Land Cover Type Distribution Over the ARM SGP Area for Atmospheric Radiation and Environmental Research

A. P. Trishchenko, Y. Luo, and R. Latifovic
Canada Centre for Remote Sensing
Ottowa, Ontario, Canada

Z. Li
University of Maryland
College Park, Maryland

Introduction

The knowledge of landcover types is essential for many applications. Landcover is closely linked to the surface albedo properties, which determine the partitioning of the solar energy between the surface and atmosphere. Diverse landcover types have different emissivity that affects the thermal radiative transfer and longwave radiation budget. Properties of various landcover types also impact in a different way on hydrological and carbon cycles. Structural properties of landcover influence the turbulent exchange and dynamics of the boundary layer by modifying the disposition of solar energy into latent and sensible heat. Land cover type is one of input parameters in the land surface scheme of the GCM models. Therefore, a good knowledge of landcover types over the Atmospheric Radiation Measurement (ARM) Program sites would greatly assist the ARM Program community in scientific research aimed at improving atmospheric radiative transfer, assessing cloud and aerosol radiative forcing, and modeling of atmospheric circulation and climate.

The only practical way to produce the systematic landcover information over large spatial area is to use the satellite observations. Satellites observe surface reflectance at several spectral bands. Landcover classes are characterized by distinct spectral signatures in various spectral bands. This multispectral information can be effectively used for landcover classification.

Producing landcover map from satellites is not a trivial task due to several reasons. First, there are frequently no well-defined boundaries between landcover classes “in the spectral space”. Therefore, different landcover types may reveal similar spectral properties and vice versa. Second, the landcover legend employed in classification must be compatible with requirements for intended application. For example, the “cropland” class may suit well for some applications, while for others this information may be excessively general to be of practical use. In this case more detailed knowledge is required about specific type of cropland, such as wheat, rye, corn etc. Third, the seasonal variations of surface properties due to climate, farming activities, natural and human-induced disturbances lead to landcover changes. An example of this kind is snow cover, harvesting/ploughing, wildfires, urban expansion etc. Therefore, landcover distribution may be a dynamic object. Landcover and land use changes (LULUC) is in the focus of International Panel on Climate Change (IPCC) as important component of climate change science, impact and adaptation research (Highton, 2001).

Large Scale Landcover Maps

There are several sources of landcover information available from different projects. We analyzed landcover map distribution over the ARM Southern Great Plains (SGP) area (320N-400N; 920W-1020W) derived from 4 sources: a) Landsat National Land Cover Data set (NLCD); b) International Geosphere-Biosphere Programme (IGBP) data archive (http://edcdaac.usgs.gov/glcc/glcc_version1.asp#NorthAmerica); c) Global Land Cover 2000 project (Latifovic et al., 2004; http://www.gvm.jrc.it/glc2000/defaultGLC2000.htm); and d) moderate-resolution imaging spectroradiometer (MODIS) observations – data product MOD12Q1 (http://edcdaac.usgs.gov/modis/dataproducts.asp, Strahler et al, 1999). The NLCD dataset was compiled from Landsat Thematic Mapper (TM) satellite imagery at 30-meter spatial resolution and supplemented by various ancillary data. It was produced as part of a cooperative project between the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (USEPA) (http://landcover.usgs.gov/natllandcover.asp). The original NLCD landcover dataset was resampled to create a landcover map that matched the spatial resolution of the MODIS data at 500 meters. Each landcover class in the resampled dataset was then converted to its IGBP equivalent following the approach described by Latifovic et al. (2004).

The landcover maps over the ARM SGP region of 80 latitude x 100 longitude are shown in Figures 1-4. The statistical distribution of landcover classes is presented in Figure 5. All four maps show similarity in the spatial distribution on large scales, though detailed comparison demonstrates some important differences at regional scales. Most differences are related to the distribution of grassland, cropland, savannas and mixture of crop and natural vegetation. This can be easily understood because of similarity of these classes from the vegetation structure point of view. Water bodies and urban/built-up classes are quite consistent between all datasets. For the area in the neighbourhood of the ARM SGP Central Facility (CF), three maps (NLCD, IGBP, MOD12Q1) indicates cropland landcover type, while Global Landcover project NC2000 shows predominantly grassland type. Overall comparison of statistical distribution of the cover types also reveals some additional important distinctions. Some differences between maps and in statistics are due to differences in landcover legends and possibly due to differences in the definitions of landcover types (such as savannas, open/closed shrublands). Based on our experience in landcover survey of the area, the preference would be given to the NLCD map (Figure 1). Although, more work is required to produce the universal landcover map of better accuracy and detailed legend.

Local Seasonal Landcover Distribution Around ARM SGP CF

Above data are useful for characterization of large-scale properties. Local application may require more detailed information with precise characterization of vegetation types and soil properties. The two local scale landcover datasets produced using ground surveys and high-resolution satellite data from Landsat-7 ETM are described in this study. They correspond to August, 2002 and May, 2003 (Trishchenko et al., 2002). The results of May of 2003 were produced as part of the ARM Aerosol Intensive Observation Period (IOP). The maps were generated at the spatial resolution of 30 meters. They are available from the ARM IOP archive (http://iop.archive.arm.gov/arm-iop/). Figure 6 presents these two maps. Figure 6a (August 2002) covers an area of ~10x10km2, Figure 6b (May 2003) covers a larger

area of ~18x18km2. Figure 7 shows the distribution of landcover types for the two datasets. Landcover types whose properties do not depend on the time of the year, such as water pixels, water/land mix and pixels with tree/shrubs show very good consistency. Striking feature of the distribution shown in Figure 7 is a high degree of reciprocity between wheat and baresoil classes, which reflects the seasonality in the land use. For this region, wheat serves as the major crop grown by farmers. It occupies approximately 65% of area around the ARM SGP CF. There are some variations in the frequency of occurrence for other classes, such as corn/milo, pasture/grassland, and wheat stubble/dry grass. They are also associated with seasonality in farming activities and land use. Some differences are due to change in the size of the area between two datasets.

Conclusions

Analysis of four large-scale datasets (NLCD, IGBP, MOD12, and NC2000) shows similarity in the spatial distribution on a large scale, though detailed comparison demonstrates some important differences in overall statistical distribution of the cover types as well as regional differences. Preference is given to the NLCD dataset as most accurate and available with better spatial resolution. Comparison identifies the need for more efforts to improve the accuracy of mapping. Seasonality in farming activities and trends in land use require systematic efforts on generating regular landcover time series for different seasons and years.

Detailed landcover maps centered at the ARM SGP CF were derived for two seasons using ground survey and high-resolution Landsat-7 ETM satellite imagery. These maps were generated at 30m spatial resolution. They show variability in the state of generic landcover types at various times of the year and emphasize the need for more detailed description of the state of different landcover types varying depending on the time of the year.

Generated datasets are available from the Canada Centre for Remote Sensing ftp-site ftp://ftp.ccrs.nrcan.gc.ca/ad/CCRS_ARM/. Data were also provided to the ARM external archive.

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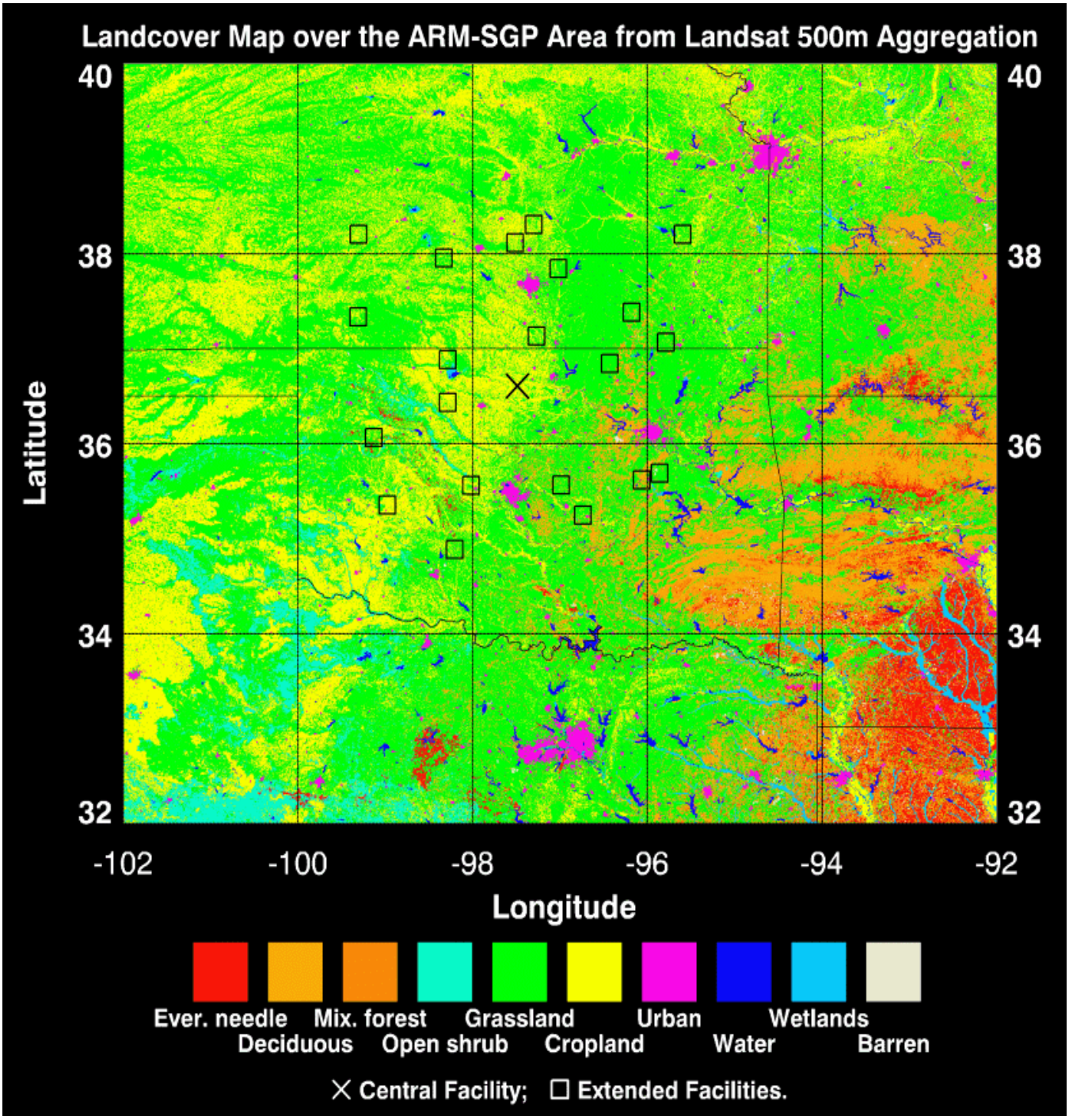


Figure 1. Landcover map of the ARM SGP area at 500m spatial resolution produced from Landsat National Land Cover Data set (NLCD). The NLCD dataset is originally derived from Landsat TM at 30m spatial resolution. It was aggregated to larger pixel size using method of Latifovic et al. (2004) as described in Luo et al. (2004). Cross (X) marks ARM Central Facility location. Squares □ denote location of ARM Extended Facilities.

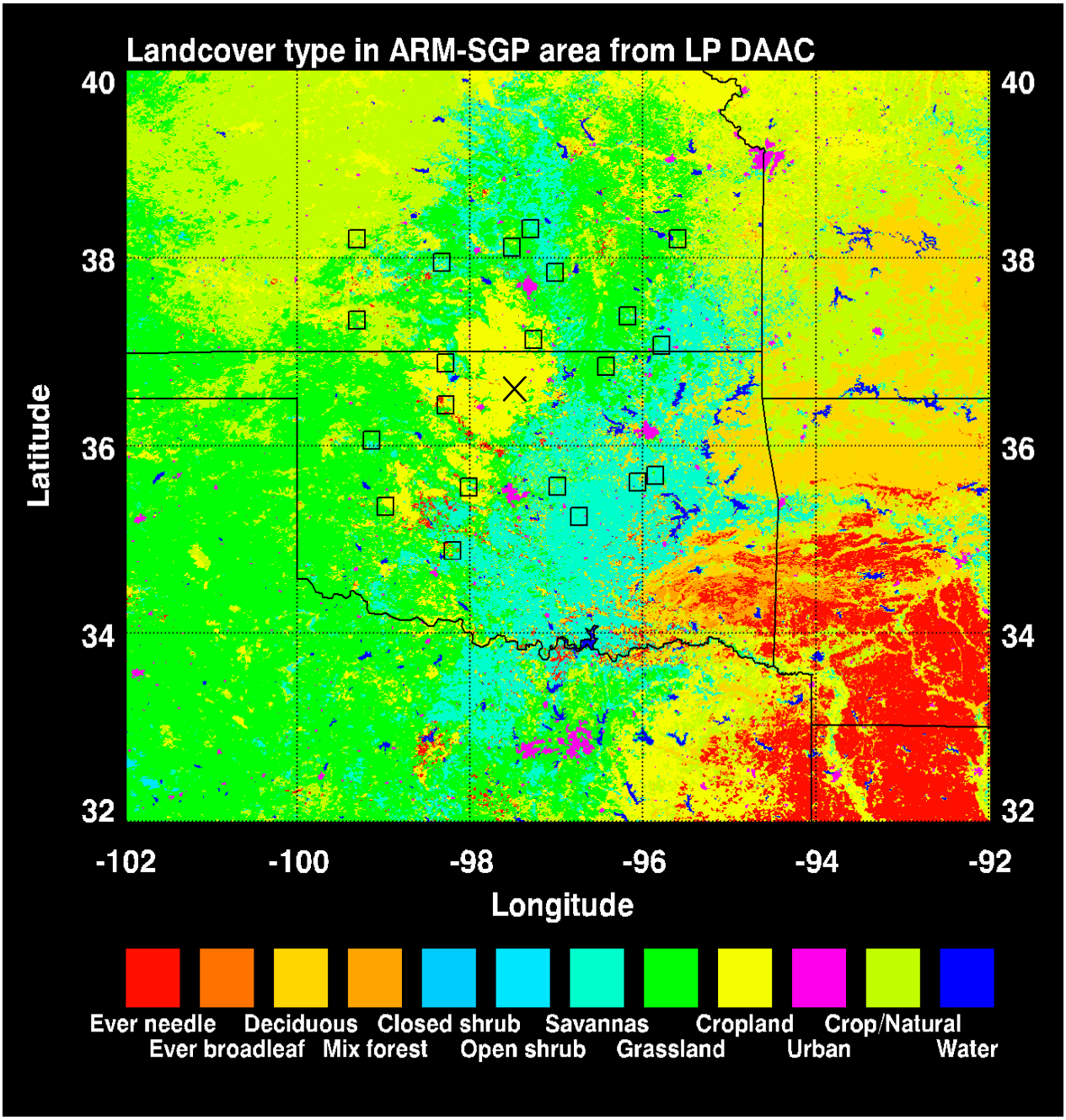


Figure 2. Landcover map of the ARM SGP area from the IGBP (LP DAAC) data archive.

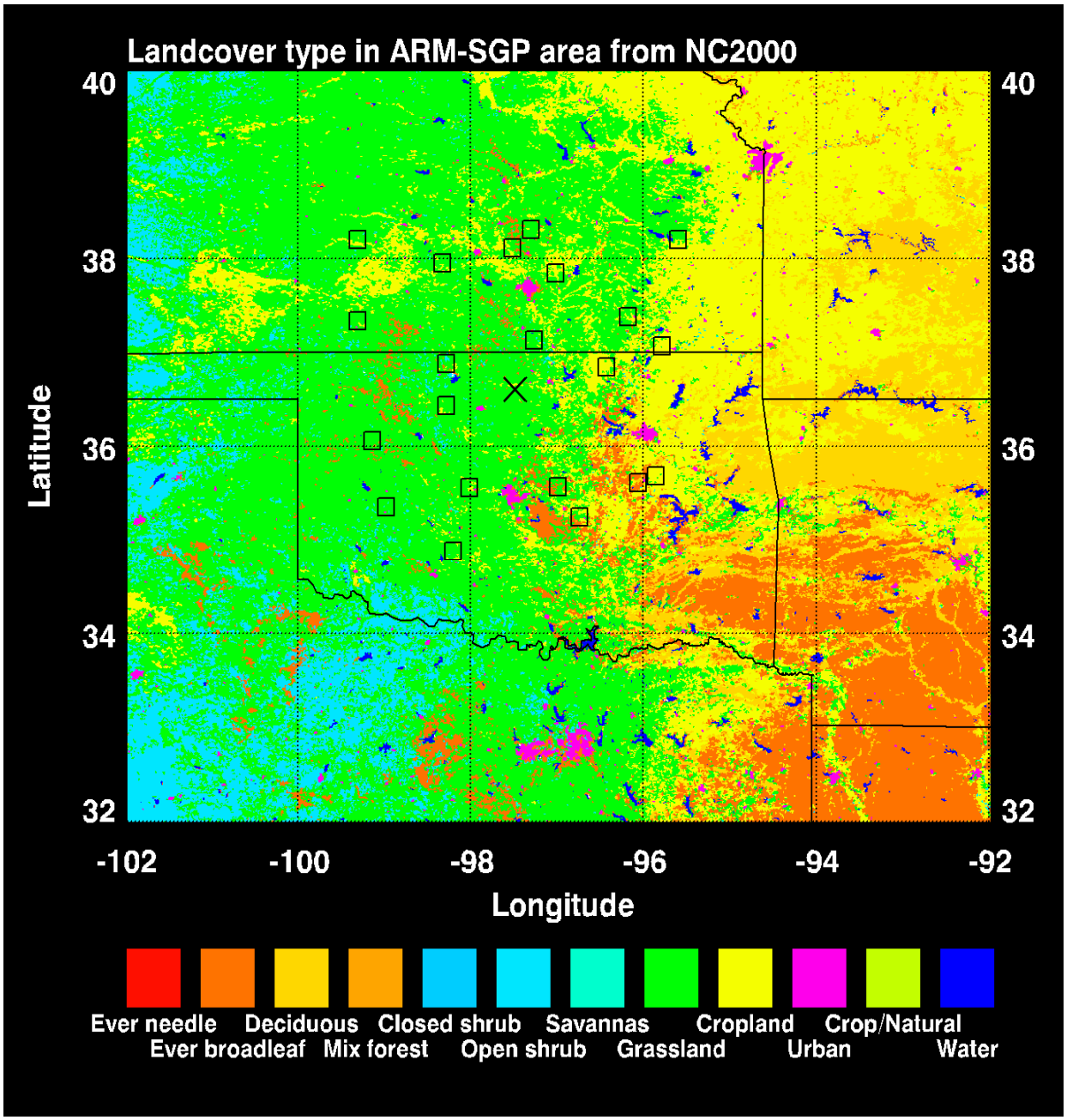


Figure 3. Landcover map of the ARM SGP area from the Global Land Cover 2000 project NC2000.

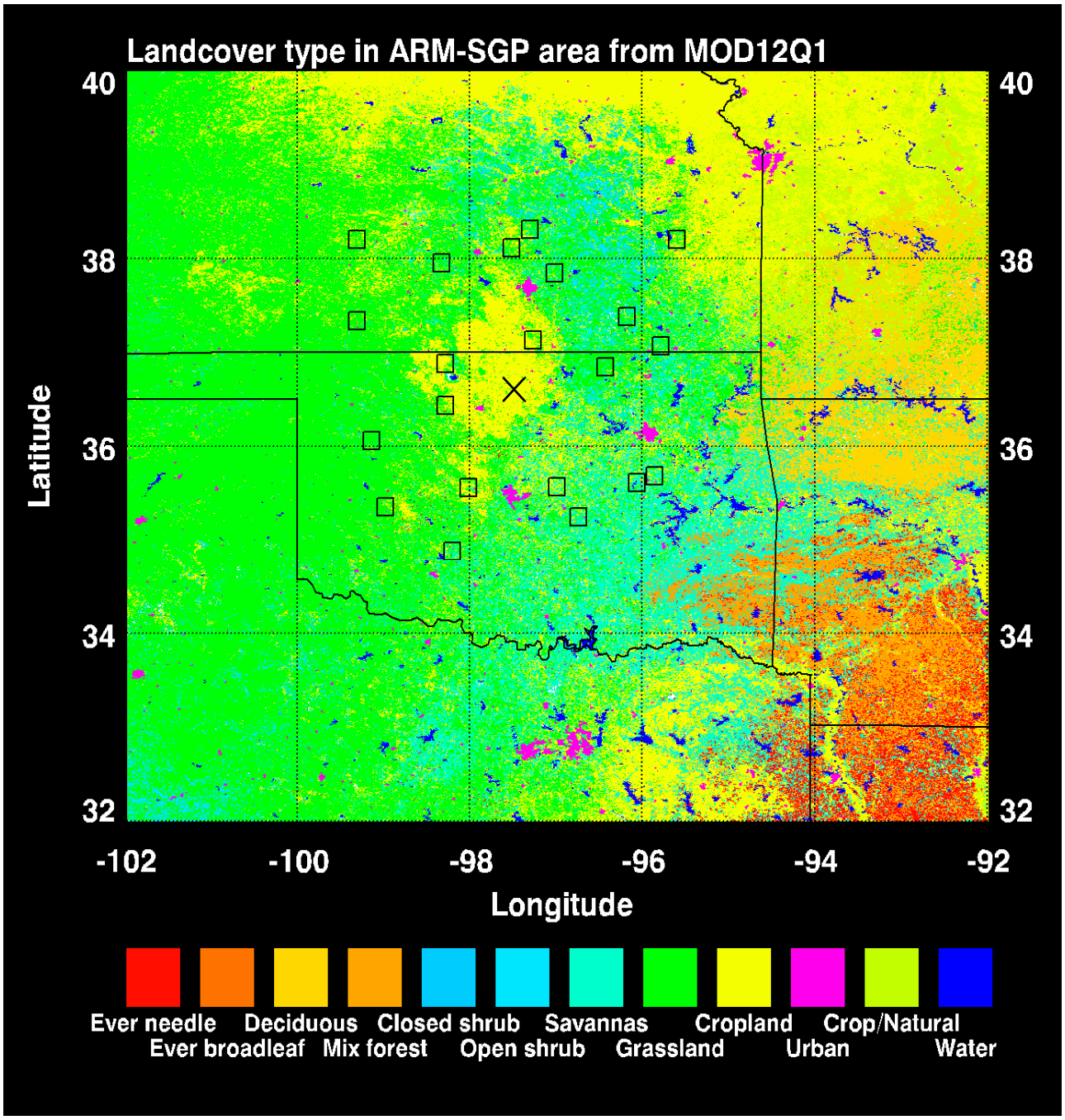


Figure 4. Landcover map of the ARM SGP area derived from MODIS observations. MODIS data product MOD12Q1

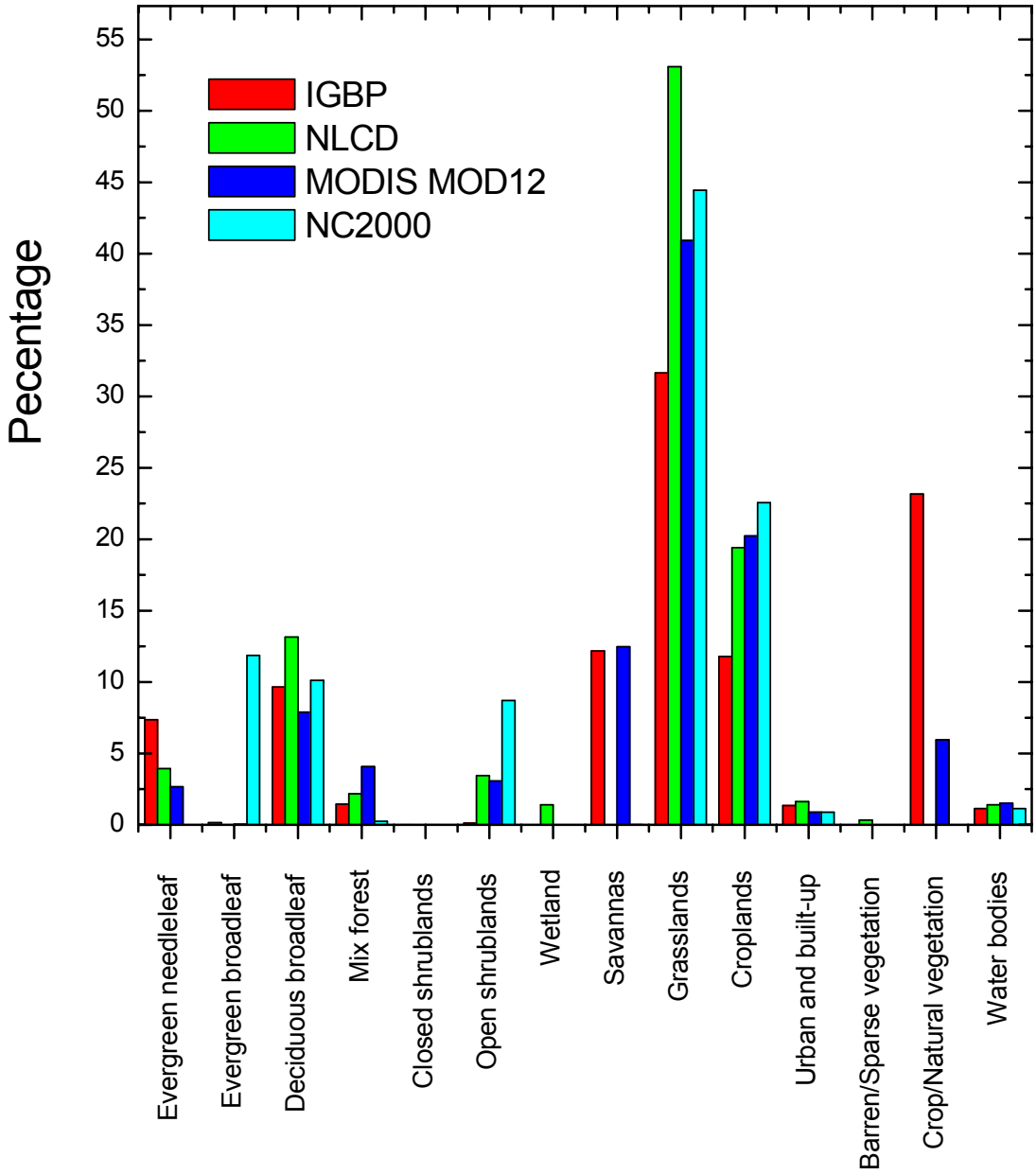
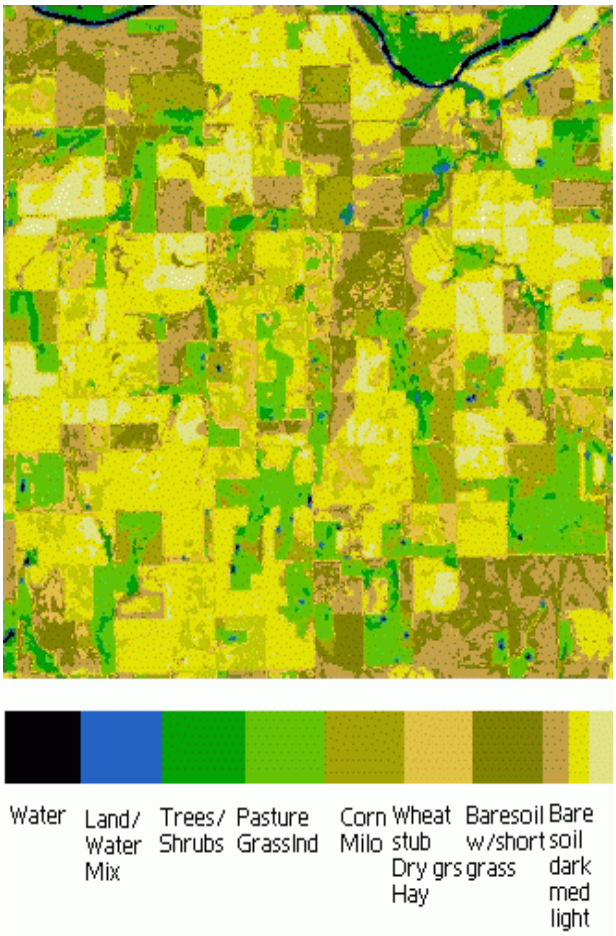


Figure 5. Statistics of landcover classes from 4 sources shown in Figures 1-4.

A



B

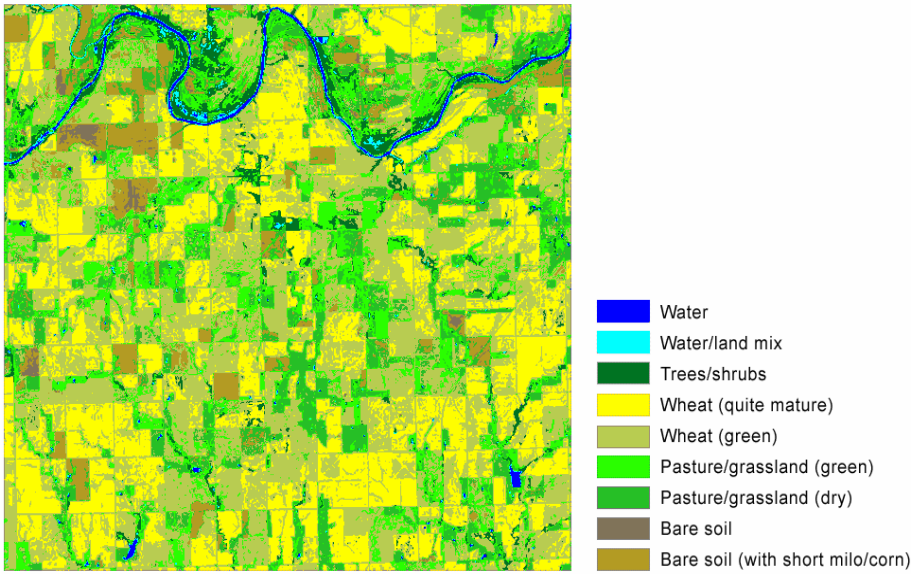


Figure 6. Landcover type distribution at high spatial resolution derived from Landsat-7 ETM and ground survey. a) August 2002; b) May, 2003.

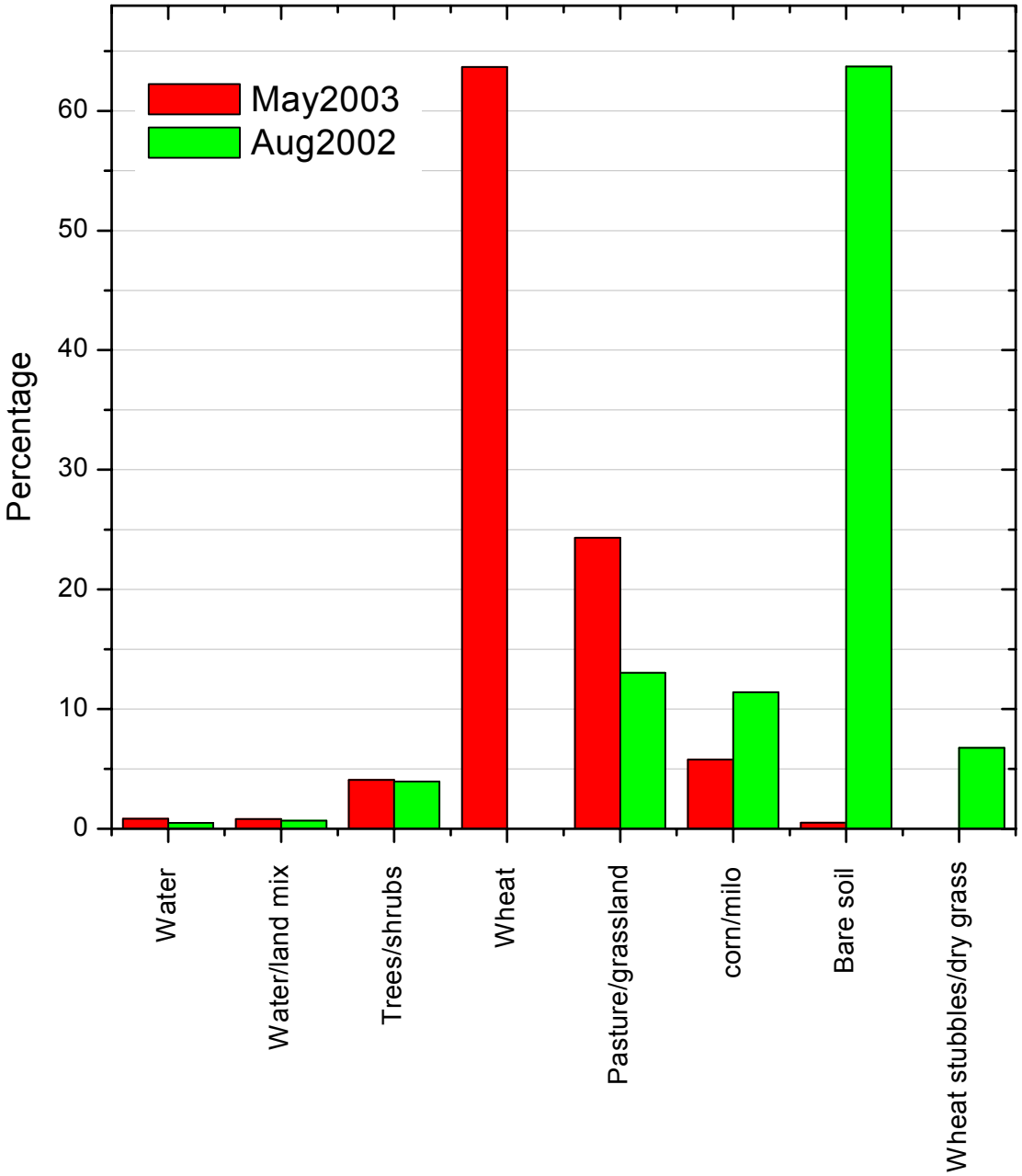


Figure 7. Comparison of landcover type statistics for the maps shown in Figure 6. Striking feature of the distributions is reciprocity between wheat class in Spring and bare soil in later Summer, which is explained by seasonal agricultural practice.