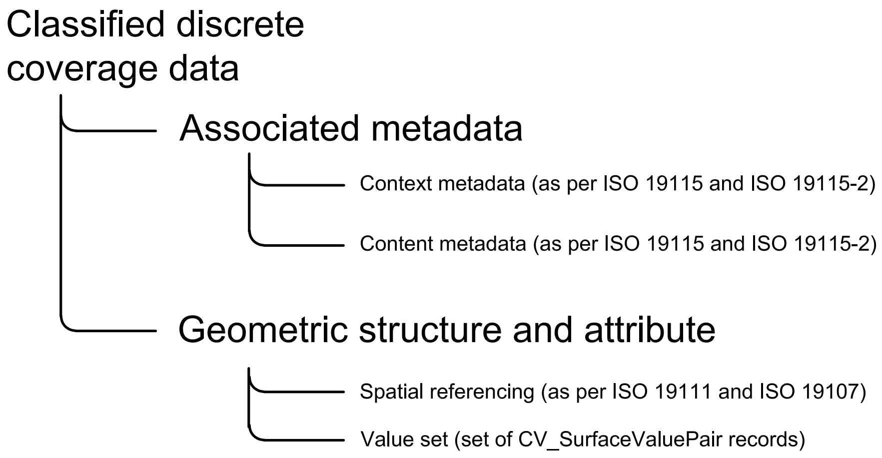

Figure 9 — Overview of a content model for classified discrete coverage data

The model shown in Figure 10 illustrates the relationship between a classification collection and associated metadata comprising a data set. The class CL_ClassificationCollection is a collection class that links the coverage to the metadata.

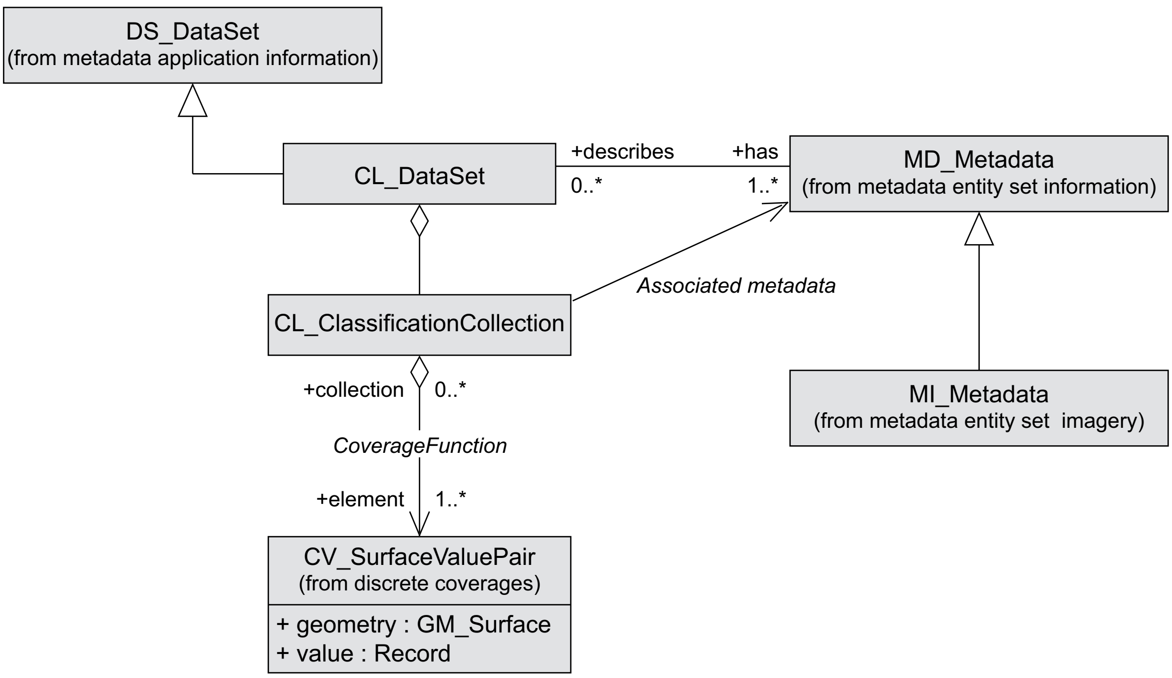

Figure 10 — Classification data set content elements

6 Management of classifiers

6.1 General

A classified object is a subtype of a feature attribute that is constrained to work within a particular classification scheme. The process of establishing a classification system subdivides the attribute range of a discrete coverage. Like a feature attribute, a classification can be predefined with the definition stored within a dictionary. The dictionary might contain all of the classifiers available within the classification scheme. New classifiers might be added to the classification scheme and the definitions of certain classifiers modified. An appropriate manner of managing such changes is through the process of registration.

NOTE 1 This is analogous to the registration of feature and attribute definitions in a feature concept dictionary.

Classified objects are described by classifiers. The definition of a classifier can also have an associated name and identifier (code). These can be registered. In addition, classified objects can have rules that relate them to other classified objects. The definition, name identifier and any relationship between classifiers can be registered.

EXAMPLE The classification "Savannah" in a particular land cover classification system[1] is dominant grass with sparse trees and/or sparse shrubs, which means that the classification requires both grass and trees, or shrubs with the grass dominant. There is a relationship of dominance between the grass and the other elements.

There can also be rules relating geometry or scale to classified objects. If an object is too small it might not be possible to consider it distinct when collected at a given scale. However, it can be desirable to combine two classifications into a mixed classification to show the existence of the material. If an object is of less than minimal area, a mixed classification, i.e. A|B mix of A and B with A dominant and with B at least a threshold percentage, can be created.

Classification schemes can become very complex and can include thousands of classes.

NOTE 2 The rules relating classified objects can relate to the hierarchy of the classification scheme or to the relationship between classifiers or to spatial aspects. For simple classification schemes, it can be possible to describe the rules relating classifiers in descriptive text. In more complex classification schemes, the rules can be described in a form that can be processed automatically.

6.2 Concept dictionary register for a classification scheme

A feature concept dictionary is described in ISO 19126 as a set of independent specifications of feature types and attribute types. In a classification system, classified objects can represent the partitioning of the range (attribute space) of a discrete coverage. There is no clear demarcation that indicates the limit to what is a feature. Classified objects are in effect features where the partitioning of the attribute space has added specificity to the definition of the feature. A classifier is used to specify a classified object. A classifier is a definition that can be used to assign objects to classes. The set of all classifiers for a particular application area form a concept dictionary for that application area and can be held in a register.

Some classifiers consist of only a descriptive definition that describes the type of classified object, whereas other classifiers contain code lists of allowed values. A set of classifiers for a particular area form a legend.

6.3 Management of classifiers through registration

Classification systems can be relatively fixed *a priori* hierarchical structures or they can be very flexible and complex *a posteriori* structures, but in both cases they are specific to the application area for which they were defined. Over time, additional classifiers could be added to the classification system or the existing classifiers might need to be modified. This type of maintenance of a set of classifiers lends itself to registration.

NOTE Registration has other indirect advantages. The overall structure of a classification system and the schema for the register can be standardized, but the specific details of the classifiers are held in the register. This permits flexibility and the handling of a large number of classifiers and resultant classified object types which are collected in a legend. It also allows for maintenance of the register by the information community supporting the application area.

6.4 Register structure

6.4.1 Elements of a register

Registers provide a basis for the flexible management of legend classes. ISO 19135 specifies how registers are to be managed and the information to be included in any proposal for registration of an item of geographic information. A register of legend classes shall be in accordance with ISO 19135.

A register of legend classes is a multi-part register that shall include a specification of

a) classifier — definition and any associated code and/or name;

b) rules describing the relationship between registered legend items or the relationship of classified object types to geometry.

Additionally, each registered item shall also include information necessary for managing that item, e.g. item identifier, management status and, possibly, information about relationships to items in external specifications.

NOTE There is potential for confusion between a "class" as used in a classification system and a "class" as used in UML. The register of legend classes contains a set of legend classes as represented in the UML diagram using the CL_ClassificationLegendClass UML class and also a set of rules that describes the relationship between legend classes as described using the CL_ClassificationRuleClass UML class.

6.4.2 Register schema

The legend class register schema is derived from the register schema given in ISO 19135 and is shown in Figure 11. The register schema is extended to include a subtype of RE_Register for a legend class register (CL_ClassificationRegister), a subtype of RE_RegisteredItem corresponding to a legend class item (CL_ClassificationItem) and a rule item (CL_ClassificationRuleItem), and a subtype of RE_ItemClass corresponding to a legend class item class (CL_ClassificationItemClass) and a rule class (CL_ClassificationRuleClass).

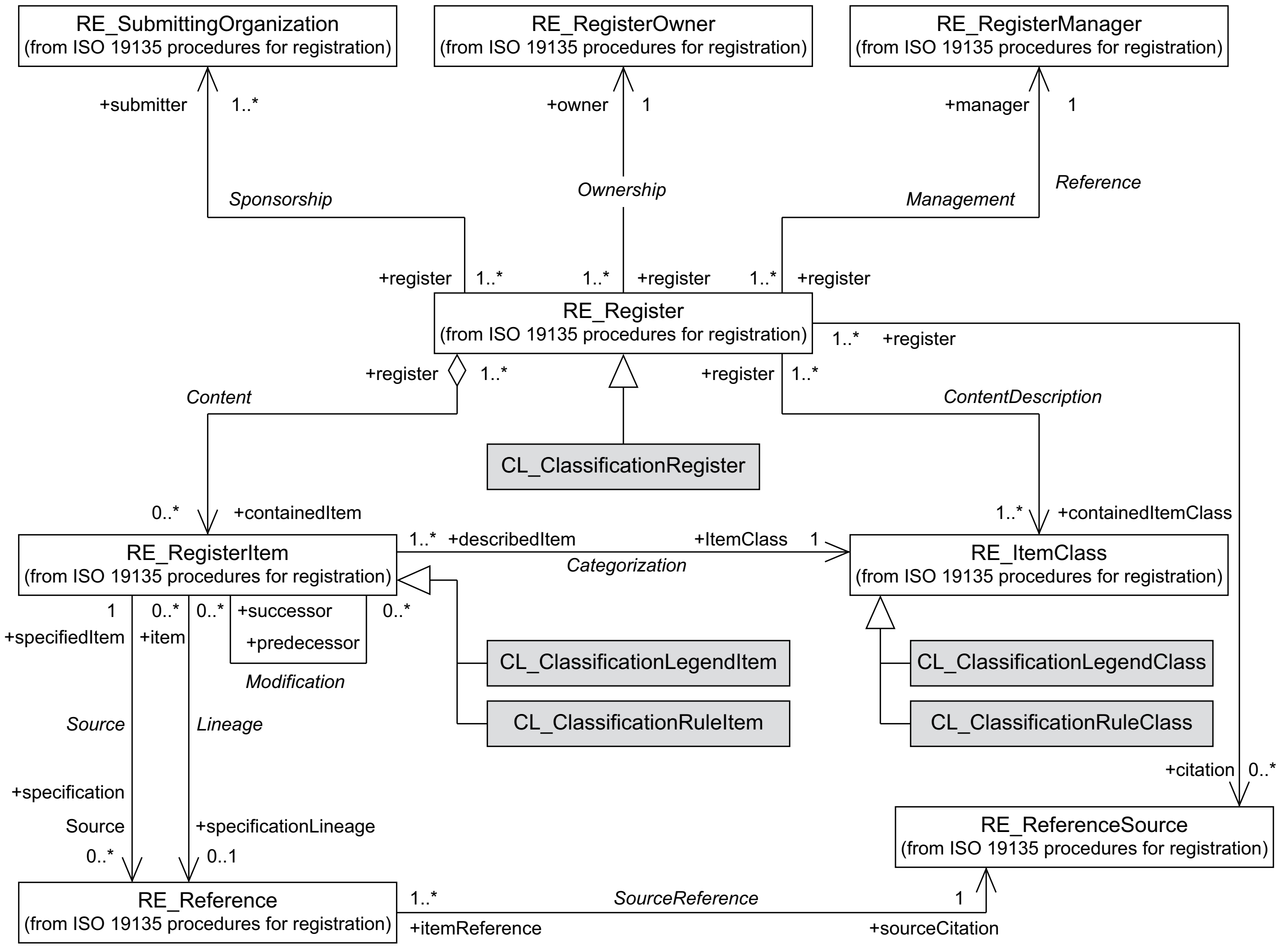

Figure 11 — Classification register schema showing added classes

6.4.3 Classification register

6.4.3.1 CL_ClassificationRegister

The class CL_ClassificationRegister specifies information about the register itself. It is a subclass of the class RE_Register, as defined in ISO 19135. It inherits six attributes from ISO 19135 and adds three additional attributes. See Figure 12.

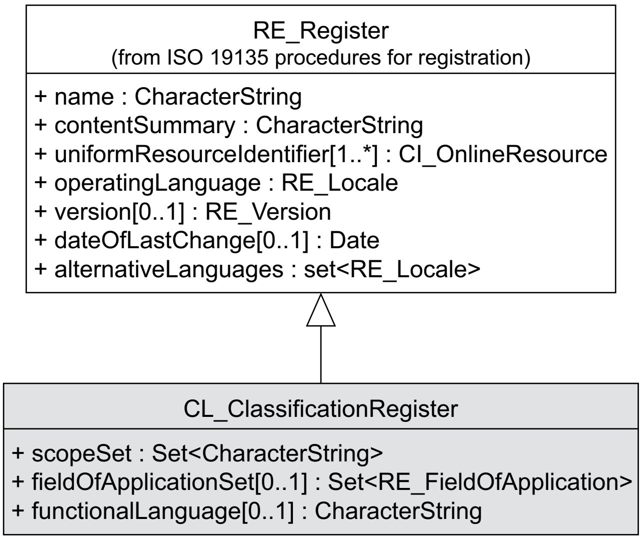

Figure 12 — Classification register

6.4.3.2 name

In accordance with ISO 19135, the attribute *name* shall be a character string that is used to uniquely identify a register within the set of registers maintained by the register owner. In the case of a classification register, the *name* shall also include an identifier of the fact that the register is a classification register.

EXAMPLE “LCCS Classification Register”.

6.4.3.3 contentSummary

In accordance with ISO 19135, the attribute *contentSummary* shall be a character string containing a general statement of the purpose for which items in the register are made, including any limits to the scope of the register, and the types of applications for which the items are intended. In the case of a classifier register, the *contentSummary* shall also indicate that the register is a classifier register.

6.4.3.4 uniformResourceIdentifier

In accordance with ISO 19135, the attribute *uniformResourceIdentifier* shall take as its value a set of instances of CI_OnLineResource (ISO 19115:2003, B.3.2.5, Row 395), each containing information about online resources associated with the register.

The set shall contain at least one instance of CI_OnLineResource for which the attribute OnLineResource.function has the value “information” (002) and the corresponding value of the attribute OnLineResource.linkage specifies a resource providing access to the complete content of the register.

EXAMPLE http://www.dgiwg.org/FAD/ is a sample value of OnLineResource.linkage.

6.4.3.5 operatingLanguage

The attribute *operatingLanguage* shall take as its value an instance of class RE_Locale in accordance with ISO 19135:2005, 8.17, used to specify language, country information and character encoding for the proper interpretation of the content of character strings in the register.

6.4.3.6 version

The conditional attribute *version* shall be represented as an instance of class RE_Version (ISO 19135:2005, 8.18) that specifies a unique state in the life of the register. A value shall be provided for this attribute if a value of dateOfLastChange (6.4.3.7) is not supplied.

6.4.3.7 dateOfLastChange

The conditional attribute *dateOfLastChange* shall be represented as an instance of the class <<Date>> according to ISO/TS 19103:2005, 6.5.2.8, and shall specify the date on which the most recent change to the status of an item in the register was made according to ISO 19135:2005, 8.8.4. A value shall be provided for this attribute if a value of version according to ISO 19135:2005, 8.2.7, is not supplied.

6.4.3.8 alternativeLanguages

The conditional attribute *alternativeLanguages* shall be represented as set of instances of the class <<RE_Locale>> and may be used in order to support cultural and linguistic adaptability and may provide elements of information in additional languages other than the operating language of the register.

6.4.3.9 scopeSet

The attribute *scopeSet* shall be a set of scope elements represented as character strings in accordance with ISO 19110:2005, Table B.1, Element 1.2, used to describe subject domains of the registered items. The *scopeSet* may be used as the basis for creating metadata for submission to search engines. Since there is a commonality between conventional geographic features and classified objects, in that they are both are abstractions of real world phenomena, elements from ISO 19110 are to be used where possible to describe the classifier register in order to maintain a parallelism in the description.

EXAMPLE {“Land Cover”, “Soil”}

6.4.3.10 fieldOfApplication

The optional attribute *fieldOfApplicationSet* shall be a set of fieldOfApplicationSet elements represented as character strings in accordance with ISO 19110:2005, Table B.1, Element 1.3, used to describe the kinds of use of the registered items. The *fieldOfApplicationSet* may be used as the basis for creating metadata for submission to search engines.

EXAMPLE {“Agricultural Production”}

6.4.3.11 functionalLanguage

The conditional attribute *functionalLanguage* shall be a character string containing a specification of the notational system used for formal definitions of rules used to relate classified objects within a classification system. The rules within a classification system are analogous to feature operations establishing a classification system according to ISO 19110:2005, Table B.1, Element 1.7, for all classified objects. The *functionalLanguage* attribute is mandatory for classification systems where rules are specified.

EXAMPLE Prolog, ISO/IEC 13211-1 (ISO standard version of Prolog language, see Reference [7]).

6.4.4 Register items

6.4.4.1 Schema for register items

6.4.4.1.1 RE_RegisterItem

The class RE_RegisterItem (see Figure 13) specifies elements of information to be recorded for each item held in a register. It has nine attributes and two associations.

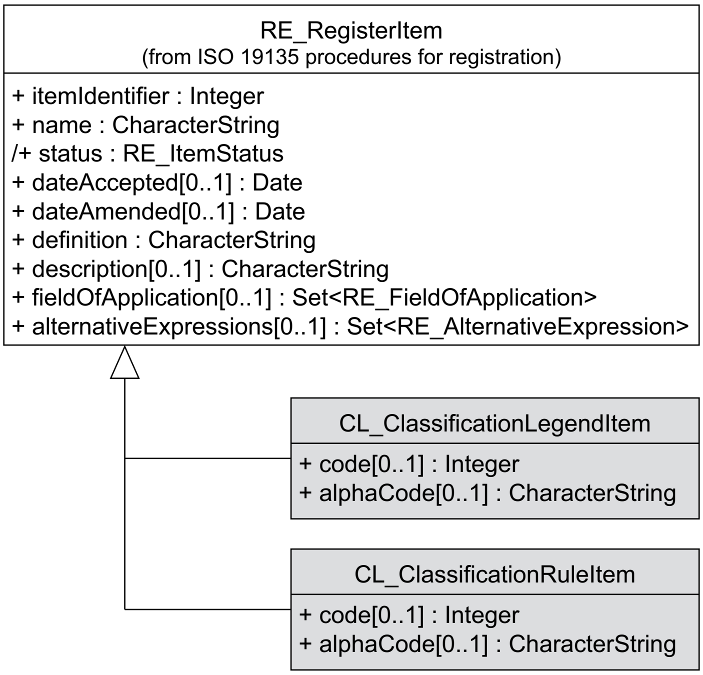

Figure 13 — Classifier registered item

6.4.4.1.2 itemIdentifier

The attribute *itemIdentifier* shall be represented as a positive integer (i.e. greater than zero), used to uniquely denote that item within the register and intended for information processing. Values shall be assigned sequentially in the order in which items are proposed for entry into the register. Once a value has been assigned, it shall not be reused.

6.4.4.1.3 name

The attribute *name* shall be represented as a CharacterString containing a compact and human-readable designator that is used to denote a register concept. Each name shall

— denote an item concept in the scope of an item class, and

— be a succinct expression of the item concept it denotes.

The name shall be unique within a register according to the following rules:

a) multiple items of the same item class may use the same value for name, but only one such item shall have a status of “valid”;

b) items in different item classes may use the same value for name.

6.4.4.1.4 status

The derived attribute *status* shall be represented as an instance of RE_ItemStatus according to ISO 19135:2005, Table 2, identifying the registration status of the RE_RegisterItem. The rule for establishing the value of RE_ItemStatus is described as a constraint in ISO 19135:2005, 8.8.4.

6.4.4.1.5 dateAccepted

The conditional attribute *dateAccepted* shall specify the date on which a proposal to add the item to the register was accepted. The condition constraint is described in ISO 19135:2005, 8.8.5.

6.4.4.1.6 dateAmended

The conditional attribute *dateAmended* shall specify the date on which a proposal to supersede or retire the item was accepted. The condition constraint is described in ISO 19135:2005, 8.8.6.

6.4.4.1.7 definition

The attribute *definition* shall be represented as a CharacterString containing the definition of the concept embodied by that item and expressed in the operating language of the register. The requirements for referencing definitions taken from an external source are given in ISO 19135:2005, 8.8.7.

6.4.4.1.8 description

The optional attribute *description* shall be represented as a CharacterString containing a description of the concept embodied by that item and expressed in the operating language of the register. The description shall be a statement of the nature, properties, scope, or non-essential qualities of the concept that are realized by the item but are not specified by the definition element.

6.4.4.1.9 fieldOfApplication

The optional attribute *fieldOfApplication* shall be represented as a set of *fieldOfApplication* elements, represented as character strings, each of which shall describe a kind of use of the item. The *fieldOfApplication* may be used as the basis for creating metadata for submission to search engines.

EXAMPLE "Agricultural Production".

6.4.4.1.10 alternativeExpressions

The optional attribute *alternativeExpressions* shall be represented as a set of elements, represented as character strings, each of which shall specify an alternative name and optionally additional information in a locale different from that of the register. No two instances of RE_AlternativeExpression within the set shall have the same value for locale.

6.4.4.2 Classification legend items

6.4.4.2.1 CL_ClassificationLegendItem

The class CL_ClassificationLegendItem specifies information about a legend item in the classifier register. It is the description of the actual legend item registered and adds two additional attributes to RE_RegisteredItem.

NOTE An itemIdentifier (see ISO 19135:2005, 10.8.2) is used to uniquely denote a register item within a register and is distinguished from a code used in data interchange outside of the scope of that register.

6.4.4.2.2 code

The optional attribute code shall be a positive integer used to denote a register item in data interchange outside of the scope of the register. Each code shall uniquely denote an item with status “valid” in the scope of a subclass of CL_ClassificationLegendItem class. Items may share the same code but have other status values.

A code is an information-process-efficient denotation; whereas a name (see ISO 19135:2005, 10.8.3) is a human-accessible denotation. There is a one-to-one relationship between the values of the name and code attributes of a register item. Therefore, a CL_ClassificationLegendItem name and a ClassificationLegendItem code may be used interchangeably to denote the same register item in data interchange.

6.4.4.2.3 alphaCode

The optional attribute *alphaCode* shall be a character string containing a compact and not necessarily human-readable designator that is used to denote a register item in data interchange outside of the scope of the register. Each *alphaCode* shall uniquely denote an item with status “valid” in the scope of a subclass of CL_ ClassificationLegendItem. Additional items may share the same code but have other status values.

6.4.4.3 Classification rule items

6.4.4.3.1 CL_ClassificationRuleItem

The class CL_ClassificationRuleItem specifies information about a rule item in the classifier register. It is the description of the rule used to describe the relationship between registered legend items or the relation to geometry. It adds one additional attribute to RE_RegisteredItem.

6.4.4.3.2 code

The optional attribute *code* shall be a positive integer used to denote a registered classification rule item in data interchange outside of the scope of the register. Each code shall uniquely denote an item with status “valid” in the scope of a subclass of CL_ClassificationRuleItem class. Additional items may share the same code but have other status values.

6.4.4.3.3 alphaCode

The optional attribute *alphaCode* shall be a character string containing a compact and not necessarily human-readable designator that is used to denote a register item in data interchange outside of the scope of the register. Each *alphaCode* shall uniquely denote an item with status “valid” in the scope of a subclass of CL_ ClassificationRuleItem. Additional items may share the same code but have other status values.

6.4.5 ItemClass

6.4.5.1 RE_ItemClass

The class RE_ItemClass (see Figure 14) specifies information about a classifier item class in a classifier register. It is the description of that which can be registered. The items that may be registered are represented as subclasses of RE_ItemClass, and shall consist of a CL_ClassificationLegendClass and CL_ClassificationRulesClass.

Since a classifier is used to partition the attribute space (range) of a discrete coverage, it is related to a *feature type* as described in ISO 19110. The class CL_ClassificationRulesClass describes the relationship between classifiers or to geometry. This is illustrated in Figure 14.

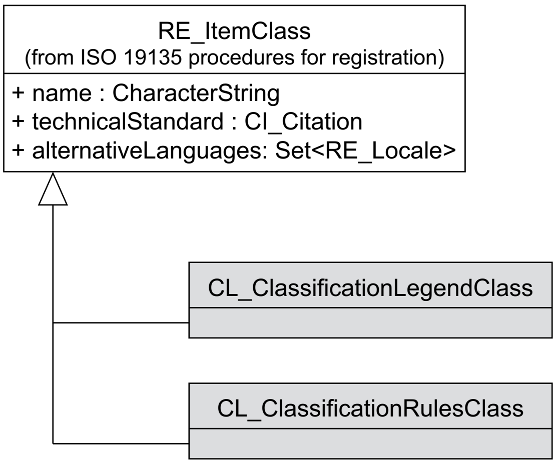

Figure 14 — Classifier item class

6.4.5.2 Item class for legend classes

The item class for legend classes (CL_ClassificationLegendClass) shall be an instance of RE_ItemClass (see ISO 19135) that is assigned the following attribute values.

The value of the attribute *name:CharacterString* shall be "Legend Class".

The value of the attribute *technicalStandard:CI_Citation* shall be:

a) title:CharacterString = "ISO 19144-1:2009, Geographic information — Classification systems — Part 1: Classification system structure";

b) alternateTitle:CharacterString = "ISO 19144-1:2009";

c) date:CI_Date

   1) date:Date = 2009-xx-xx,

   2) dateType:CI_DateTypeCode = "publication".

6.4.5.3 Item class for rules classes

The item class for rules classes (CL_ClassificationRulesClass) shall be an instance of RE_ItemClass (see ISO 19135) that is assigned the following attribute values.

The value of the attribute *name:CharacterString* shall be "Rules Class".

The value of the attribute *technicalStandard:CI_Citation* shall be:

a) title:CharacterString = "ISO 19144-1:2009, Geographic information — Classification systems — Part 1: Classification system structure";

b) alternateTitle:CharacterString = "ISO 19144-1:2009";

c) date:CI_Date

   1) date:Date = 2009-xx-xx,

   2) dateType:CI_DateTypeCode = "publication".

6.4.5.4 alternativeLanguages

In order to support cultural and linguistic adaptability, individual items in a register may provide elements of information in additional languages other than the operating language of the register. The attribute alternativeLanguages shall be represented as a set of instances of RE_Locale (ISO 19135:2005, 8.17), each specifying an additional unique locale used by items in the register. Every member of the set shall be used by at least one item in the register. The locale of every alternativeExpression according to ISO 19135:2005, 8.8.10, used by any item in the register shall be included in this set of RE_Locales. This attribute provides a summary of alternative locales used by items in a register. See ISO 19135:2005, 8.15, for additional information.

Annex A
(normative)

Abstract test suite

A.1 General

This annex presents the abstract test suite for evaluating conformance to this part of ISO 19144. The abstract test suite contains a test module for a classification system (A.2), a test module for a register of classifiers (A.3) and a test module for the representation of classification results (A.4).

A.2 Conformance of a classification system — Constraint on feature types in a classification system

a) Test purpose: to verify that an application schema or profile that implements classes or includes elements from this part of ISO 19144 constrains feature types to those established as part of the classification system.

b) Test method: inspect the set of feature types to ensure that they correspond to those permitted within the classification system, by ensuring that they can be described in terms of the classifiers that define the classification system.

c) Reference: 5.3, 5.5.

d) Test type: capability.

A.3 Conformance of a register of classifiers — Classifier register schema

a) Test purpose: to verify that a register of classifiers for a classification system complies with the register schema defined in ISO 19135 and instantiates the additional classes CL_ClassifierRegister, CL_ClassifierRegisteredItem and CL_ClassifierItemClass.

b) Test method: inspect the documentation of the register schema.

c) Reference: 6.4.2.

d) Test type: capability.

A.4 Conformance for representation of classification results

A.4.1 Discrete surface coverage classification system

a) Test purpose: to verify that an application schema or profile that implements classes or includes elements from this part of ISO 19144 satisfies the requirements that it instantiate CV_DiscreteCoverage and that it instantiate the class CV_SurfaceValuePair with the attributes *value* and *geometry*, with the geometry attribute set to *GM_Surface*.

b) Test method: inspect the documentation of the application schema or profile.

c) Reference: 5.5.

d) Test Type: capability.

A.4.2 Discrete grid coverage classification system

a) Test purpose: to verify that an application schema or profile that implements classes or includes elements from this part of ISO 19144, satisfies the requirements that it instantiates CV_DiscreteCoverage and that it instantiates the class CV_GridPointValuePair with the attributes *point* set to CV_GridPoint, and also that it instantiates the class CV_GridValuesMatrix with the attributes *values, sequenceRule* and *startSequence*.

b) Test method: inspect the documentation of the application schema or profile.

c) Reference: 5.5.

d) Test type: capability.

A.4.3 Legend

a) Test purpose: to verify that a legend is a selection of a set of the classifiers from all of the possible classifiers within a classification system.

b) Test method: inspect the legend to ensure that all elements conform to the classification rules for the classification system.

c) Reference: 5.2.

d) Test type: capability.

Annex B
(informative)

A priori and *a posteriori* classification systems

Classification can be done in two ways: either *a priori* or *a posteriori*.

In an *a priori* classification system the classes are abstractions of the types actually occurring. The approach is based upon definition of a classification system developed before the collection of the data to which it is applied. This means that all possible combinations of diagnostic criteria must be dealt with beforehand in the classification.

EXAMPLE 1 Plant taxonomy and soil science, as in References [5] and [6].

The main advantage of an *a priori* classification system is that classes are standardized independent of the area and the means used. The disadvantage of this method is that it is rigid, as some of the field samples might not be easily assignable to one of the pre-defined classes.

A posteriori classification systems are based upon definition of classes after clustering similarity or dissimilarity of the field samples collected.

EXAMPLE 2 The Braun-Blanquet method, used in vegetation science — a floristic classification approach using the total species combination to cluster samples in sociological groups (see Reference [4]).

The advantage of an *a posteriori* classification system is its flexibility and adaptability compared to the implicit rigidity of the *a priori* classification system. The *a posteriori* approach implies a minimum of generalization. This type of classification better fits the collected field observations in a specific area. At the same time, however, because an *a posteriori* classification depends on the specific area described and is adapted to local conditions, it is unable to define standardized classes. Clustering of samples to define the classes can only be done after data collection, and the relevance of certain criteria in a certain area could be limited when used elsewhere or in geographically quite different regions. Although the *a posteriori* approach to classification cannot pre-define standardized classes, it can establish standardized rules for establishing classes.

Figures B.1 to B.3 illustrate examples comparing the two approaches.

Figure B.1 represents the application of a classification schema that addresses two sets of independent attribute value types. The three-by-three groupings are sets of attribute value types consisting of shape (circle, triangle) and colour (black and white). The shape values for instances of these types vary from all triangles in a set to all circles in a set, and the colour varies from black to white. For illustration purposes, all the possible combinations are organized into a two-dimensional matrix going from only triangles in a set to only circles in a set (“a” to “j”) and from white to black (“1” to “10”). In this limited example the number of combinations is not excessive so it is possible to build a legend based on the sets of attribute values in Figure B.1 that would contain all of the combinations. In many real world situations the number of combinations may be too large, so a legend would necessarily need to be only a subset of the possible combinations. Real world data may not directly fit the legend and some form of approximation may be needed to assign collected real world data values to the nearest legend class.

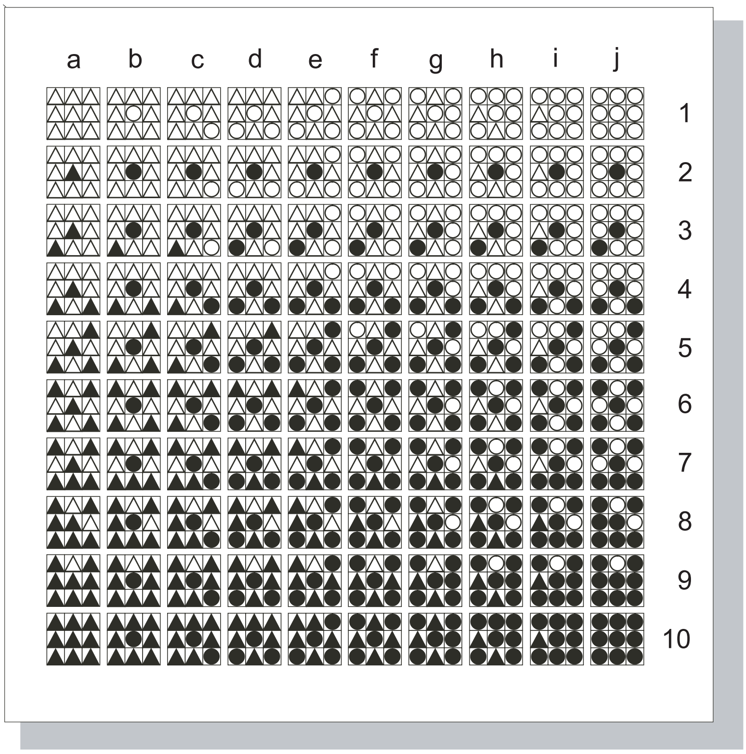

Figure B.1 — Abstract presentation of classification consisting of two sets of independent attribute value types — Circles and triangles in black and white represent all possible values of the attribute types[4]

Figure B.2 represents the situation in the field (reality) for one geographic area. Note that there is some duplication in Figure B.2, where particular combinations of shapes and colours have more than one instance and all possible combinations do not occur. A legend based on the sets or attributes in Figure B.2 would only contain those combinations of attributes that actually occurred in the particular geographic area. The collected data would fit the legend because the legend was derived based on the collected data. Another geographic area might contain some other combinations and a legend developed based only on the sets of attributes from Figure B.2 might not address all of the cases that appear in the other geographic area.

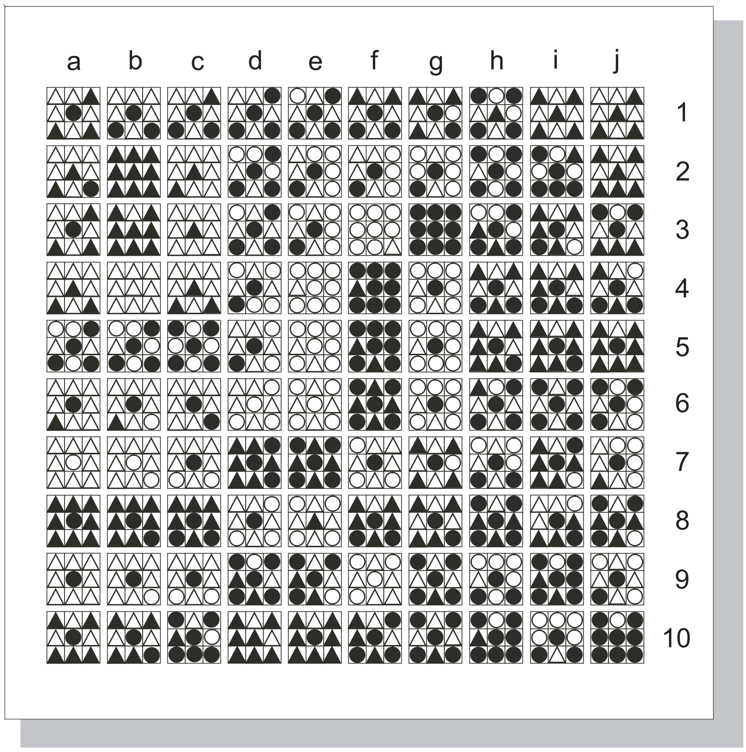

Figure B.2 — Concrete field situation in particular area

Figure B.3 compares an *a priori* and an *a posteriori* classification scheme, with two legends.

The first legend in Figure B.3, established in an *a priori* manner, consists of only the four classes — all white triangles, all white circles, all black triangles and all black circles. None of the data in the example area directly matches any of these legend classes, so an algorithm is required to assign the real data to the nearest legend class.

The second legend in Figure B.3, established in an *a posteriori* manner, has been developed from a subset of the data, contained within the black rectangle. This legend perfectly matches the data within the black rectangle, but it is a poor match for the other data. Again, an algorithm is required to assign the real data to the nearest legend class.

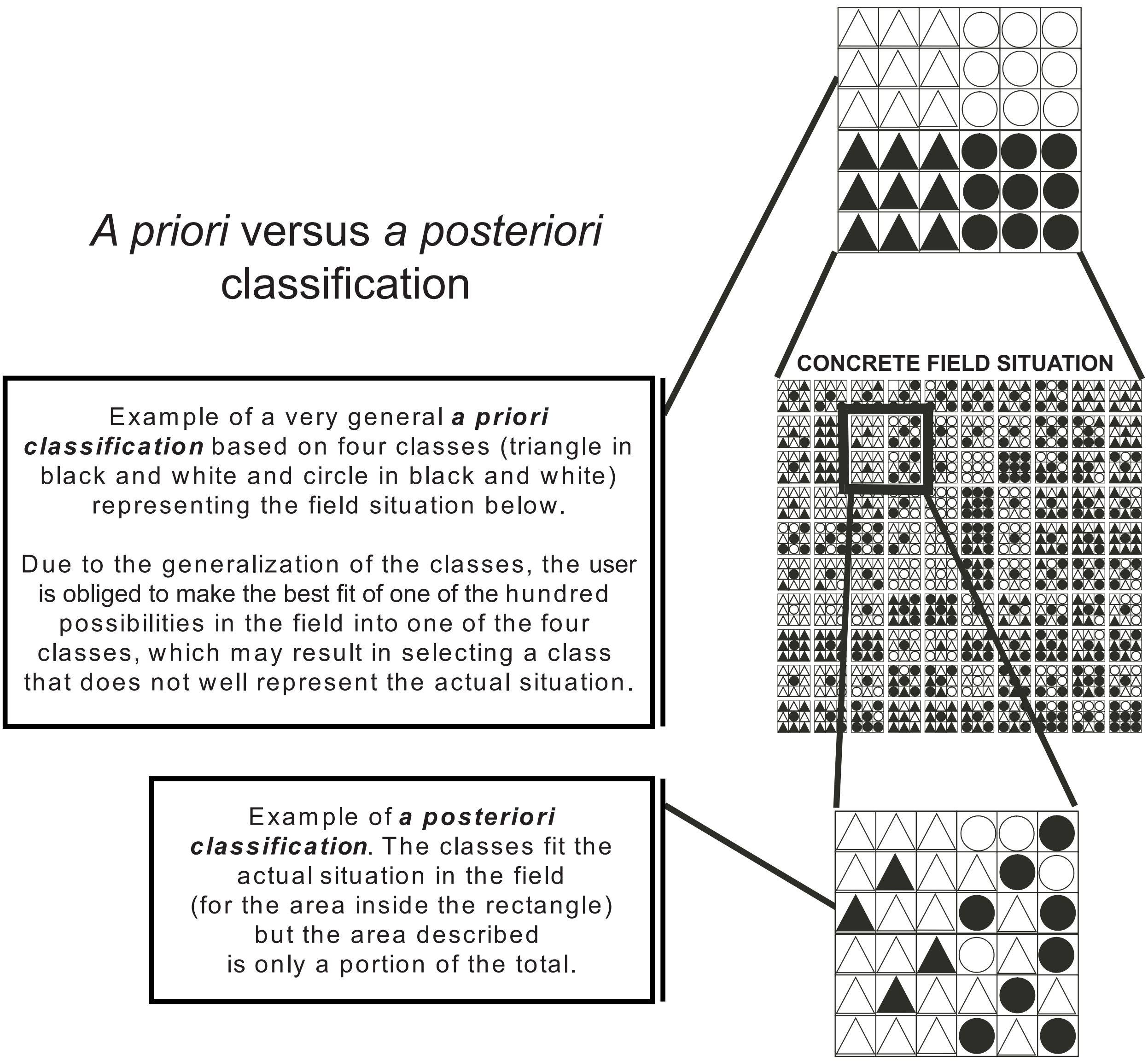

Figure B.3 — Comparison of *a priori* and *a posteriori* classifications related to concrete field situation

Bibliography

[1] DI GREGORIO, A., JANSEN, L.J.M., *Land Cover Classification System (LCCS), version 1: Classification Concepts and User Manual*. FAO. Rome, 2000

[2] DI GREGORIO, A., *Land Cover Classification System (LCCS), version 2: Classification Concepts and User Manual*. FAO. Rome, 2005

[3] SOKAL, R. 1974. *Classification: purposes, principles, progress, prospects*. Science 185 (4157): 1115-1123.

[4] KUECHLER, A.W. and ZONNEVELD, I.S. (eds.) 1988. *Vegetation Mapping: Handbook of Vegetation Science*. Vol. 10. Dordecht, the Netherlands, Kluwer Academic

[5] Soil Map of the World. Revised Legend. *FAO/UNESCO/ISRIC World Soil Resources Reports.* No. 60 (Reprinted 1990). FAO. 1988

[6] Soil Taxonomy, *USDA Agriculture Handbook No. 436*. Soil survey staff, U.S. Soil Conservation Service. Washington, D.C, 1975

[7] ISO/IEC 13211-1, *Information technology — Programming languages — Prolog — Part 1: General core*

[8] ISO 19101, *Geographic information — Reference model*

[9] ISO 19107:2003, *Geographic information — Spatial schema*

[10] ISO 19108, *Geographic information — Temporal schema*

[11] ISO 19109:2005, *Geographic information — Rules for application schema*

[12] ISO 19111, *Geographic information — Spatial referencing by coordinates*

[13] ISO 19115-2, *Geographic information — Metadata — Part 2: Extensions for imagery and gridded data*

[14] ISO/TS 19129, *Geographic information — Imagery, gridded and coverage data framework*

[15] ISO 19126, *Geographic information — Feature concept dictionaries and registers*[3)]

3) To be published.

ICS 35.240.70

Price based on 30 pages