1. TITLE

1.1 Data Set Identification

ISLSCP II Historical Land Cover and Land Use, 1700-1990

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The files in this data set are named **historic_landcover_XX_YYYY.asc**, where XX can be either hd or 1d, meaning a spatial resolution of 0.5 and 1.0 degree in both latitude and longitude, respectively and YYYY is the year from 1700 to 1990. For each spatial resolution, 8 files with global estimates of historical land cover and land use are provided for every 50 years from 1700 to 1950, and then every 20 years to 1990. An additional file called **historic_landcover_hd_chngm.asc** is also provided that shows the differences between the original 0.5 degree land/water mask and the 0.5 degree land/water mask used in this collection. Note that the land/water mask difference file is only available at a 0.5 degree spatial resolution.

1.4 Revision Date of this Document

February 9, 2010

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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National Institute of Public Health and the Environment (RIVM), The Netherlands

2.2 Title of Investigation

Historical global land use change over the past 300 years.

2.3 Contacts (For Data Production Information)

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2.4 Data Set Citation

Goldewijk, K.K. 2007. ISLSCP II Historical Land Cover and Land Use, 1700-1990. In Hall, Forest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/967

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Klein Goldewijk, K., 2001. Estimating global land use change over the past 300 years: The HYDE database, *Global Biogeochemical Cycles* 15(2): 417-433.

3. INTRODUCTION

3.1 Objective/Purpose

The data set was developed to provide the global change science community with historical land cover and land use estimates. This data set can be used directly within spatially explicit climate and biogeochemical models.

3.2 Summary of Parameters

The data set describes historical land cover and land use changes over a 300-year historical period (1700–1990). Data are given for 50-year periods from 1700 to 1950 and then for 20-year periods to 1990.

3.3 Discussion

Testing against historical data is an important step for validating integrated models of global environmental change. Owing to long time lags in the climate and biogeochemical systems, these models should aim to simulate the land use dynamics for long periods, i.e., spanning decades to centuries. Developing such models requires an understanding of past and current trends and is therefore strongly data dependent. For this purpose, a historical database of the global environment has been developed: the History Database of the Global Environment (HYDE), available from http://www.pbl.nl/en/themasites/hyde/index.html. Historical statistical inventories on agricultural land (census data, tax records, land surveys, etc.) and different spatial analysis techniques were used to create a geographically-explicit data set of land use change, with a regular time interval. The data set can be used to test integrated models of global change.

The original 0.5 degree data set submitted by the Principal Investigator is available from the National Institute for Public Health and the Environment (RIVM) in the Netherlands from http://www.pbl.nl/en/themasites/hyde/index.html. This original data set has been modified by the staff of the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data collection in order to match the land/water boundaries used in the collection. A separate file that shows the differences between the original 0.5 degree land/water boundaries and the ISLSCP II land/water mask is provided. Finally, the ISLSCP II staff has created a 1.0 degree version of the data set by aggregating the 0.5 degree data set to the coarser resolution. This 1.0 degree version was produced so that all data sets within the ISLSCP II collection contained 1.0 degree versions of all data sets and should be considered a 'browse' product.

4. THEORY OF ALGORITHM/MEASUREMENTS

Population data on a country basis for the period 1950-1995 were derived from the 1996 Revision of the United Nations World Population Prospects [*United Nations*, 1997]. Pre-1950 data were taken from the History Database of the Global Environment - HYDE (Klein Goldewijk, 2001), with large input from *Mitchell* [1993, 1998a,b], who provides country population estimates for most countries of the world for a long historical time path (1750-1993). Another important source is *Maddison* [1994] who presents estimates of population numbers and Gross Domestic Product (GDP) for several countries for the period 1820-1992. In order to create a consistent data set, the historical country data points from *Mitchell* and *Maddison* were scaled to match the United Nations data in 1950. Data gaps were filled in with a logistic curve. Country and regional totals obtained in this way were checked against other available estimates.

The starting point for the global georeferenced historical population maps is the 0.5 x 0.5 degreedegree longitude/latitude population density map of 1994 from the National Center for Geographic Information and Analysis (NCGIA) [*Tobler et al.*, 1995]. The NCGIA population data set was overlaid with the HYDE country borders, and grid cells of the NCGIA database belonging to countries as defined by HYDE were aggregated to country totals. The HYDE country totals were scaled in order to equal the country totals of the United Nations population

database. Finally, the population densities were scaled to a 0.5 x 0.5 degree latitude/longitude grid by using the historical country totals combined with the same population distribution as in the NCGIA population database, under the assumption that high population density areas remain in the same place over time. Of course, this assumption places a bias on the distribution of past populated areas. Therefore, subnational population data for large countries like Canada, United States, Mexico, Brazil, Argentina, India, China, and Australia derived from *Mitchell* [1993, 1998a,b] were used to allow for at least some internal population changes.

The starting point in this study for the land use estimates is the statistical database of the Food and Agricultural Organization of the United Nations (FAO) [*FAO*, 1996], which was considered most authoritative. The categories "Arable Land and Permanent Crops" were used for cultivated land and "Permanent Pasture" for pasture. The FAO presents for each country data for the period 1961-1994. Additionally, for the United States, state level information on cropland area was used, as described by *Ramankutty and Foley* [1998] for the period 1850-1990 (N. Ramankutty personal communication, 2000). Data for the period 1700-1850 were estimated by taking into account the colonization of the different states over time, which resulted in different curves per state. For India, Sri Lanka, Bangladesh, Myanmar, Laos, Thailand, Vietnam, Brunei, Indonesia and the Philippines, estimated cropland areas from *Richards and Flint* [1994] were used for 1880, 1920, 1950, and 1980; the years in between were interpolated. The 1700 estimate for countries belonging to the regions of Latin America, South Asia, Former USSR, China, Pacific Developed, and Southeast Asia were scaled to match the totals as estimated by *Richards* [1990] and *Klein Goldewijk and Battjes* [1997]. The analysis of *Richards* [1990] is drawn from the original work of *Houghton et al*. [1983], and *Klein Goldewijk and Battjes* [1997] added pasture estimates to the data of *Richards* [1990]. The rest of the countries in the world were scaled to match the global estimate of *Richards* [1990].

Estimates from *Richards* [1990] for the world, *Houghton et al.* [1991] for Latin America, and *Klein Goldewijk and Battjes* [1997] for other regions have been used to estimate the change in pasture areas. Again, countries in one region were assumed to follow the same regional trend if no additional country specific data were available. Furthermore, the former Soviet Republics Armenia, Azerbaijan, Belarus, Estonia, Georgia, Latvia, Lithuania, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan were assumed to follow the same trend as the former USSR. The assumption was made that the share of cropland of each republic relative to the total area of the USSR has remained constant over the period between 1700 and the present. The same applies to the republics of Slovenia, Croatia, Bosnia-Herzegovina, the former Yugoslav Republic of Macedonia, and the Federal Republic of Yugoslavia which follow the trend of former Yugoslavia, the Czech Republic and Slovakia which follow Czechoslovakia, and Ethiopia DPR and Eritrea which follow the trend of former Ethiopia.

Potential natural vegetation patterns were simulated with a modified version of the BIOME model (original version described by *Prentice et al.* [1992]) with some modifications as presented by *Leemans and van den Born* [1994], driven with climate from the IIASA climate database of *Leemans and Cramer* [1991]. Global vegetation patterns can be derived by agglomerations of plant functional types, each having definable environmental constraints (temperature, moisture, etc.).

The initial boundary map for agricultural land is based on a combination of a georeferenced data set and national land use statistics. Calibration criteria are that "(i) geographic patterns of agricultural land are consistent with the national statistics from the *FAO* [1996], (ii) it supports the computation of the transient vegetation response to both historical and future climate change, and (iii) computed geographic patterns of individual crops and potential national

vegetation resemble the patterns simulated in the Terrestrial Vegetation Model of IMAGE 2" [*Alcamo et al.*, 1998]. Initial agricultural land cover is derived from the DISCover land use data set, classified according to the International Geosphere Biosphere Programme Global Land Cover Legend [*Loveland and Belward*, 1997]. The scheme consists of 17 classes, of which "Croplands" and "Urban and built-up" were given the same weight, and then used for allocation of the amount of "arable Land and Permanent Crops" as presented by FAO. If the need for arable area could not be satisfied with these categories, the DISCover classes "Savannas" (9), "Grasslands" (10) and "Cropland/Natural Vegetation Mosaic" (14) were also given the same weight (but lower than the "Cropland" and "Urban and Built-up") and used to allocate the rest.

The allocation of cropland was done by applying the following rules: (1) The total amount of cropland on a sub-national (when available) or country scale was allocated according to historical population density maps (as described in Section 3.1). The grid cells with the highest population densities were first assigned to cropland, then those with the second highest density, etc., until the total amount of cropland was allocated in that unit. (2) The allocation of cropland is restricted to the agricultural area as determined by the initial land cover map, which is considered as being representative for present agricultural activity. This area is regarded as a maximum boundary for agricultural activities. Cropland was not allocated outside that area.

The allocation of pasture was done by applying the following rules: (1) The total amount of pasture in a country or state was also allocated according to population density, while excluding those grid cells that were already allocated to cropland on the basis of the above-described rules (2) The allocation of pasture is restricted to the agricultural area as determined by the initial land cover map. This map serves as a maximum boundary where agricultural activities are assumed to be feasible.

5. EQUIPMENT

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

This data set is derived from various ancillary data sources that do not include satellite and/or ground measurements. The DIScover global land cover data set *(Loveland and Belward* [1997]) that is used in the production of this data set is produced using data acquired by the satellite-based Advanced Very High Resolution Radiometer (AVHRR) instrument.

5.1.2 Mission Objectives

Not applicable to this data set.

5.1.3 Key Variables

Not applicable to this data set.

5.1.4 Principles of Operation

Not applicable to this data set.

5.1.5 Instrument Measurement Geometry

Not applicable to this data set.

5.1.6 Manufacturer of Instrument

Not applicable to this data set.

5.2 Calibration

5.2.1 Specifications

5.2.1.1 Tolerance

Not applicable to this data set.

5.2.2 Frequency of Calibration

Not applicable to this data set.

5.2.3 Other Calibration Information

Not applicable to this data set.

6. PROCEDURE

6.1 Data Acquisition Methods

This data set was compiled using several sources such as country censuses, historical statistics volumes, national inventories, land surveys and satellite derived images. Furthermore, missing data were filled in using interpolation techniques. See Section 4 and Klein Goldewijk (2001) for more details.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The coverage is global, except for Antarctica.

6.2.2 Spatial Resolution

The data are provided in two equal-angle latitude/longitude Earth grids with spatial resolutions of 0.5 by 0.5 and 1 by 1.0 degree in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

The data set starts in the year 1700 and ends in 1990.

6.3.2 Temporal Resolution

The temporal resolution is 50 years for the years 1700 to 1950 and then 20 years from 1950 to 1990.

7. OBSERVATIONS

7.1 Field Notes

Not applicable to this data set.

8. DATA DESCRIPTION

8.1 Table Definition with Comments

Not applicable to this data set.

8.2 Type of Data

8.2.1 Parameter/ Variable Name	8.2.2 Parameter/ Variable Description	8.2.3 Data Range	8.2.4 Units of Measurement	8.2.5 Data Source
Historical Land Cover/Land Use Classes	Land Cover/Use classes from 1700 to 1990. **Class Codes*:** 0) Oceans/Water 1) Cultivated Land 2) Pasture/Land used for Grazing 5) Ice 6) Tundra 7) Wooded Tundra 8) Boreal Forest 9) Cool Conifer Forest 10) Temperate Mixed Forest 11) Temperate Deciduous Forest 12) Warm Mixed Forest 13) Grassland/Steppe 14) Hot Desert 15) Scrubland 16) Savanna 17) Tropical Woodland 18) Tropical Forest 19) No Data Over Land	Min=0 Max=19	See 8.2.2	Klein Goldewijk (2001)
Point Changed	Differences between the ISLSCP II land/water mask and the original data: -1 = ISLSCP II mask is water and original data is land (data removed) 0 = Data sets agree over land or water (data unchanged) 1 = ISLSCP II mask is land or water and original data is missing (fill value used).	-1 to 1	See 8.2.2	Original data and ISLSCP II land/water mask

* Please note that the data values 3 and 4 are non-existent in this data set.

8.3 Sample Data Record

Not applicable to this data set.

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the standard ArcGIS ASCII grid, or text format. The file format consists of numerical fields of varying length, which are delimited by a single space and arranged in columns and rows. The files in this data set contain 720 columns by 360 rows for the 0.5 degree data sets, and 360 columns and 180 rows for the 1.0 degree data sets. All values are written as integer numbers. Water bodies are assigned the value of 0 (zero) while land areas with no data are assigned the value of 19.
potential_veg_XX.asc files and 0 to 15 for the **potential_veg_diffs_XX.asc** files.

All files are gridded to a common equal-angle lat/long grid, where the coordinates of the upper left corner of the files are located at 180 degrees W, 90 degrees N and the lower right corner coordinates are located at 180 degrees E, 90 degrees S. Data in the files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North.

8.5 Related Data Sets

A historical croplands fraction data set, *ISLSCP II Historical Land Cover and Land Use, 1700-1990,* has been developed by Ramankutty and Foley (1999) and is provided in this collection. Several contemporary land cover data sets are provided in the ISLSCP II data collection.

9. DATA MANIPULATIONS

9.1 Formulas

9.1.1 Derivation Techniques/Algorithms

See Section 4 and Klein Goldewijk (2001) for more details.

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

See Section 4 and Klein Goldewijk (2001) for more details.

9.2.2 Processing Changes

See Section 4 and Klein Goldewijk (2001) for more details.

9.2.3 Additional Processing by the ISLSCP II Staff

The original files were submitted in the ArcINFO ASCII format. In these original files water bodies and missing data (e.g. Antarctica) were assigned to the same category (Value=0). The ISLSCP II staff has created two categories from this single category, assigning a value of 0 to all water bodies, and a value of 19 to missing data over land. The ISLSCP II staff has also made the data set consistent with the 0.5 degree land/water mask used in the collection. Points where the original data showed water and the ISLSCP II mask showed land have been filled in, where possible, from the dominant land cover/use type of all surrounding cells in a 3 by 3 window, not including water or missing data. Points that did not have any values within this surrounding window have been assigned a value of 19 (i.e. No data over land). ISLSCP II water points have also been forced over

original land points where needed. A separate file (**historic_landcover_hd_chngm.asc**) that shows the differences between the original 0.5 degree land/water boundaries and the 0.5 degree ISLSCP II land/water mask was produced. Finally, the ISLSCP II staff has created a 1.0 degree version of the data set by aggregating the 0.5 degree files to the coarser resolution. This was done by determining the dominant land cover/use type for the 4 0.5 degree cells contained within each 1.0 degree cell, ignoring any water or missing data cells. In some cases, the number of 0.5 degree cells from two or more land cover classes within the 1.0 degree cell was equal. In these cases, land cover classes with higher vegetation and/or tree cover were arbitrarily selected over those with lower vegetation/tree cover.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

See Section 4 and Klein Goldewijk (2001) for more details.

9.4 Graphs and Plots

See Section 4 and Klein Goldewijk (2001) for more details.

10. ERRORS

10.1 Sources of Error

A major source of error is the non-availability of historical statistics of the amount of cropland and pasture for several countries. Even for the countries that did present historical data on land use, the data were often classified in many different ways, so many assumptions had to be made in order to make them comparable. A considerable number of time series showed gaps in them, requiring filling in by interpolation and backcasting techniques. The resulting uncertainty to the earliest historical estimates (pre 1800) is therefore increasingly larger depending on the earliest recording of land use estimate per country. This may have an impact on the allocation of cropland and pasture (due to the boolean way of distributing; yes or no for an entire grid cell), but the overall trends will not be greatly influenced.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Comparison with other data sets is quite difficult, because there is at the moment only one other similar data set (Ramankutty and Foley 1999), who used many of the same data sources.

10.2.2 Confidence Level/Accuracy Judgment

See section 11.1.

10.2.3 Measurement Error for Parameters and Variables

See section 11.1.

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems with the data

Note that the data set is constructed on the basis of many historical statistics, census data, tax records, etc. with numerous assumptions and interpolations for missing data and data gaps. Also the assumption that historical population density is a reasonable proxy for distribution of historical agricultural activities through time can be questioned for some regions and certain time periods.

11.2 Usage Guidance

It is recommended that this data set be used to examine long term trends of *global* land use changes (e.g. coupled land-atmosphere climate models), rather than exact estimates of a certain amount of land use/cover class for a certain country/region. We also note that the 1.0 degree version is a simple aggregation of the 0.5 degree data and is not produced according to the same methodology described in Section 4. We consider this 1.0 degree data set as a 'browse' product that is more suitable for visual assessment of the data and not necessarily scientific purposes. The user should always refer to the 0.5 degree data or the original data set available from RIVM at http://www.pbl.nl/en/themasites/hyde/index.html

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

See the following website http://www.pbl.nl/en/themasites/hyde/index.html

12.2 Journal Articles and Study Reports

Journal:

Klein Goldewijk, K., 2001. Estimating global land use change over the past 300 years: The HYDE database, *Global Biogeochemical Cycles* 15(2): 417-433.

Report:

Klein Goldewijk, C.G.M. and J.J. Battjes, 1997. A hundred year (1890 - 1990) database for integrated environmental assessments (HYDE, version 1.1), RIVM Report no. 422514002. 110 pp.

CD-ROM:

Klein Goldewijk, K. and N. Ramankutty (2001), Historical land use changes over the past 300 years: New global data sets. A joint effort of the National Institute for Public Health and the Environment (RIVM) and the Center for Sustainability and the Global Environment (SAGE). To order the CD–ROM contact: kees.klein.goldewijk@rivm.nl.

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Ramankutty, N. and J.A. Foley, Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochem. Cycles, 13*(4), 997-1027, 1999.

Richards, J.F., Land transformation, in *The Earth as Transformed by Human Action,* edited by B.L. Turner II et al., pp. 163-178, Cambridge Univ. Press, New York, 1990.

Richards, J.F., and E. Flint, historic land use and carbon estimates for South and Southeast Asia 1880-1980, *Data set NDP-046 CDIAC/ORNL*, Carbon Dioxide Infor. Anal. Cent., Oak Ridge Natl. Lab., Oak Ridge, Tenn., 1994.

Tobler, W., U. Deichmann, J. Gottsegen, and K. Maloy, The global demography project. *Tech. Rep. TR-95-6*, National Center for Geographic Information and Analysis (NCGIA), Santa Barbara, California, 1995.

United Nations, *World Population Prospects, 1950 – 2050*, The 1996 Revision. rep. UN Population Division, New York. 1997.

13. DATA ACCESS

13.1 Data Access Information

The ISLSCP Initiative II data are archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

AVHRR	Advanced Very High Resolution Radiometer
DAAC	Distributed Active Archive Center
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
GSFC	Goddard Space Flight Center
HYDE	History Database of the Global Environment
ISLSCP	International Satellite Land Surface Climatology Project
NCGIA	National Center for Geographic Information and Analysis
ORNL	Oak Ridge National Laboratory
RIVM	National Institute of Public Health and the Environment (The Netherlands)