Report on the Harmonization of Global and Regional Land Cover Products Meeting

Rome, Italy

14th – 16th July 2004

Herold, M. and Schmullius, C.

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD)
ESA GOFC-GOLD Land Cover Implementation Team Project Office

GOFC-GOLD Report No. 20

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and other land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management.

GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality.

GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GOFC-GOLD Secretariat is hosted by Canada and supported by the Canadian Space Agency and Natural Resources Canada. Other contributing agencies include NASA, ESA, START and JRC. Further information can be obtained at http://www.fao.org/gtos/gofc-gold

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1. November 2004

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1 Summary and main outcomes

The workshop focused on finding international consensus and development of an implementation strategy for a joint initiative on harmonization and validation of global and regional land cover datasets. The overall goal was to improve the compatibility and comparability of land cover products with particular focus on harmonizing upcoming mapping projects such as GLOBCOVER. Besides the development of a general framework for harmonization efforts, the main components of the implementation strategy are:

- **Harmonization resources:** GOFC-GOLD in conjunction with GTOS and FAO will provide resources for harmonizing land cover datasets and encourage actors involved in land cover mapping to use them. A key resource is the FAO Land Cover Classification System (LCCS). During the workshop, LCCS was identified and tested as appropriate classification system for a common land cover language. GOFC-GOLD and GTOS recommend to space agencies and other actors involved in land cover mapping to use LCCS as a standard for land cover legend generation, translation and as exploratory tool for comparing and contrasting different legends. GOFC-GOLD will work towards international consensus for the classifier thresholds and their hierarchy use in LCCS.
- **Harmonization evaluation:** Legend translations and harmonization exercises will be completed in order to evaluate the harmonization resources and provide better understanding on how to approach the heterogeneity of existing land cover datasets and their legends. The first step was to develop legend translation protocols for different existing legends into LCCS (e.g. for IGBP, CORINE, IPCC etc.). Several case studies coordinated through GOFC-GOLD will develop and document harmonization procedures for both global and regional datasets in specific test sites, i.e. in Siberia, Mongolia, SE-Asia, Thuringia etc..
- **Harmonized future mapping projects:** It can be expected that true harmonization has its most impact in the development phase of land cover datasets. In fact, the whole initiative can only be successful if the harmonization efforts influence operational land cover data collection. Mapping projects are encouraged to profit from resources and knowledge acquired on harmonization, especially in terms of identified problems and inconsistencies in existing legends. This should be particularly true for land cover products that are derived for a variety of purposes and not for a specific user or applications. GOFC-GOLD fosters capacity building to influence land cover mapping activities and projects.
- **Harmonization and validation:** A common language and understanding of semantic differences between the dataset is essential for comparative analyses of accuracy between different land cover datasets. Thus, harmonization and validation are parallel efforts. In close cooperation with the CEOS Cal/Val Group, GOFC-GOLD will push forward an international proposal and identify resources to validate all existing and planned global land cover datasets including ESA's future GLOBCOVER products. The validation will follow the best practice guidance from CEOS Cal/Val and incorporate the GOFC-GOLD regional networks.

In general, the workshop has resulted in a framework for international cooperation to approach a joint harmonization and validation initiative for land cover datasets. The individual members of the land cover mapping community are encouraged to provide their share in this initiative. The space agencies and major users of global land cover datasets should support the initiative with resources and funding. An essential requirement for this initiative to be successful is continuity in satellite observations. This includes both global land cover mapping sensors (e.g. MODIS, MERIS etc.) and higher spatial resolution systems for continuous accuracy assessment.

2 Introduction and objectives

There is a growing need for detailed and accurate information on land cover and land cover change on all geographic scales. Based on a variety of international mapping efforts and standards, a variety of regional and global land cover products have been derived such as IGBP DISCOVER, MODIS land cover product, GLC2000, CORINE LC1990 and 2000, AFRICOVER etc.. There is, however, no common language between these different maps and their thematic legends. This hinders useful application, in particular for analysis of changes, the comparison between them and complicates their validation.

During the 2nd GOFC-GOLD Land Cover Implementation Team (LC-IT) meeting in Jena, Germany in March 2004, GOFC-GOLD, ESA, GTOS and FAO agreed to foster the harmonization and validation of global land cover products. The action plan of the Jena-meeting identifies the need for an additional workshop on this issue. The ESA GOFC-GOLD Project Office prepared and organized, jointly with FAO, this workshop on harmonization of land cover products. The workshop was held 14th-16th of July 2004 at the FAO in Rome. Several topics were discussed during the workshop:

- Framing international harmonization efforts (consensus on theory, key actors and participants, harmonization mechanism and implementation strategy),
- Application of the FAO Land Cover Classification System (LCCS-2) as common language and translator,
- Establishment of test beds for development and evaluation of harmonization efforts
- Harmonization as part of global land cover validation efforts

The outcome of the meeting is of particular interest for future global land cover mapping efforts such as GLOBCOVER.

3 Participants

The workshop brought together key participants essential for a successful implementation of harmonization efforts. Participants included GOFC-GOLD LC-IT members, representatives from FAO and GTOS, ESA, CEOS, IGBP and UNEP, JRC, DLR, research universities focused on global land cover mapping (i.e. Boston University, University of Maryland), and from national academies of sciences of Slovakia and Mongolia. The complete participation list is shown in Appendix A.

4 Agenda

The workshop was organized in three parts:

1) The presentations focus was on reviewing current approaches to land cover classification, knowledge and requirements for harmonization, establishment of processes for harmonization of land cover products as well as identification of test beds and case studies.
2) A tutorial of the LCCS was held to introduce this classification system to the workshop participants. LCCS was tested as a device to translate several existing land cover legends such as IGBP and CORINE.
3) The workshop discussions and the knowledge gained during the LCCS tutorial were emphasized as important tools in the development of implementation strategy for harmonization of regional and global land cover products. This process identified

several action items to implement harmonization processes and foster a coordinated international effort in validation of global land cover products.

A detailed agenda can be found in Appendix B.

5 Summary of presentations and workshop topics

5.1 Harmonization procedure and processes

Harmonization is a process to union similarities in existing definitions to allow intercomparability between heterogeneous land cover datasets. The process follows a "bottom up" perspective. Beginning from a state of divergence in land cover datasets it seeks compatibility and comparability. Harmonization does not necessarily eliminate all inconsistencies. Standardization, in contrast, is a "top down" process. It requires common definitions and standards to derive land cover information and should eliminate all inconsistencies between the datasets.

In general, dataset heterogeneity in land cover maps results from different standards being used to derive them and is multifaceted. They include syntactic issues (e.g. logical data models: vector/raster), schematic heterogeneity (e.g. database models, spatial reference systems, cartographic standards) and semantic aspects. The latter one refers to naming and cognitive conceptualizations of land cover legends and has been the focus of this workshop. Land cover legends are developed for multiple purposes but rarely result from a systematic or standardized classification system. For example, maps have been derived by different national and international mapping agencies or for several applications with their specific legends and mapping approaches. In remote sensing applications, land cover definitions often result from spectral classes. Despite such differences, there is no internationally accepted land cover classification system. Many applications, however, require compatibility of land cover data and the ability to compare them within and between countries, within and between applications and from local to global scales. This is especially true for datasets that were derived to serve multiple purposes like many regional and global land cover products.

Harmonization efforts to overcome these issues were initiated by UNEP/FAO in the early 1990s parallel with the increased use of GIS and spatial analysis. The main objective of this initiative was a response to the need for harmonized and standardized collection of data mentioned in UNCED's Agenda 21 (Chapter 10), for which the FAO is task manager within the UN system. The importance of harmonized land cover/use information was further endorsed by the WSSD in Johannesburg and four UN-coordinated international conventions on climate, biodiversity, desertification and forest. Versatile international harmonization experiences exist, e.g. in fields of economy, legal issues, medicine and environmental statistics. A prominent example is the world-wide harmonization of soil maps. The FAO classification system was used as common classification system and common language to join national and regional soil maps and their legends. The first expert meeting on harmonizing land cover and land use maps was hosted by UNEP/FAO in November 1993 in Geneva. The meeting was framed by a strong push for a single land cover and land use legend. However, several participants emphasized that too much standardization reduces application relevance of such data and should be more important to standardize terminology rather than categories. The participants of this meeting suggested that two independent working groups on land cover and land use be formed. The development of a prototype international reference system was fostered, which eventually became the FAO Land Cover Classification System (LCCS).

Also, there was need for case studies to evaluate the usefulness of such a bridging classification system. To have an impact on operational land cover/use data collection, harmonization efforts have to involve representatives from producers of land cover maps (space agencies, land cover facilities), users of such products (FAO, UNEP) and the science community. GOFC-GOLD provides the appropriate framework to establish and coordinate the communication between these actors. During the GOFC-GOLD workshop in March 2004, the land cover implementation team decided to coordinate and foster the international harmonization efforts. The implementation strategy included a current focus on 'land cover', the establishment of test beds and case studies, the evaluation of LCCS as land cover legend translation device and an implementation workshop to coordinate the initiative, which then resulted in the organization of this Rome workshop.

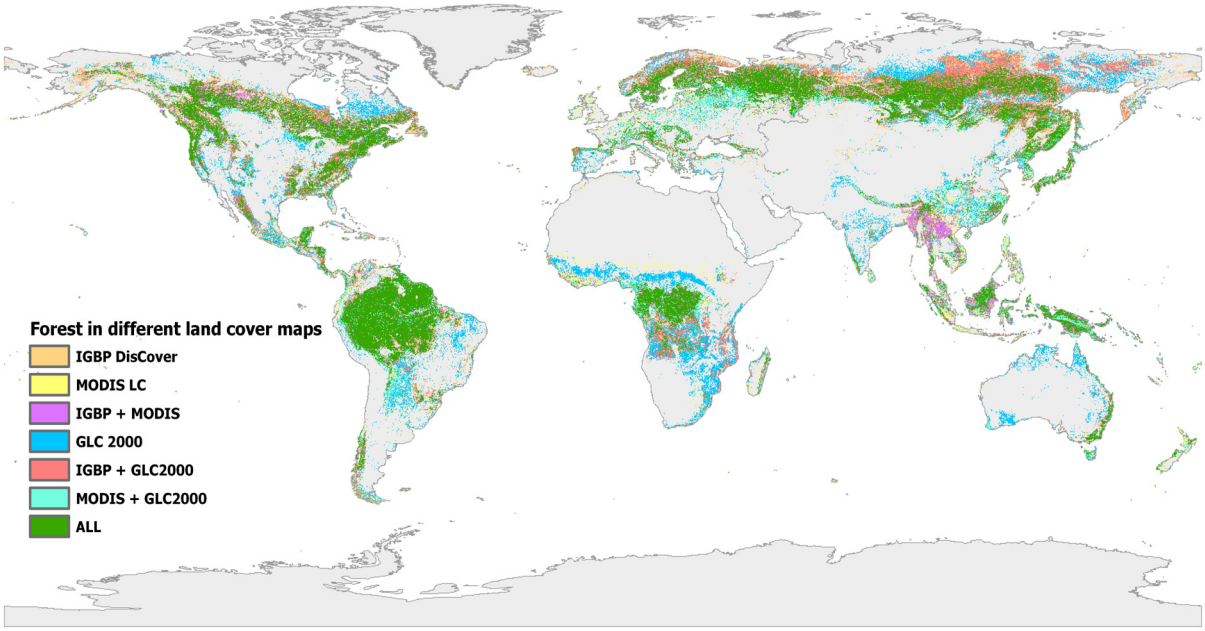


Fig.1: Forest areas as represented in three different global land cover maps: IGBP Discover (classes 1-5), MODIS land cover (classes 1-5) and GLC2000 (classes 1-8).

Participants of the harmonization workshop in Rome represented different regional and global earth observation land cover mapping programs and agencies. They emphasized the framework and approaches used to derive their legends and elaborated on probable inconsistencies in their land cover definitions. There often is confusion between the terms classification and legend, especially in treatment of mixed units, as well as unclear separations between land cover and land use terms (e.g. Anderson classification system). Common problems exist in definitions of land cover types. For example the description of forest, hence the discrimination between trees and shrubs is usually based on the minimum height and percent cover of trees. The IGBP legend defines a forest with a percent tree cover >60% and a height exceeding 2 meters. GLC2000 uses percent tree cover >15% and height exceeding 3 meters to discriminate shrubs and trees. This difference is a major reason for the disagreement between the forested areas represented in existing global land cover maps (Fig.1). Although there is a fair amount of agreement (green areas), GLC2000 represents the most forested areas (on blue) since the percent cover threshold is the lowest and more areas are assigned to forests. This difference is most prominent in transition zones between tropical forests and savannahs and boreal forests to tundra vegetation.

Existing land cover classification systems sometimes show internal imbalances and inconsistencies. For example, the EarthSat GeoCover Global Land Cover legend defines a forest with woody vegetation >35% canopy closure and a minimum of 3m height. Shrubs are represented with a height less than 3m. However, it is not clear how to categorize areas with trees more than 3m height with less than 35% cover hence there is a gap between the classes forest and scrubland. Some legends have artifacts that result from the mapping approach and process. In the EarthSat GeoCover Global Land Cover legend, the grassland category may include herbaceous wetlands if the remote sensing images used to derive the land cover map were collected during the dry season or in periods of drought. This class definition represents an overlap between grasslands and wetlands and complicates the application of the map. These experiences again emphasized the importance to foster harmonization between existing legends and for future mapping initiatives.

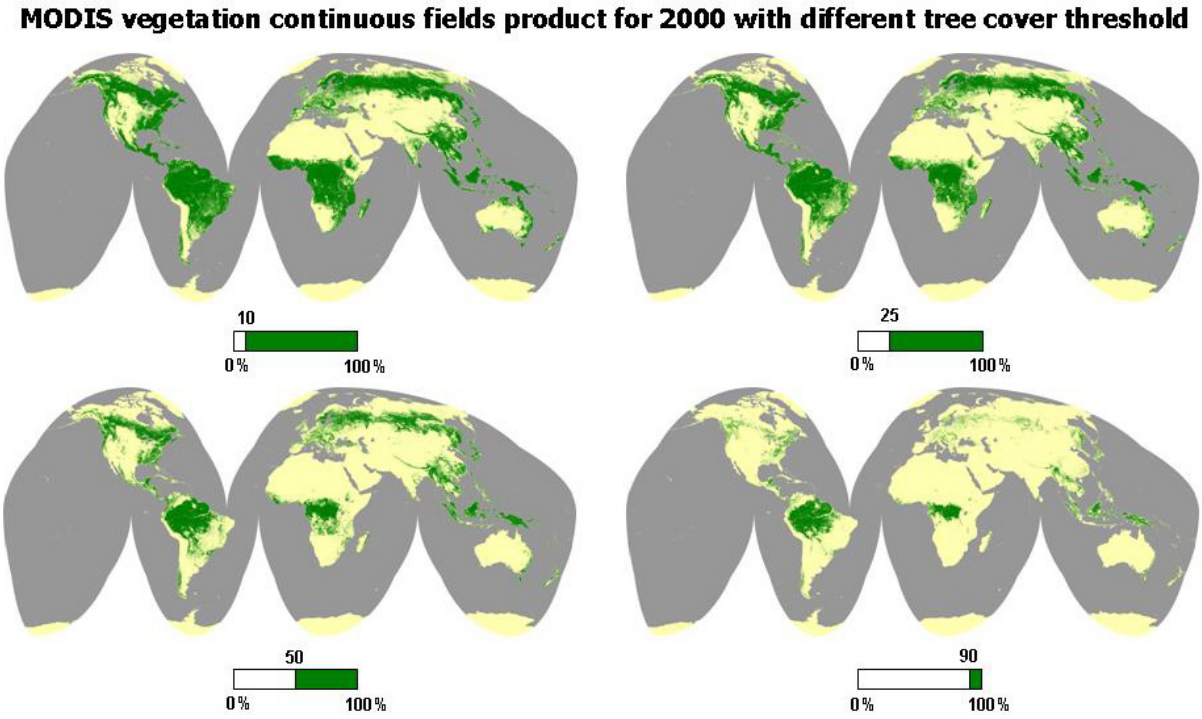


Fig. 2: Comparison of MODIS vegetation continuous field product with different thresholds for percent tree cover (courtesy of M. Hansen, Global Land Cover Facility)

Vegetation continuous field products can play an important role in harmonization of global and regional land cover products. Given a clear definition of the basic vegetation traits (e.g. trees), these products could be incorporated into existing classifications and used to overcome some of the definition differences. Fig. 2 shows an example of the MODIS continuous field tree cover dataset for the year 2000. The variable tree cover thresholds and help to harmonize variably defined vegetation categories.

The harmonization efforts should consider the experiences in the field dealing with 'Interoperability in GIS'. The research has developed methods to resolve terminological and conceptual incompatibilities in spatial datasets. There are approaches to measure semantic similarities between categories using natural language processing or concept lattices and for integration of heterogeneous ontologies.

5.2 Land Cover Classification System (LCCS)

During the GOFC-GOLD meeting in Jena, Germany, the FAO Land Cover Classification System (LCCS) was identified as appropriate classification system to provide a common language and legend translation device. It was recommended to hold a training workshop. This workshop was conducted in Rome, where a tutorial on the LCCS-2 software was held. During the workshop participants were able to familiarize with LCCS concepts, applications and legend translation capabilities (Fig.3).

Fig 3: Discussions during the LCCS tutorial at the harmonization workshop in Rome (from left: C. Schmullius, M. Brady, C.Woodcock, M. Keil, A. Di Gregorio, H.-J. Stibig).

LCCS was created by FAO and UNEP in response to a need for harmonized and standardized collection of land cover data, availability of land cover data for a wide range of applications and users, and comparison and correlation of land cover classes. LCCS is a priori classifier. It represents a world-wide reference system for land cover able to combine high flexibility (ability to describe land cover features all over the world at any scale or level of detail) with an absolute level of standardization of class definitions between different users. The system allows a dynamic creation of classes without the user having to relate to a pre-defined list of names by a dynamic combination of land cover diagnostic attributes called classifiers. In its basic dichotomous categorization level LCCS distinguished eight major land-cover groups (Fig. 4). These classes can be further described in the modular-hierarchical phase where the set of classifiers and their hierarchical arrangement are tailored to the major land cover type. Further definition of the Land Cover Class can be achieved by adding attributes. Two types of attributes, which form separate levels in the classification, are distinguished: environmental attributes (e.g. climate, land form, soils/lithology and erosion) and specific technical attributes (e.g. floristic composition, crop type and soil type).

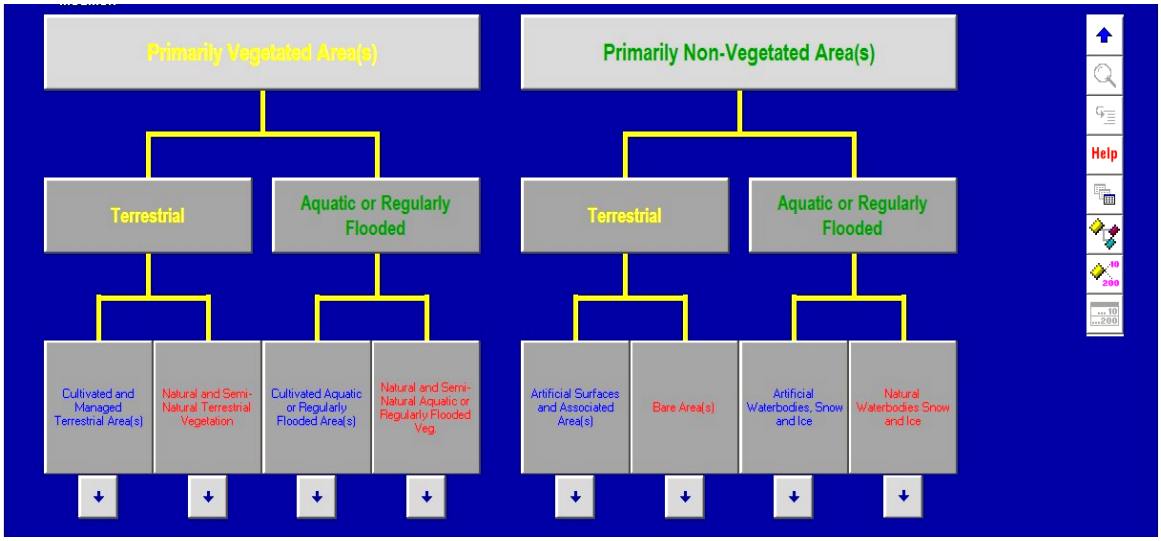


Fig 4: LCCS-2 user interface at the initial dichotomous classification phase.

The LCCS software program contains four different Modules (Fig.5). In the classification module land cover classes are defined by the combination of a set of independent classifiers, which are hierarchically arranged and which can be linked with environmental and specific discipline related attributes. The section on legends stores defined land cover classes according to the domains to which these classes belong. This module allows export of data in commonly used file formats and allows users to add user-defined names to the standard names provided. The field data module helps to store detailed field survey information and automated classification of the data using retrieval and edit functions. Finally, the translator can be used to compare and correlate classifications and/or legends. The new version of the Land Cover Classification System (LCCS-2) has been released recently. The software is completed and ready for download from the LCCS web page from beginning of September 2004. The LCCS-2 manual is in the language editing phase and will be ready for download at the end of September 2004. Translations in French, Spanish and Arabic are scheduled for 2005.

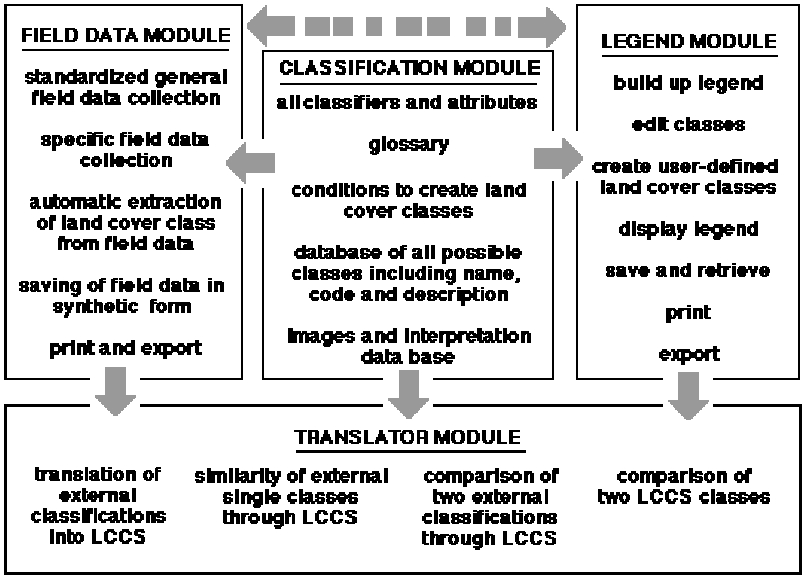


Fig. 5: Overview of LCCS software program functionalities.

A central component in creating land cover legends from LCCS-2 is the incorporation of mixed unit classes. Several kinds of mixed units exist and can be defined within LCCS-2 (Fig.6). The mixture **A/B** between two classes represents a cartographic generalization, since the extent of the features is smaller than the M.M.A. It means that both features A and B exist, i.e. in classes of mixed forest. The feature A is predominant (larger area extent in the polygon) as compared to B (B covers at least 20% of the polygon area). A cartographic mixed unit can be used with more than 2 classes. **A//B** is a thematic generalization. It means the area can have the feature A or the feature B, i.e. for classes like "snow and ice". **A///B:** is time-related information. It is used only for agricultural classes and means the area has the class A one year and the other year the class B. Another type of mixed units **A+B** exists if different layers are present, e.g. to describe areas with agro-forestry.

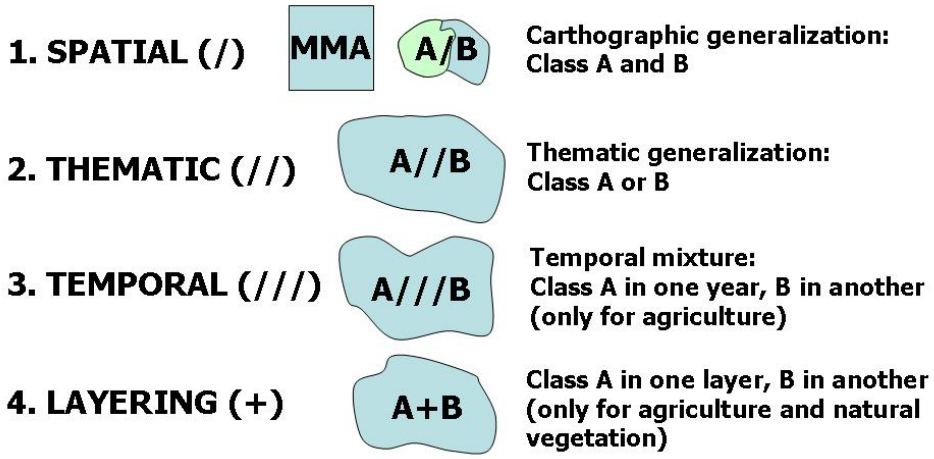


Fig.6: Mixed unit concept within LCCS-2 (MMA = minimum mapable area).

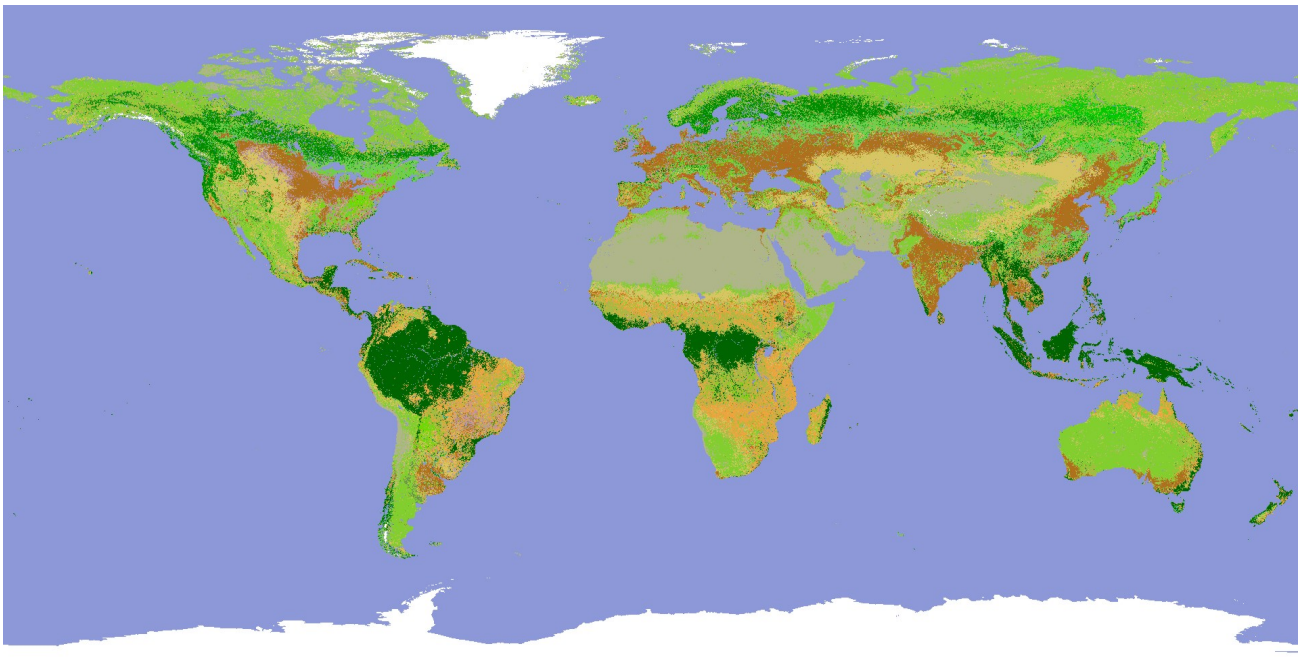
5.3 LCCS tutorial and legend translation demonstration

Since the first release of LCCS-1 in 2000 several training and workshops have been organized by FAO/UNEP to familiarize users with LCCS. During the harmonization workshop in Rome a tutorial was held to demonstrate LCCS-2 capability in translating existing land cover legends. Appendix C describes translation examples for the IGBP and CORINE legend into LCCS. The IGBP legend was translated based on their class definitions (Fig.7). The comparison shows general differences in terminology (forest versus trees), different types of thematic and cartographic land cover mixtures (e.g. woody savannah versus woodland with herbaceous layer). A more detailed description of the IGBP translation can be found in Appendix C.

The translation of the CORINE 2000 (Appendix D) legend seems more complicated than for IGBP (Appendix C). CORINE reflects this specific issue because of two main reasons. First it is legend for visual, polygon-based interpretation of remote sensing data and secondly it represents a mix between land cover and land use categories. The class definition for the translation were taken from the 'CORINE land cover technical guide 2000' prepared by M. Bossard, J. Feranec and J. Otahel. Some classes are quite complex in their definition this needs to be taken into consideration in the translation process. Some class translation are straightforward, e.g. for some artificial surfaces, or class 211 (Non-irrigated arable land). Other categories have complex land characteristics like 242 (Complex cultivation pattern) or

243 (Land principally occupied by agriculture, with significant areas of natural vegetation). In LCCS they reflect multifaceted thematic and cartographic mixtures (Appendix D).

Legend translations should also consider the land cover/use requirements of international conventions, guidelines and treaties. For the implementation of the Kyoto Protocol, the Intergovernmental Panel on Climate Change (IPCC) has provided Good Practice Guidelines (GPG, 2003) for Land Use, Land-Use Change, and Forestry (LULUCF). Although the report defines a mixture of land use and land cover categories they are defined in a land cover context. The translations of the six major categories into LCCS are presented in Appendix E. The legend for GLC2000 was developed in LCCS and related resources can be found in Appendix F. Further suggestions for LCCS-2 legend translation are shown in Appendix G (Canadian EOSD classification system) and Appendix H (Anderson Level I and II).



Color	IGBP class	LCCCode	LCCLevel	LCCLabel
	Evergreen needleleaf forests	20092	A3A10B2XXD2E1	Needleleaved Evergreen Trees
	Evergreen broadleaf forests	20089	A3A10B2XXD1E1	Broadleaved Evergreen Trees
	Deciduous needleleaf forests	20093	A3A10B2XXD2E2	Needleleaved Deciduous Trees
	Deciduous broadleaf forests	20090	A3A10B2XXD1E2	Broadleaved Deciduous Trees
	Mixed forests	20006(1)[Z1]	A3A10B2Z1	Closed Trees
	Closed shrublands	20018-13476	A4A10B3-B9	Closed Medium High Shrubland (Thicket)
	Open shrublands	20022-13476	A4A11B3-B9	Open Medium High Shrubs (Shrubland)
	Woody savannas	20317-1	A3A11B2XXXXXXF2F4F7G4-A12	((70-60) - 40%) Woodland with Herbaceous Layer
	Savannas	20014-3012	A3A11B2-A13	Open (40 - (20-10)%) Trees (Woodland)
	Grasslands	21453	A2A20	Herbaceous Closed to Open Vegetation
	Permanent wetlands	0007	A24	Natural And Semi-Natural Aquatic or Regularly Flooded Vegetation
	Croplands	10025	A3	Herbaceous Crop(s)
	Urban and built up lands	5001	A1	Built Up Area(s)
	Cropland/natural vegetation mosaics	10025 / 0004	A3 / A12	Herbaceous Crop(s) / Natural And Semi-Natural Primarily Terrestrial Vegetation
	Snow and Ice	8005 // 8008	A2 // A3	Snow // Ice
	Barren	6001 // 6004	A1 // A2	Consolidated Material(s) // Unconsolidated Material(s)
	Water bodies	8001 // 7001	A1 // A1	Natural Waterbodies // Artificial Waterbodies

Fig 7: MODIS global land cover map with IGBP legend. The IGBP legend was translated to LCCS during the harmonization workshop in Rome. The MODIS product is available for download from Boston University: http://duckwater.bu.edu/lc/mod12q1.html.

During the workshop, the participants learned that nearly every legend can be translated into the LCCS framework if sufficient information is available on the category definitions. The translation process should be described as well and a complete translation protocol should

include the original definitions of the land cover classes (including class codes and name etc.), the LCCS label, level and code, and a translation note for each class. The translation note should ensure that every user of the translated legend understands how the class conversion into LCCS was done. If the translation is straightforward a note might not be required but it is essential if there are remaining problems or incompatibilities with LCCS. Translated legends will be made available on the GOFC-GOLD webpage (http://www.gofc-gold.uni-jena.de/).

However, despite successful examples for legend translation, this step does not resolve all inconsistencies between the semantics of land cover datasets. It rather provides an outline of differences and shows, which classes can be harmonized and which cannot. Furthermore, the translation provides only the first step in the harmonization. Other heterogeneities still remain, e.g. from cartographic standards. There was consensus at the workshop that harmonization will have limitations for retro-fitting and intercomparison of existing classification schemes even after a successful translation. Harmonization exercises for existing datasets should mainly focus on outlining these inconsistencies and try to provide better understanding on how and why these datasets are not comparable. This information is essential for future projects and harmonization should take particular action for upcoming land cover mapping efforts. Thus, LCCS will be endorsed for land cover legend generation and as exploratory tool for comparing and contrasting classification schemes. GOFC-GOLD LC IT and GTOS will recommend LCCS as a standard to space agencies to endorse this to CEOS and any related land cover projects. As part of that process, GOFC-GOLD will work towards international consensus for the thresholds and a hierarchy of thresholds used in LCCS.

5.4 Test beds and case studies

Knowledge on translation, harmonization and comparison between global and regional land cover maps will be acquired through case studies coordinated by the ESA GOFC-GOLD LC IT project office. The goal is to complete harmonization exercises between global and regional datasets in specific test sites. Test bed studies will be established in Siberia, Mongolia, SE-Asia and Thuringia/Germany. Comparative analysis and evaluation of the harmonized products are based on local expertise and in situ data. The final documentation will include limitations and capabilities of the harmonization mechanisms, the use of LCCS, and should provide indications for inconsistencies in existing land cover maps. The experiences should help to refine the implementation strategies and support the development of future land cover products (e.g. GLOBCOVER).

5.5 Validation of global land cover maps

Validation is important both during the production and after the completion of land cover maps. For global land cover datasets this becomes a particularly challenging effort and requires coordinated international efforts. Since a harmonization strategy forms the basis for a joint validation of existing global land cover maps this issue has been discussed and proposed during the workshop. In conjunction with the CEOS Cal/Val Group, GOFC-GOLD will push forward an international proposal to parallelize harmonization and validation efforts and identify resources to validate all existing and planned global land cover datasets including GLOBCOVER products. The general approach is to develop a "living" dataset of validation sites that could be used to verify any new land cover map. The intent is to select the sites in such a way that they are not associated with any specific land cover map and that they may retain statistically rigor when used on a variety of maps. The validation will be based on high-resolution satellite data and incorporate the GOFC-GOLD regional networks. LCCS provides the framework to translate the individual interpretations into the various legends. The process

will also foster the capacity building efforts to make LCCS more known and available to the community involved in earth observation. In that context, the efforts in harmonization and validation of land cover products will influence the ESA initiated GLOBCOVER project.

6 Discussions and action items

Based on the workshop presentations, the LCCS tutorial and legend translation exercise, the following decisions were made during the wrap-up discussions:

1) GOFC-GOLD endorses LCCS-2 for land cover legend generation.
2) GOFC-GOLD endorses LCCS-2 as an exploratory tool for comparing and contrasting classification schemes.
3) Limitations are recognized for retro-fitting of existing classification schemes. Most impact for harmonization efforts is expected for future mapping efforts.
4) Endorsement of a hierarchy of thresholds (different levels of specificity) within LCCS for compliance.
5) GOFC-GOLD LC IT/GTOS recommends that space agencies use LCCS-2 as a standard, space agencies should endorse this to CEOS and any land cover project.

Specific action items have been identified to foster the land cover harmonization efforts:

1) Elaborate thresholds / search for consensus (height, canopy closure, crown area, fragmentation) – (AI: Woodcock)
2) Contact active mapping projects to apply thresholds developed under 1) (AI: Herold)
3) Translation action for CORINE (AI: Keil)
4) Summarize experience with LCCS-2 in test beds (AIs: Herold for Thuringia, Skinner for Sib-II, Samek for SE-Asia, Davaasuren for Mongolian test sites)
5) Review the list of minimum LCCS-2 classifiers to be used for GLOBCOVER (AI: Stibig)
6) GOFC-GOLD LC IT/GTOS supports LCCS-2 outreach via regional networks (regional network leads = LCCS-2 incubators) (AI: Brady)
7) Present LCCS-2 during NASA LCLUC-meeting organised by Garik Gutman (AI: Woodcock) and LUCC-meeting (AI: Herold)
8) Protocol on filling gaps, help manual on creating legends (AI: Di Gregorio)

An important outcome of the meeting was an outline for the next step in GOFC-GOLD efforts in a joint validation of existing global land cover datasets. The next validation action items are:

1) Comparison of MODIS LC product and GLC2000 with validation datasets (Landsat or ground-truth) in testbeds Thuringia and Sib-II (FSU), East Africa (JRC)
2) Through LC IT, Regional Networks implement field work in LCCS-2 nomenclature.
3) NASA`s Validation Proposal revisited, BACKGROUND: globally inconsistent validation site network (exploit GLCN?), no link between MODIS LC and GLC validation procedures, prepare GLOBCOVER strategy

SUGGESTIONS: LC IT, LCCS-2 MAP (Mapping Accuracy Program)

FUNDING OPTIONS (IMMEDIATE ACTION NECESSARY NOW): ESA – only in the long run, NASA – only partially, GOFC IT?, GLCN – validation money only through provision of software/images/proposal support, GMES proposal, CEOS validation white paper, IGOL initiative. BU/ESA GOFC-GOLD LC PO/GLCN (tbd) will be the home for the global validation site's living database. (AI White Paper Draft on validation strategy: Woodcock+Brady)

Open Issues to be revisited:

1) LC IT Regional Network Field Implementation (MAP Software not ready yet)
2) Cartographic standards - requirement: minimum mapping unit
3) "regional" definitions vs. FRA definition vs. historical work
4) Compliance with inventories?
5) Conflict with land **use** categories
6) Protocol on filling gaps, help manual on creating legends
7) Outreach
8) Harmonisation is a PROCESS: each project should start with "global harmonisation"

Appendix A - List of Participants

External participants:

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Appendix B - Agenda

Wednesday, 14 July **MEXICO ROOM - D211**

15.00-17.00 Preparation of workshop, installation of the test bed datasets
A. Martucci, M. Herold, C. Neumann

Thursday, 15 July **LEBANON ROOM - D209**

8.45 - 09.40 **SESSION 1: Update on GOFC-GOLD Land Cover activities.**

1.1 Welcome, scope and organizational information
J. Latham

1.2 Framing harmonization of land cover products
M. Herold

09.40 -10.00 **Coffee**

10.00 -12.00 **SESSION 2: Global Land Cover Products and Harmonization Experiences.**

2.1 LCCS-2 – Status-quo
A. Di Gregorio

2.2 MODIS / Validation of global land cover products
C. Woodcock

2.3 Harmonized land cover products from continuous fields products - requirements for a translation
M. Hansen

2.4 Learning from GLC2000 – harmonization requirements
H-J Stibig

2.5 GLOBCOVER
O. Arino

2.6 Local versus Global legends, LCCS a tool for harmonization?
A. Di Gregorio

12.00 -13.00 **Lunch**

13.00 -14.40 **SESSION 3: Harmonization: Test Beds and Implementation**

3.1 CORINE/European harmonization needs + efforts
J. Feranec

3.2 Thuringia as testbed for harmonization of global land cover product and change analysis
K. Neumann

3.3 Land cover classification in Siberia
L. Skinner

3.4 Tropical forest cover change monitoring in Amazon and SE Asia
J. Samek

3.5 Land cover mapping in Mongolia and contribution of harmonized land cover maps for national mapping agencies
N. Davaansuren and N. Zagdaa

14.40 -15.00 **Coffee**

15.00 -18.00 **SESSION 4: LCCS-2 Tutorial on Computer (lead by Antonio Di Gregorio)**

Friday, 16 July **LEBANON ROOM - D209**

9.00 -10.30 **SESSION 5: Practical Training: Application of LCCS-2 for legend translation**

10.30 -11.00 **Coffee**

11.00 -13.00 **SESSION 5: continued**

13.00 -14.00 **Lunch**

14.00 -16.00 **SESSION 6: Synthesis**

Wrap-up, Discussion, Future plans
Framing global land cover product harmonization
Harmonization and validation
Local versus global harmonization
Testbeds and implementation strategy

16.00 **Meeting closure**

Appendix C – Example of legend translation – IGBP

(Note: This legend translation is a suggestion and open for consensus discussion.)

IGBP class	LCCLabel	LCC-Code	LCCLevel	IGBP description	Translation Notes
Evergreen Needleleaf Forests	Needleleaved Evergreen Trees	20092	A3A10B2XXD2E1	Lands dominated by woody vegetation with a percent cover > 60 % and height exceeding 2 meters. Almost all trees remain green all year. Canopy is never without green foliage.	LCCS limits tree height classification to > 3 m
Evergreen Broadleaf Forests	Broadleaved Evergreen Trees	20089	A3A10B2XXD1E1	Lands dominated by woody vegetation with a percent cover > 60 % and height exceeding 2 meters. Almost all trees and shrubs remain green year round. Canopy is never without green foliage.	LCCS limits tree height classification to > 3 m
Deciduous Needleleaf Forests	Needleleaved Deciduous Trees	20093	A3A10B2XXD2E2	Lands dominated by woody vegetation with a percent cover > 60 % and height exceeding 2 meters. Consists of seasonal needleleaf tree communities with an annual cycle of leaf-on and leaf-off periods.	LCCS limits tree height classification to > 3 m
Deciduous Broadleaf Forests	Broadleaved Deciduous Trees	20090	A3A10B2XXD1E2	Lands dominated by woody vegetation with a percent cover > 60 % and height exceeding 2 meters. Constists of broadleaf tree communities with an annual cycle of leaf-on and leaf-off periods.	LCCS limits tree height classification to > 3 m
Mixed Forests	Broadleaved Closed Trees / Needleleaved Closed Trees	20088 / 20091	A3A10B2XXD1 / A3A10B2XXD2	Lands dominated by woody vegetation with a percent cover > 60 % and height exceeding 2 meters. Consists of tree communities with interspersed mixtures or mosaics of the other four forest types. None of the forest types exceeds 60 % of landscape.	LCCS limits tree height classification to > 3 m Tricky IGBP definition, since none of the other 4 forest types should exceed a 60 % coverage. However, often not all those types are present so that one type may exceed this threshold easily.
Closed Shrublands	Closed Medium High Shrubland (Thicket)	20018-13476	A4A10B3-B9	Lands with woody vegetation less than 2 meters tall and with shrub canopy cover > 60 %. The shrub foliage can be either evergreen or deciduous.	LCCS defines shrubland between 5 m and 0.3 m

IGBP class	LCCLabel	LCC-Code	LCCLevel	IGBP description	Translation Notes
Open Shrublands	Open Medium High Shrubs (Shrubland)	20022-13476	A4A11B3-B9	Lands with woody vegetation less than 2 meters tall and with shrub canopy cover between 10 - 60 %. The shrub foliage can be either evergreen or deciduous.	LCCS defines shrubland between 5 m and 0.3 m
Woody Savannas	((70-60) - 40%) Woodland with Herbaceous Layer	20317-1	A3A11B2XXXXXXF2F4F7G4-A12	Lands with herbaceous and other understory systems, and with forest canopy cover between 30 - 60 %. The forest cover height exceeds 2 meters.	LCCS limits tree height classification to > 3 m Lower threshold LCCS vs. IGBP: 40 vs. 30 % “and other understory systems” cannot be specified within LCCS
Savannas	(40 - (20-10)%) Woodland with Herbaceous Layer	20317-3012	A3A11B2XXXXXXF2F4F7G4-A13	Lands with herbaceous and other understory systems, and with forest canopy cover between 10 - 30 %. The forest cover height exceeds 2 meters.	Upper threshold LCCS vs. IGBP: 40 vs. 30 % “and other understory systems” cannot be specified within LCCS
Grasslands	Herbaceous Closed to Open Vegetation	21453	A2A20	Lands with herbaceous types of cover. Tree and shrub cover is less than 10 %.	
Permanent Wetlands	Natural And Semi-Natural Aquatic or Regularly Flooded Vegetation	0007	A24	Lands with a permanent mixture of water and herbaceous or woody vegetation. The vegetation can be present in either salt, brackish, or fresh water.	
Croplands	Herbaceous Crop(s)	10025	A3	Lands covered with temporary crops followed by harvest and a bare soil period (e.g., single and multiple cropping systems). Note that perennial woody crops will be classified as the appropriate forest or shrub land cover type.	
Urban and Built-Up Lands	Built Up Area(s)	5001	A1	Land covered by buildings and other man-made structures.	
Cropland/Natural Vegetation Mosaics	Cultivated and Managed Terrestrial Area(s) / Closed to Open Trees / Closed to Open Shrubland (Thicket) // Herbaceous Closed to Open Vegetation	0003 / 21445 / 21449 // 21453	A11 / A3A20 / A4A20 // A2A20	Lands with a mosaic of croplands, forests, shrubland, and grasslands in which no one component comprises more than 60 % of the landscape.	It was impossible to define a spatially mixed class with more than 3 parts, therefore the last class was added as thematic mix. An alternative could be to define it as layer. Both remedies are not actually correct.
Snow and Ice	Snow // Ice	8005 // 8008	A2 // A3	Lands under snow/ice cover throughout the year.	

IGBP class	LCCLabel	LCC-Code	LCCLevel	IGBP description	Translation Notes
Barren	Bare Area(s)	0011	B16	Lands with exposed soil, sand, rocks, or snow and never has more than 10 % vegetated cover during any time of the year.	LCCS specifies < 4 % vegetation cover for bare areas, snow is actually not included
Water Bodies	Artificial Waterbodies // Natural Waterbodies	7001 // 8001	A1 // A1	Oceans, seas, lakes, reservoirs, and rivers. Can be either fresh or salt-water bodies.	

Appendix D – Example of legend translation – CORINE 2000

The document for the CORINE class definitions can be found here:
http://reports.eea.eu.int/tech40add/en/tab_content_RLR
(Note: This legend translation is a suggestion and open for consensus discussion.)

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
1 Artificial surfaces					
1.1 Urban fabric					
111 Continuous urban fabric	High Density Urban Area(s)	5003-13	A4-A13A14	Most of the land is covered by structures and the transport network. Building, roads and artificially surfaced areas cover more than 80 % of the total surface. Non-linear areas of vegetation and bare soil are exceptional.	> 75 % minimum impermeable area / Note: Should vegetated urban areas be included? They can amount up to 20 % of the total area.
112 Discontinuous urban fabric	Medium Density Urban Area(s) // Low Density Urban Area(s) / Vegetated Urban Area(s)	5003-14 // 5003-15 / 11176	A4-A13A15 // A4-A13A16 / A6	Most of the land is covered by structures. Building, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces. [30 to 80 % of the surface is impermeable.]	Between 30 and 75 % impermeable area / Note: Has 'Vegetated Urban Area(s)' to be included within the LCCS class?
1.2 Industrial, commercial and transport units					
121 Industrial or commercial units	Industrial And/Or Other Area(s)	5003-8	A4-A12	Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilised, e.g. beaten earth) without vegetation occupy most of the area, which also contains buildings and/or vegetation.	Note: LCCS class actually doesn't include many buildings/structures, Corine does, e. g. hospitals, universities, stud farms, security and law and order services etc.
122 Road and rail networks and associated land	Road(s) // Railway(s)	5002-3 // 5002-6	A3-A7 // A3-A10	Motorways and railways, including associated installations (stations, platforms, embankments). Minimum width for inclusion: 100 m.	Note: Corine's 'associations' are strictly speaking not included within LCCS's class.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
123 Port areas	Built Up Area(s) Built-Up Object: Port Area (including Docks, Shipyards, Locks)	5001-A32	A1-A32	Infrastructure of port areas, including quays, dockyards and marinas.	
124 Airports	Built Up Area(s) Built-Up Object: Airport	5001-A21	A1-A21	Airports installations: runways, buildings and associated land.	
1.3 Mine, dump and construction sites					
131 Mineral extraction sites	Extraction Site(s)	5004-2	A2-A6	Areas with open-pit extraction of construction material (sandpits, quarries) or other minerals (open-cast mines). Includes flooded gravel pits, except for river-bed extraction.	
132 Dump sites	Waste Dump(s)/Deposit(s)	5004-1	A2-A5	Public, industrial or mine dump sites.	
133 Construction sites	Built Up Area(s)	5001	A1	Spaces under construction development, soil or bedrock excavations, earthworks.	Note: This can be anything under construction in any state. That's why it is impossible to define with LCCS.
1.4 Artificial, non-agricultural vegetated areas					
141 Green urban areas	Vegetated Urban Area(s)	11176	A6	Areas with vegetation within urban fabric, includes parks and cemeteries with vegetation, and mansions and their grounds.	
142 Sport and leisure facilities	Built Up Area(s) Built-Up Object: Sports and Leisure Facilities	5001-A38	A1-A38	Camping grounds, sports grounds, leisure parks, golf courses, racecourses, etc. Includes formal parks not surrounded by urban areas.	Note: It all depends how you define 'sport and leisure facilities'. Vague LCCS definition.
2 Agricultural areas					

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
2.1 Arable land					
211 Non-irrigated arable land	Rainfed Herbaceous Crop(s)	11498	A3XXXXXXD1	Cereals, legumes, fodder crops, root crops and fallow land. Includes flowers and fruit trees (nurseries cultivation) and vegetables, whether open field, under plastic or glass (includes market gardening). Includes aromatic, medicinal and culinary plants. Does not include permanent pastures.	Notes: Corine includes abandoned land, but only if it lies fallow not more than 3 years. 'Under plastic or glass' and non-irrigated?
212 Permanently irrigated land	Permanently Cropped Area With Irrigated Herbaceous Crop(s)	11506	A3XXXXXXD3D9	Crops irrigated permanently or periodically, using a permanent infrastructure (irrigation channels, drainage network). Most of these crops cannot be cultivated without an artificial water supply. Does not include sporadically irrigated land.	
213 Rice fields	Irrigated Graminoid Crop(s) Dominant Crop: Cereals - Rice (Oryza spp.)	11388-S0308	A4XXXXC1D3-S0308	Land prepared for rice cultivation. Flat surfaces with irrigation channels. Surfaces periodically flooded.	
2.2 Permanent crops					
221 Vineyards	Broadleaved Deciduous Shrub Crop(s) Dominant Crop: Fruits & Nuts - Grapes (Vitis vinifera) Crop Cover: Plantation(s)	10013-1891-S0610W7	A2-A7A10-S0610W7	Areas planted with vines.	Notes: Corine extension - Vineyard areas are classified as 221 if the vineyard parcels exceed 50 % of the area and/or they determine the land use of the area.
222 Fruit trees and berry plantations	Tree Crop(s) Crop Cover: Orchard(s) // Shrub Crop(s)	10001-W8 // 10013	A1-W8 // A2	Parcels planted with fruit trees or shrubs: single or mixed fruit species, fruit trees associated with permanently grassed surfaces. Includes chestnut and walnut groves.	Note: Corine includes hop plantations. A 'may include' (e. g. grassed surface) cannot defined with LCCS, unfortunately. You can only build a mixed class, which is plainly super-inconvenient.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
223 Olive groves	Broadleaved Evergreen Tree Crop(s) Dominant Crop: Industrial Crops - Olive (Olea europaea L.) // Field(s) Of Broadleaved Evergreen Tree Crop(s) (One Additional Crop) (Shrub Crop With Simultaneous Period) . Dominant Crop: Industrial Crops - Olive (Olea europaea L.) Second Crop: Fruits & Nuts - Grapes (Vitis vinifera)	10001-1-S0910 // 11345-1275-S0910S0610	A1-A7A9-S0910 // A1XXXXC2-A7A9C3C6C17-S0910S0610	Areas planted with olive trees, including mixed occurrence of olive trees and vines on the same parcel.	Note: A herbaceous layer may exist.
2.3 Pastures					
231 Pastures	Closed Grassland // Open Woody Vegetation with Closed Herbaceous Layer	20033 // 20299-15057	A6A10 // A1A11B1XXXXXXF2F4F7G4-F8	Dense grass cover, of floral composition, dominated by graminacea, not under a rotation system. Mainly for grazing, but the fodder may be harvested mechanically. Includes areas with hedges (bocage).	'Open Vegetation' = (70-60) to (20-10) % / Notes: Pastures are actually semi-natural. They should not be mentioned here. Corine includes further: Wooded meadows - Meadows where dispersed trees and shrubs occupy up to 50 % of surface of the area. These meadows are characterised by rich floristic composition.
2.4 Heterogeneous agricultural areas					

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
241 Annual crops associated with permanent crops	Field(s) Of Herbaceous Crop(s) (One Additional Crop) (Tree Crop With Simultaneous Period)	11370-12602	A3XXXXC2-C3C5C17	Non-permanent crops (arable land or pasture) associated with permanent crops on the same parcel.	Notes: LCCS, generally, does not consider horizontal spatial arrangement and leaves the choice to the user to consider areas between the fields as part of the cultivated area or not (by building a mixed class). Corine extension - Permanent crops are either in juxtaposition with arable land/pastures or located along the border of the parcels. The occupation rate of non-permanent crops is more than 50 %. Should pastures be included, explicitly?
242 Complex cultivation patterns	Herbaceous Crop(s) // Shrub Crop(s) // Tree Crop(s) // Vegetated Urban Area(s) // Scattered Urban Area(s)	10025 // 10013 // 10001 // 11176 // 5003-17	A3 // A2 // A1 // A6 // A4-A13A17	Juxtaposition of small parcels of diverse annual crops, pasture and/or permanent crops.	Notes: To build this class with LCCS correctly, it would take a multitude of mixtures (thematically and spatially) and mixed classes. Corine extension - This class includes juxtaposition of small parcels of annual crops, city garden pastures, fallow land and/or permanent crops eventually with scattered houses or gardens.
243 Land principally occupied by agriculture, with significant areas of natural vegetation	Herbaceous Crop(s) // Shrub Crop(s) // Tree Crop(s) // Open (40 - (20-10)%) Woody Vegetation // Natural And Semi-Natural Aquatic or Regularly Flooded Vegetation // Natural Waterbodies	10025 // 10013 // 10001 // 20009-3012 // 0007 // 8001	A3 // A2 // A1 // A1A11-A13 // A24 // A1	Areas principally occupied by agriculture, interspersed with significant natural areas.	Notes: Corine extension - This class includes land occupied by agriculture with areas of natural or semi-natural origin (including wetlands and water bodies, out crops). cf. note to class 242

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
244 Agro-forestry areas	Field(s) Of Tree Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop With Simultaneous Period) // Closed to Open (100-40)% Trees + Herbaceous Crop(s)	11345-12626 // 21445-121340 + 10025	A1XXXXC2-C3C7C17 // A3A20-A21 + A3	Annual crops or grazing land under the wooded cover of forestry species.	Notes: Corine extension - This class includes annual crops or grazing land and fallow land covering less than 50 % of the surface. Mixture of forest trees and tree crops building the 'wooded cover' possible, but cannot be defined within LCCS. A tree cover of > 75 % one should define as forest, but there is no possibility in LCCS to define this upper threshold. Has 'grazing land' to be identified (and replenished in LCCS) as pasture?
3 Forest and semi-natural areas					
3.1 Forests					
311 Broad-leaved forests	Broadleaved Evergreen Closed to Open (100-40)% Trees // Broadleaved Deciduous Closed to Open (100-40)% Trees	21496-121340 // 21497-121340	A3A20B2XXD1E1-A21 // A3A20B2XXD1E2-A21	Vegetation formation composed principally of trees, including shrub and bush understoreys, where broad-leaved species predominate.	≥ 40 % crown cover vs. Corine's > 30 % Notes: Could be spatial mix, too. Corine extension - This class includes areas with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure, broad-leaved trees represent more than 75 % of the planting pattern. In case of young plants or seedlings the proportion of broad-leaved plants to be considered is at least 75 % of the total amount of plants.
312 Coniferous forests	Needleleaved Evergreen Closed to Open (100-40)% Trees // Needleleaved Deciduous Closed to Open (100-40)% Trees	21499-121340 // 21500-121340	A3A20B2XXD2E1-A21 // A3A20B2XXD2E2-A21	Vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate.	≥ 40 % crown cover vs. Corine's > 30 % Notes: 'Coniferous' is a floristic term and should be replaced with 'needle-leaved'. Corine extension - Coniferous trees represent more than 75 % of the formation. In case of young plants or seedlings, the proportion of coniferous plants to be considered is at least 75 % of the total amount of plants and their texture is very similar to a surrounding coniferous forest texture.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
313 Mixed forests	Mixed Closed to Open (100-40)% Trees	21497-121341	A3A20B2XXD1E2-A21E3	Vegetation formation composed principally of trees, including shrub and bush understoreys, where neither broad-leaved nor coniferous species predominate.	≥ 40 % crown cover vs. Corine's > 30 % Notes: Corine extension - Mixed forests with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure. The share of coniferous or broad-leaved species does not exceed 25 % *(*)* in the canopy closure. *(Comment: 25 % is perhaps a misprint, more likely is 75 %.)
3.2 Scrub and/or herbaceous vegetation associations					
321 Natural grasslands	Closed Grassland	20033	A6A10	Low productivity grassland. Often situated in areas of rough, uneven ground. Frequently includes rocky areas, briars and heathland.	Notes: Rocks, trees, shrubs (amounting to less than 25 % of the total area) may be included. Corine extension - Natural grasslands are areas with herbaceous vegetation (maximum height is 150 cm and gramineous species are prevailing) which cover at least 75 % of the surface covered by vegetation which developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass); here belong for instance grass formations of protected areas, karstic areas, military training fields, etc. (even though the human interference cannot be altogether discarded in quoted areas, it does not suppress the natural development or species composition of the meadows), areas of shrub formations of scattered trees.
322 Moors and heathland	Closed Shrubland (Thicket)	20017	A4A10	Vegetation with low and closed cover, dominated by bushes, shrubs and herbaceous plants (heather, briars, broom, gorse, laburnum, etc.).	Notes: May include mosses, lichens and herbaceous vegetation. Corine extension - This class includes temperate shrubby area vegetation (climax stage of development): includes dwarf forest trees with a 3 m maximum height in climax stage.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
323 Sclerophyllous vegetation	Closed to Open (100-40)% Shrubland (Thicket)	21449-121340	A4A20-A21	Bushy sclerophyllous vegetation, includes maquis and garrigue. In case of shrub vegetation areas composed of sclerophyllous species such as Juniperus oxycedrus and heathland species such as Buxus spp. or Ostrya carpinifolia with no visible dominance (each species occupy about 50% of the area), priority will be given to sclerophyllous vegetation and the whole area will be assigned class 323.	Note: Corine extension - This class includes evergreen sclerophyllous bushes and scrubs which compose maquis, garrigue, mattoral and phrygana.
324 Transitional woodland-scrub	Closed to Open Shrubland (Thicket) // Open Trees (Woodland) // Herbaceous Open Vegetation	21449 // 20014 // 20037	A4A20 // A3A11B2 // A2A11	Bushy or herbaceous vegetation with scattered trees. Can represent either woodland degradation or forest regeneration/recolonisation.	Note: Corine extension - Areas of natural developmental forest formations (young broad–leaved and coniferous wood species with herbaceous vegetation and dispersed solitary trees) for instance; in abandoned meadows and pastures or after calamities of various origin, part of this class may be also various degenerative stages of forest caused by industrial pollution, etc.
3.3 Open spaces with little or no vegetation					
331 Beaches, dunes, and sand plains	Loose And Shifting Sands	6006	A6	Beaches, dunes and expanses of sand or pebbles in coastal or continental locations, including beds of stream channels with torrential regime.	Note: Corine extension - This class includes supra-littoral beaches and dunes developed at the back of the beach from high water mark towards land.
332 Bare rocks	Bare Rock(s) // Bare Rock(s) / Herbaceous Sparse Vegetation	6002-1 // 6002-1 / 20058	A3-A7 // A3-A7 / A2A14	Scree, cliffs, rock outcrops, including active erosion, rocks and reef flats situated above the high-water mark.	Note: Includes sparsely vegetated areas where 75 % of the land surface is covered by rocks.
333 Sparsely vegetated areas	Herbaceous Open (40 - (20-10)%) Vegetation	20037-3012	A2A11-A13	Includes steppes, tundra and badlands. Scattered high-altitude vegetation.	15 – 40 % vegetation cover vs. Corine's 15 – 40 % / Note: Corine extension - Scattered vegetation is composed of gramineous and/or ligneous and semi-ligneous species for determining the ground cover percentage, excluding cryptograms.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
334 Burnt areas	Bare Area(s) // Sparse Woody Vegetation // Herbaceous Sparse Vegetation	0011 // 20049 // 20058	B16 // A1A14 // A2A14	Areas affected by recent fires, still mainly black.	Note: Corine extension - This class includes burnt forest areas, moors and heathlands, transitory forest-shrub formations, areas with sparse vegetation.
335 Glaciers and perpetual snow	Perennial Ice // Perennial Snow / Bare Rock(s)	8009 // 8006 / 6002-1	A3B1 // A2B1 / A3-A7	Land covered by glaciers or permanent snowfields.	Note: Bare rocks may amount up to 50 % of the surface.
4 Wetlands					
4.1 Inland wetlands					
411 Inland marshes	Closed Grassland	40017	A6A12	Low-lying land usually flooded in winter, and more or less saturated by water all year round.	Note: Corine extension - This class includes non-forested areas of low-lying land flooded or liable to flooding by fresh, stagnant or circulating water. Covered by specific low ligneous, semi-ligneous or herbaceous vegetation.
412 Peat bogs	Closed to Open Herbaceous Vegetation / Closed to Open Lichens/Mosses. // Bare Soil And/Or Other Unconsolidated Material(s)	42155 / 42260 // 6005	A2A20 / A7A20 // A5	Peatland consisting mainly of decomposed moss and vegetable matter. May or may not be exploited.	Note: Includes uncovered peat bogs.
4.2 Maritime wetlands					
421 Salt marshes	Closed Herbaceous Vegetation. Water Quality: Saline Water	40013-R3	A2A12-R3	Vegetated low-lying areas, above the high-tide line, susceptible to flooding by seawater. Often in the process of filling in, gradually being colonized by halophilic plants.	

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
422 Salines	Shallow Artificial Perennial Waterbodies (Standing) Salinity: Brine	7013-5-V5	A1B1C2-A5-V5	Salt-pans, active or in process of abandonment. Sections of salt marsh exploited for the production of salt by evaporation. They are clearly distinguishable from the rest of the marsh by their parcellation and embankment systems.	
423 Intertidal flats	Tidal Area	8004	A1B3	Generally unvegetated expanses of mud, sand or rock lying between high and low water marks. 0 m contour on maps.	Note: Corine extension - Warning: 0 m marine contour on maps is not always based on the same reference system and might differ up to 2 m between European countries.
5 Water bodies					
5.1 Inland waters					
511 Water courses	Natural Waterbodies (Flowing) // Artificial Waterbodies (Flowing)	8001-1 // 7001-1	A1-A4 // A1-A4	Natural or artificial water-courses serving as water drainage channels. Includes canals. Minimum width for inclusion: 100 m.	
512 Water bodies	Natural Waterbodies (Standing) // Artificial Waterbodies (Standing)	8001-5 // 7001-5	A1-A5 // A1-A5	Natural or artificial stretches of water.	
5.2 Marine waters					
521 Coastal lagoons	Perennial Natural Waterbodies (Standing) Salinity: Slightly Saline / Perennial Natural Waterbodies (Standing) Salinity: Moderately Saline	8002-5-V2 / 8002-5-V3	A1B1-A5-V2 / A1B1-A5-V3	Stretches of salt or brackish water in coastal areas which are separated from the sea by a tongue of land or other similar topography. These water bodies can be connected to the sea at limited points, either permanently or for parts of the year only.	Note: One should be able to define saline water without being forced to specify the salinity grade.

CLC class	LCCLabel	LCC-Code	LCC-Level	Corine description	Translation Notes and LCCS specifications
522 Estuaries	Tidal Area (Flowing) Salinity: Slightly Saline	8004-1-V2	A1B3-A4-V2	The mouth of a river within which the tide ebbs and flows.	Note: cf. note on class 521, there is no possibility to define 'brackish' water.
523 Sea and ocean	Perennial Natural Waterbodies Salinity: Slightly Saline / Perennial Natural Waterbodies Salinity: Moderately Saline / Perennial Natural Waterbodies Salinity: Very Saline // Perennial Natural Waterbodies Salinity: Brine	8002-V2 / 8002-V3 / 8002-V4 // 8002-V5	A1B1-V2 / A1B1-V3 / A1B1-V4 // A1B1-V5	Zone seaward of the lowest tide limit.	Note: cf. note on class 521.

Appendix E – Example of legend translation – IPCC

The document for the IPCC class definitions can be found here:
http://www.ipcc-nggip.iges.or.jp/lulucf/cop9/Chp2/Chp2_COP9.pdf
(Note: This legend translation is a suggestion and open for consensus discussion.)

IPCC class	LCCLabel	LCCCode	LCCLevel	IPCC Description	Translation notes
Forest land	Closed to Open Trees // Tree Crop(s)	21445 // 10001	A3A20 // A1	This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided at the national level into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines 3. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.	Note: This IPCC translation is based on thresholds according to GLC2000. *Forest land* requires a tree cover > 15 % and a tree height > 3 m.
Cropland	Herbaceous Crop(s) // Shrub Crop(s)	10025 // 10013	A3 // A2	This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions.	Note: All crops that are below the forest/tree threshold (e.g. 3 m height) are included in this category.
Grassland	Closed to Open Grassland // Closed to Open Shrubland (Thicket)	21461 // 21450-13476	A6A20 // A4A20B3-B9	This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that falls below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, subdivided into managed and unmanaged consistent with national definitions.	Note: All natural and semi-natural shrublands that are below the forest/tree threshold (e.g. 3 m height) are included in this category.
Wetlands	Natural Waterbodies // Artificial Waterbodies	8001 // 7001	A1 // A1	This category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.	The land cover definition of IPCC Wetlands differ substantially from common understanding since all vegetated wetlands fall in the vegetation categories above.
Settlements	Artificial Surfaces and Associated Area(s)	0010	B15	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.	
Other land	Bare Area(s) // Perennial Ice // Perennial Snow	0011 // 8009 // 8006	B16 // A3B1 // A2B1	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.	

Appendix F – Resources on legend translations - GLC2000

The GLC2000 legend was developed from LCCS. There are several resources on the web concerning the GLC2000 legend:

1) Legend description:
http://www.gvm.jrc.it/glc2000/Legend/GLC2000_legend_summary.doc

2) GLC2000 legend an LCCS class coding:
http://www.gvm.jrc.it/glc2000/Legend/GLC2000_Lccs_110604.pdf

3) GLC2000 legend in LCCS import format (xls):
http://www.gvm.jrc.it/glc2000/Legend/GLC2000_Lccs_110604_export.xls

4) Table relating GLC2000 classes to IGBP classes:
http://www.gvm.sai.jrc.it/glc2000/Legend/GLC2000-LCCS_global-legend200602.doc

Appendix G – Example of legend translation – EOSD

This translation is based on the report: by Wulder, M. And T. Nelson 2003. EOSD Land Cover Classification Legend Report. Canadian Forest Service, Natural Resources Canada. Victoria, British Columbia: http://www.pfc.forestry.ca/eosd/cover/EOSD_legend_report-v2.pdf
(Note: This legend translation is a suggestion and open for consensus discussion.)

EOSD Class	LCC Label	LCC Code	LCC Level	EOSD Description	Translation Notes and LCCS specifications (from Wulder and Nelson, 2003)
Coniferous – Dense	Needle leaved Closed Forest	20098	A3A10B2C1D2	Greater than 60% crown closure; coniferous trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Broadleaf – Dense	Broadleaved Closed Forest	20095	A3A10B2C1D1	Greater than 60% crown closure; broadleaf trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Mixed Wood – Dense	Mixed Forest	20099-15045	A3A10B2C1D2 E1-E3	Greater than 60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Coniferous - Open	Needle leaved Woodland	20140	A3A11B2C1D2	26-60% crown closure; coniferous trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD

EOSD Class	LCC Label	LCC Code	LCC Level	EOSD Description	Translation Notes and LCCS specifications (from Wulder and Nelson, 2003)
Broadleaf - Open	Broadleaved Woodland	20137	A3A11B2C1D1	26-60% crown closure; broadleaf trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Mixed Wood - Open	Mixed Woodland	20141-15045	A3A11B2C1D2 E1-E3	Greater than 60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Coniferous - Sparse	Needle leaved Sparse ((20-10) - 4%) Trees	20235-6022	A3A14B2C3D2 -A15	10-25% crown closure; coniferous trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Broadleaf - Sparse	Broadleaved Sparse ((20-10) - 4%) Trees	20232-6022	A3A14B2C3D1 -A15	10-25% crown closure; broadleaf trees are 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD
Mixed Wood - Sparse	Mixed Sparse ((20-10) - 4%) Trees	20236-9018	A3A14B2C3D2 E1-A15E3	10-25% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.	The exhaustiveness of the EOSD classification is no longer ensured when mapped to the LCCS standard, as the inter-class division occur at different locations, such as crown closure and height criteria of the forested classes. Tree height is not specified in the EOSD

EOSD Class	LCC Label	LCC Code	LCC Level	EOSD Description	Translation Notes and LCCS specifications (from Wulder and Nelson, 2003)
Shrub – Tall	Closed High Shrubland (Thicket) Open High Shrubs (Shrubland) Open High Shrubs (Shrubland)	20018-13395 / 20022-13395 / 20022-13395	A4A10B3-B8 / A4A11B3-B8 / A4A11B3-B8	At least 20% ground cover which is at least one-third shrub; average shrub height greater than or equal to 2 m	The shrub classes are over specified in the LCCS scheme with respect to Landsat level information content. No maximum height specified in the EOSD
Shrub – Low	Closed Dwarf Shrubland (Thicket) Open Dwarf Shrubs (Shrubland) Open Dwarf Shrubs (Shrubland)	20018-12050 / 20022-12050 / 20022-12050	A4A10B3-B10 / A4A11B3-B10 / A4A11B3-B10	At least 20% ground cover which is at least one-third shrub; average shrub height less than 2 m.	The shrub classes are over specified in the LCCS scheme with respect to Landsat level information content.
Herb	Open Grassland	20045	A6A11	Vascular plant without woody stem (grasses, crops, forbs, gramminoids); minimum of 20% ground cover **or** one-third of total vegetation must be herb.	Based on the hierarchical Canadian National Forest Inventory land cover classification scheme, the EOSD herb class has two further subdivisions based on the proportion of forbs and graminoid plants. The subclasses Forbs and Graminoids are used when any one group accounts for greater than 50% of the herb cover.
Bryoids	Open Lichens Open Mosses Closed Mosses	21439 / 21440 / 2143	A8A11 / A9A11 / A9A10	Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose; not crustose); minimum of 20% ground cover **or** one-third of total vegetation must be a bryophyte or lichen	To fully capture the EOSD bryoid class need to select four groups or categories as follows: Lichens/Mosses – lichens -closed (>65%) Lichens/Mosses – lichens – open (65-15%) Lichens/Mosses – mosses – closed (>65%) Lichens/Mosses – mosses – open (65-15%)

EOSD Class	LCC Label	LCC Code	LCC Level	EOSD Description	Translation Notes and LCCS specifications (from Wulder and Nelson, 2003)
Exposed Land	Built Up Area(s) Consolidated Material(s) Unconsolidated Material(s)	5001 / 6001 / 6004	A1 / A1 / A2	River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces.	EOSD classes are defined by the dominant material or feature of the non-vegetated area. Exposed land has 16 subclasses
Rock/Rubble	Bare Rock(s) Gravels, Stones And/Or Boulders Bare Rock And/Or Coarse Fragments - Stones	6002-1 / 6002-2 / 6002-9	A3-A7 / A3-A8 / A3-A15	Bedrock, rubble, talus, blockfield, rubbley mine spoils, or lava beds.	EOSD rock/rubble has four subclasses
Wetland - Treed	Woodland Forest Forest	40007 / 40003 / 40003	A3A13 / A3A12 / A3A12	Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is coniferous, broadleaf, or mixed wood.	The EOSD wetland classes are not well captured with the LCCS.
Wetland - Shrub	Open Shrubs Closed Shrubs Closed Shrubs	40011 / 40009 / 40009	A4A13 / A4A12 / A4A12	Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is tall, low, or a mixture of tall and low shrub.	The EOSD wetland classes are not well captured with the LCCS.
Wetland - Herb	Open Medium To Tall Forbs Open Medium To Tall Grassland	40022-44611 / 40024-44611	A5A13B4-B15 / A6A13B4-B15	Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is herb.	The EOSD wetland classes are not well captured with the LCCS.

EOSD Class	LCC Label	LCC Code	LCC Level	EOSD Description	Translation Notes and LCCS specifications (from Wulder and Nelson, 2003)
Snow / Ice	Snow /Ice	8005 / 8008	A2 / A3	Glacier/snow	EOSD Snow/Ice has two subclasses
No Data	N/A				
Cloud	N/A				
Shadow	N/A				

Appendix H – Example of legend translation – Anderson Level I and II

This translation is based on the class descriptions in Anderson, J.R., Hardy, E.E., Roach, J.T., & Witmer, R.E. 1976. A land use and land cover classification system for use with remote sensor data. U.S. Geological Survey Professional Paper, No. 964. USGS, Washington, D.C.: http://www.ncrs.fs.fed.us/4153/deltawest/landcover/LLCoverPub.html
(Note: This legend translation is a suggestion and open for consensus discussion.)

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
1 Urban or Built-Up					Classification does follow land use patterns.
11 Residential	Non-Linear Built Up Area(s)	5003	A4	Residential land uses range from high density, represented by the multiple-unit structures of urban cores, to low density, where houses are on lots of more than an acre, on the periphery of urban expansion.	
12 Commercial and Services	Urban Area(s)Built-Up Object: Commercial Area (e.g. Shopping) // Urban Area(s)Built-Up Object: Commercial Area (e.g. Warehousing, Wholesaling, Retailing) // Urban Area(s)Built-Up Object: Hospital Premises // Urban Area(s)Built-Up Object: Military Facilities // Urban Area(s)Built-Up Object: Religious Site // Urban Area(s)Built-Up Object: School Premises	5003-9-A24 // 5003-9-A25 // 5003-9-A29 // 5003-9-A31 // 5003-9-A35 // 5003-9-A36	A4-A13-A24 // A4-A13-A25 // A4-A13-A29 // A4-A13-A31 // A4-A13-A35 // A4-A13-A36	Commercial areas are those used predominantly for the sale of products and services. Institutional land uses, such as the various educational, religious, health, correctional, and military facilities are also components of this category.	
13 Industrial	Industrial And/Or Other Area(s)	5003-8	A4-A12	Industrial areas include a wide array of land uses from light manufacturing to heavy manufacturing plants.	

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
14 Transportation, Communications, and Utilities	Linear Built Up Area(s) // Non-Linear Built Up Area(s)Built-Up Object: Airport // Non-Linear Built Up Area(s)Built-Up Object: Port Area (including Docks, Shipyards, Locks) // Non-Linear Built Up Area(s)Built-Up Object: Sewage Treatment Plant // Non-Linear Built Up Area(s)Built-Up Object: Station (including Depots) // Non-Linear Built Up Area(s)Built-Up Object: Transportation Facilities - Bus Area // Non-Linear Built Up Area(s)Built-Up Object: Transportation Facilities - Car Park // Non-Linear Built Up Area(s)Built-Up Object: Water Treatment Facilities	5002 // 5003-A21 // 5003-A32 // 5003-A37 // 5003-A39 // 5003-A40 // 5003-A41 // 5003-A43	A3 // A4-A21 // A4-A32 // A4-A37 // A4-A39 // A4-A40 // A4-A41 // A4-A43	Highways and railways including rights-of-way, areas used for interchanges, and service and terminal facilities. Rail facilities include stations, parking lots, roundhouses, repair and switching yards, and related areas, as well as overland track and spur connections of sufficient width for delineation at mapping scale. Airports including facilities (runways, intervening land, terminals, service buildings, navigation aids, fuel storage, parking lots, and a limited buffer zone), seaports, and major lake ports (including docks, shipyards, drydocks, locks, and waterway control structures). Terminal facilities generally include the associated freight and warehousing functions. Communications and utilities areas such as those involved in processing, treatment, and transportation of water, gas, oil, and electricity and areas used for airwave communications are also included in this category.	
15 Industrial and Commercial Complexes	High Density Industrial And/Or Other Area(s)	5003-10	A4-A12A14	Industrial and commercial land uses that typically occur together or in close functional proximity.	'High Density' not defined by the Anderson Classification System, but follows conclusively from the class description.

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
16 Mixed Urban or Built-Up Land	Built Up Area(s)	5001	A1	Mixture of Level II Urban or Built-up uses where individual uses cannot be separated at mapping scale. Where more than one-third intermixture of another use or uses occurs in a specific area, it is classified as Mixed Urban or Built-up Land.	
17 Other Urban or Built-Up Land	Artificial Surfaces and Associated Area(s) // Vegetated Urban Area(s)	0010 // 11176	B15 // A6	Other Urban or Built-up Land typically consists of uses such as golf driving ranges, zoos, urban parks, cemeteries, waste dumps, water-control structures and spillways, the extensive parts of such uses as golf courses and ski areas, and undeveloped land within an urban setting.	
2 Agricultural Land					
21 Cropland and Pasture	Herbaceous Crop(s) // Shrub Crop(s)Crop Type: Fruits & Nuts // Herbaceous Closed to Open Vegetation	10025 // 10013-S6 // 21453	A3 // A2-S6 // A2A20	Includes: cropland harvested, including bush fruits; cultivated summer fallow and idle cropland; land on which crop failure occurs; cropland in soil- improvement grasses and legumes; cropland used only for pasture in rotation with crops; and pasture on land more or less permanently used for that purpose.	'Pasture' classified as semi-natural vegetation.

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas	Tree Crop(s)Crop Cover: Orchard(s) // Shrub Crop(s)Dominant Crop: Fruits & Nuts - Grapes (Vitis vinifera) // Shrub Crop(s)Crop Cover: Plantation(s) // Herbaceous Crop(s)	10001-W8 // 10013-S0610 // 10013-W7 // 10025	A1-W8 // A2-S0610 // A2-W7 // A3	Orchards, groves, and vineyards produce the various fruit and nut crops. Nurseries and horticultural areas, which include floricultural and seed-and-sod areas and some greenhouses, are used perennially for those purposes. Tree nurseries which provide seedlings for plantation forestry also are included here.	Tree nurseries defined as 'Shrub Crop(s) Crop Cover: Plantation(s) 'Horticultural areas defined as 'Herbaceous Crop(s)', 'horticultural' does not exist in LCCS
23 Confined Feeding Operations	Industrial And/Or Other Area(s)Built-Up Object: Breeding Centre	5003-8-A22	A4-A12-A22	Confined Feeding Operations are large, specialized livestock production enterprises, chiefly beef cattle feedlots, dairy operations with confined feeding, and large poultry farms, but also including hog feedlots. Confined Feeding Operations have a built-up appearance, chiefly composed of buildings, much fencing, access paths, and waste-disposal areas.	
24 Other Agricultural Land	Scattered Urban Area(s) // Scattered Industrial And/Or Other Area(s) // Cultivated and Managed Terrestrial Area(s)	5003-17 // 5003-16 // 0003	A4-A13A17 // A4-A12A17 // A11	Includes farmsteads, holding areas for livestock such as corrals, breeding and training facilities on horse farms, farm lanes and roads, ditches and canals, small farm ponds, and similar uses.	
3 Rangeland					‘Rangeland’ is not a land cover term.
31 Herbaceous Rangeland	Herbaceous Closed to Open Vegetation	21453	A2A20	Lands dominated by naturally occurring grasses and forbs, areas of actual rangeland which have been modified to include grasses and forbs as their principal cover, when the land is managed for rangeland purposes and not managed using practices typical of pastureland.	

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
32 Shrub and Brush Rangeland 81 Shrub and Brush Tundra	Closed to Open Shrubland (Thicket)	21449	A4A20	32 Typical for arid or semiarid regions, characterized by xerophytic vegetative types with woody stems and also by desert succulent xerophytes. 81 The Shrub and Brush Tundra category consists of the various woody shrubs and brushy thickets found in the tundra environment. These occur in dense-to- open evergreen and deciduous thickets.	32 and 81 classes result in the same LCCS land cover class.
33 Mixed Rangeland	Herbaceous Closed to Open Vegetation // Closed to Open Shrubland (Thicket)	21453 // 21449	A2A20 // A4A20	More than one-third intermixture of either herbaceous or shrub and brush rangeland species occurring in a specific area.	
4 Forest Land					
41 Deciduous Forest Land	Broadleaved Deciduous Closed to Open Trees // Needleleaved Deciduous Closed to Open Trees	21497 // 21500	A3A20B2XXD1E2 // A3A20B2XXD2E2	Deciduous Forest Land includes all forested areas having a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of a dry season.	
42 Evergreen Forest Land	Broadleaved Evergreen Closed to Open Trees // Needleleaved Evergreen Closed to Open Trees	21496 // 21499	A3A20B2XXD1E1 // A3A20B2XXD2E1	Evergreen Forest Land includes all forested areas in which the trees are predominantly those which remain green throughout the year. Both coniferous and broadleaved evergreens are included in this category.	
43 Mixed Forest Land	Broadleaved Evergreen Woodland // Needleleaved Evergreen Woodland // Broadleaved Deciduous Woodland // Needleleaved Deciduous Woodland	20131 // 20134 // 20132 // 20135	A3A11B2XXD1E1 // A3A11B2XXD2E1 // A3A11B2XXD1E2 // A3A11B2XXD2E2	Includes areas where both evergreen and deciduous trees are growing. More than one third intermixture of either evergreen or deciduous species occurs in a specific area.	

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
5 Water					
51 Streams and Canals	Natural Waterbodies (Flowing) // Artificial Waterbodies (Flowing)	8001-1 // 7001-1	A1-A4 // A1-A4	The boundary between streams and other bodies of water is the straight line across the mouth of the stream up to 1 nautical mile (1.85 km).	
52 Lakes	Natural Waterbodies (Standing)	8001-5	A1-A5	Lakes are nonflowing, naturally enclosed bodies of water, including regulated natural lakes but excluding reservoirs.	
53 Reservoirs	Artificial Waterbodies (Standing)	7001-5	A1-A5	Reservoirs are artificial impoundments of water used for irrigation, flood control, municipal water supplies, recreation, hydroelectric power generation, and so forth.	
54 Bays and Estuaries	Natural Waterbodies (Flowing) // Natural Waterbodies (Standing) // Tidal Area	8001-1 // 8001-5 // 8004	A1-A4 // A1-A5 // A1B3	Inlets or arms of the sea that extend inland, included only when they are considered to be inland water.	
6 Wetland					
61 Forested Wetland	Closed to Open Woody Vegetation	41519	A1A20	Dominated by woody vegetation, including seasonally flooded bottomland hardwoods, mangrove swamps, shrub swamps, and wooded swamps.	
62 Nonforested Wetland	Closed to Open Herbaceous Vegetation. // Closed to Open Lichens/Mosses. // Tidal Area	42155 // 42260 // 8004	A2A20 // A7A20 // A1B3	Dominated by wetland herbaceous vegetation or nonvegetated. Includes tidal and nontidal fresh, brackish, and salt marshes and nonvegetated flats and also freshwater meadows, wet prairies, and open bogs.	Hard to define non-vegetated wetlands with LCCS.
7 Barren Land					
71 Dry Salt Flats	Bare Soil And/Or Unconsolidated Material(s) With Salt Flats	6020	A5B13	Dry Salt Flats occurring on the flat-floored bottoms of interior desert basins which do not qualify as Wetland are included in this category.	

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
72 Beaches	Loose And Shifting Sands // Bare Rock And/Or Coarse Fragments - Gravels	6006 // 6002-8	A6 // A3-A14	Beaches are the smooth sloping accumulations of sand and gravel along shorelines.	
73 Sandy Areas other than Beaches	Loose And Shifting Sands	6006	A6	Sandy areas other than Beaches are composed primarily of dunes accumulations of sand transported by the wind. Sand accumulations most commonly are found in deserts although they also occur on coastal plains, river flood plains, and deltas and in periglacial environments. When such sand accumulations are encountered in tundra areas, they are not included here but are placed in the Bare Ground Tundra category.	
74 Bare Exposed Rock	Bare Rock(s)	6002-1	A3-A7	The Bare Exposed Rock category includes areas of bedrock exposure, desert pavement, scarps, talus, slides, volcanic material, rock glaciers, and other accumulations of rock without vegetative cover, with the exception of such rock exposures occurring in tundra regions.	
75 Strip Mines, Quarries and Gravel Pits	Extraction Site(s)	5004-2	A2-A6	Those extractive mining activities that have significant surface expression are included in this category. Vegetative cover and overburden are removed to expose such deposits as coal, iron ore, limestone, and copper. Quarrying of building and decorative stone and recovery of sand and gravel deposits also result in large open surface pits.	

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
76 Transitional Areas 77 Mixed Barren Land	Bare Area(s)	0011	B16	76 Transition from one land use activity to another, characterized by the lack of any remote sensor information which would enable the land use interpreter to predict reliably the future use or discern the past use. 77 Mixture of Barren Land features, dominant land use occupies less than two-thirds of the area.	'Transitional Areas' can be anything, 'Mixed Barren' also comprises any occurrences of barren land. That's why these classes only can be combined into LCCS's 'Bare Area(s)'
8 Tundra 81 Shrub and Brush Tundra (= 32 Shrub and Brush Rangeland)					'Tundra' is not a land cover term. see 32
82 Herbaceous Tundra	Herbaceous Closed to Open Vegetation // Closed to Open Lichens/Mosses	21453 // 21465	A2A20 // A7A20	Composed of various sedges, grasses, forbs, lichens, and mosses, all of which lack woody stems.	
83 Bare Ground Tundra	Bare Area(s) // Herbaceous Sparse Vegetation // Sparse Shrubs	0011 // 20058 // 20055	B16 // A2A14 // A4A14	Tundra occurrences less than one third vegetated. Sites visually dominated by considerable areas of exposed bare rock, sand, or gravel interspersed with low herbaceous and shrubby plants.	< 1/3 cannot be defined within LCCS ('Sparse' = (20 -10) to 1 percent) Is it necessary to define 'Bare Area(s)' additionally?
84 Wet Tundra	Closed to Open Herbaceous Vegetation. // Shallow Non-Perennial Natural Waterbodies (Standing)	42155 // 8020-5	A2A20 // A1B2C2-A5	Standing water is almost always present during months when temperatures average above the freezing level. Numerous shallow lakes are also common.	
85 Mixed Tundra	Herbaceous Open Vegetation // Open Shrubs (Shrubland) // Open Herbaceous Vegetation. // Shallow Non-Perennial Natural Waterbodies (Standing)	20037 // 20021 // 40019 // 8020-5	A2A11 // A4A11 // A2A13 // A1B2C2-A5	Mixture of the Level II Tundra occurrences where any particular type occupies less than two-thirds of the area of the mapping unit.	
9 Perennial Snow or Ice					

Anderson class	LCCLabel	LCCCode	LCCLevel	Anderson description	Translation notes
91 Perennial Snowfields	Perennial Snow	8006	A2B1		
92 Glaciers	Perennial Ice (Moving)	8009-9	A3B1-A6		