
# The Role of Land-Cover Change in Montane Mainland Southeast Asia in Altering Regional Hydrological Processes Under A Changing Climate

PI: Jefferson Fox, East-West Center, Honolulu
Co-I: Thomas Giambelluca, University of Hawai'i, Honolulu
Co-I: Bart Nijssen, University of Arizona, Tucson
Co-I: Omer Sen, Istanbul Technical University, Honolulu
Collaborators: Xu Jianchu, Kunming Institute of Botany; Khamla Phanvilay, National University of Laos; Pornchai Preeshapanya, Thai Forestry Department; Chatchai Tantarasin, Kasetsart University; Gerald Meehl, NCAR; Taikan Oki, Tokyo University; Yuqing Wang, University of Hawaii

http address: http://research.eastwestcenter.org/mmsea/

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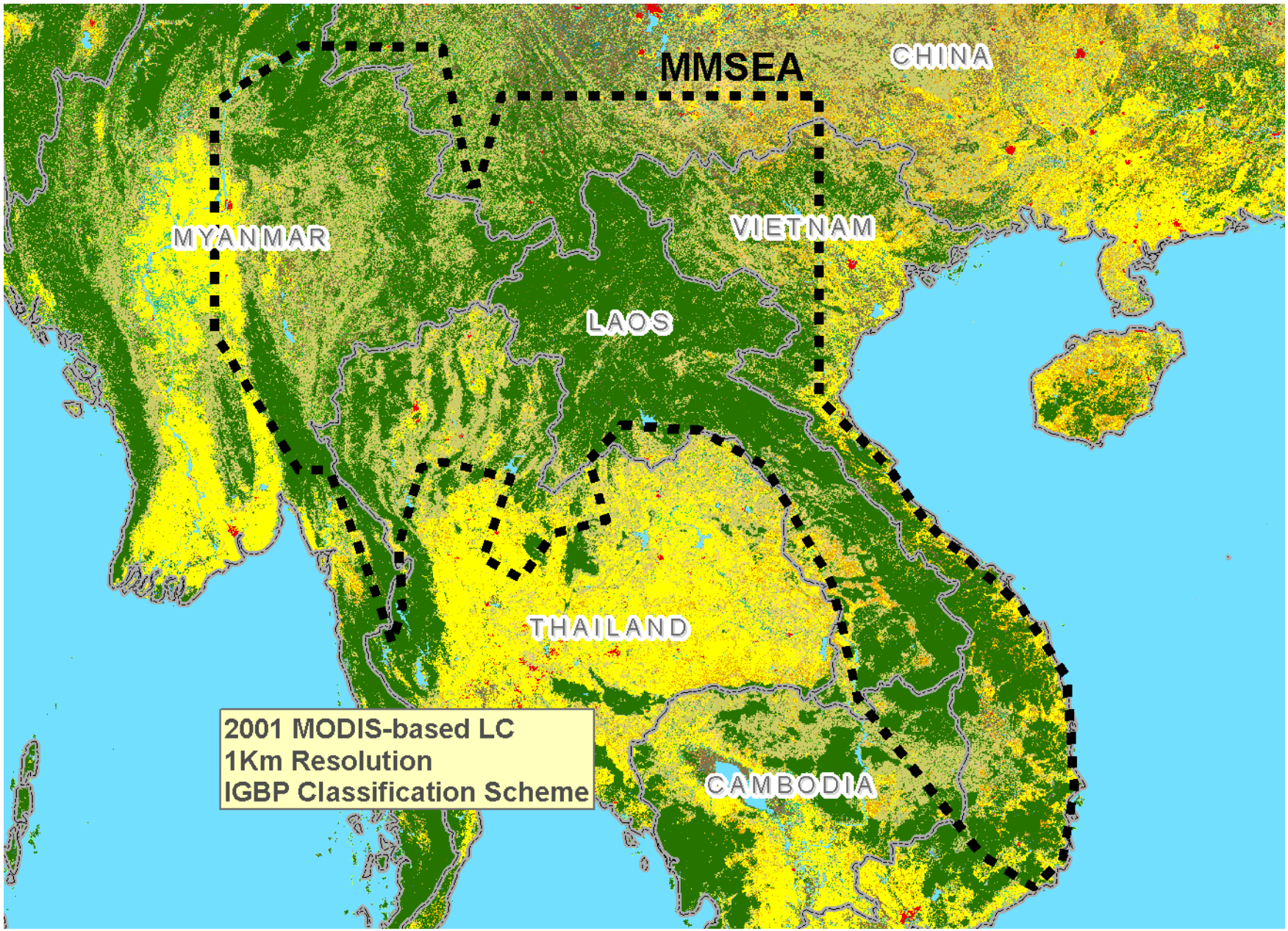
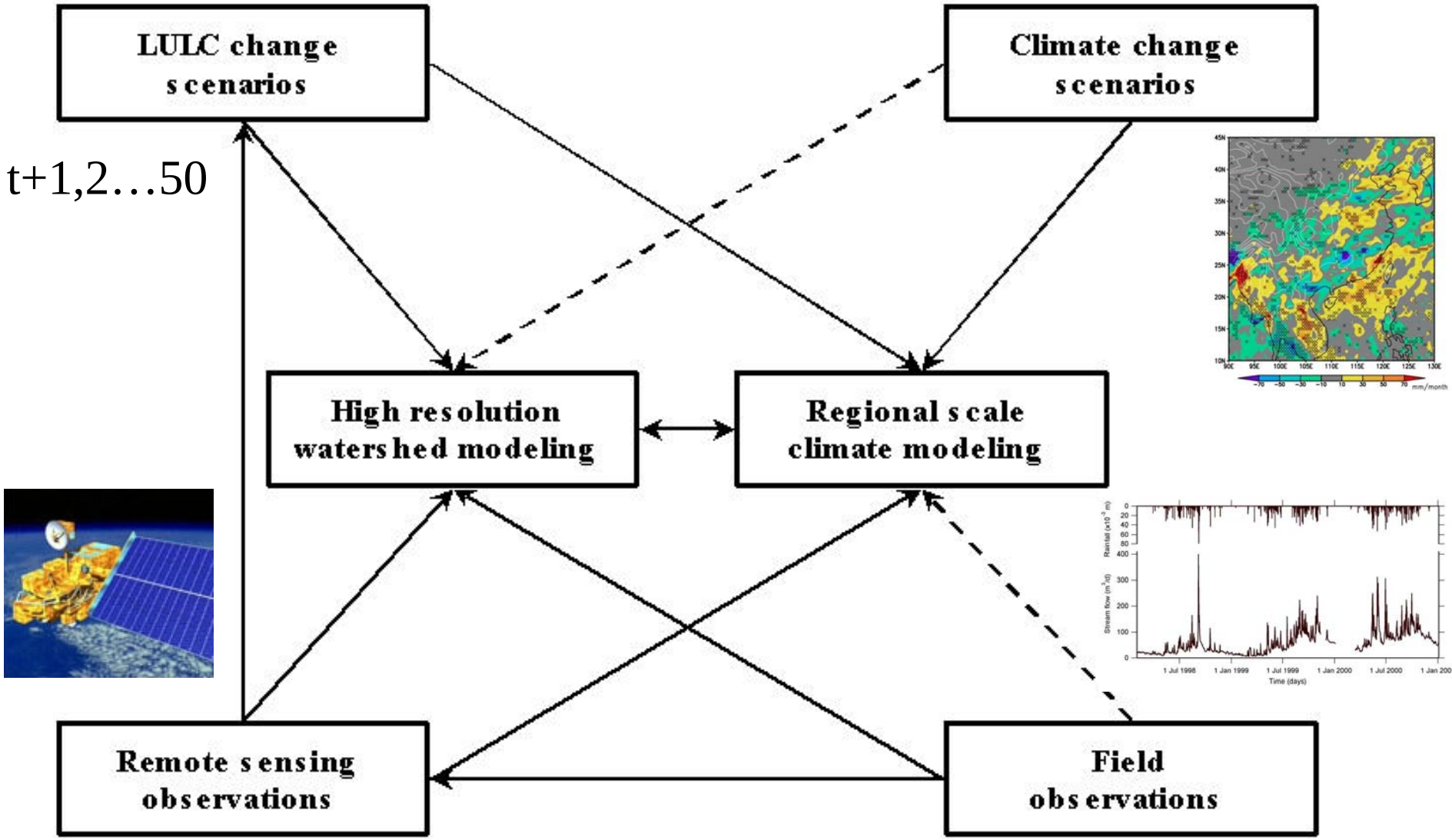

MMSEA
CHINA
MYANMAR
VIETNAM
LAOS
THAILAND
CAMBODIA
2001 MODIS-based LC
1Km Resolution
IGBP Classification Scheme


# Research Questions

1. How has LCLU changed in recent decades and what hydrologically-significant LCLUC is likely to occur in MMSEA in the coming decades?
2. How do changes in LCLU alter the hydrological functioning of watersheds in MMSEA? In particular, how will LCLUC affect the moisture and energy fluxes in these basins?
3. To what degree and over what spatial extent will these LCLUC in MMSEA effect changes in atmospheric circulations and climate?


## Approach Adopted

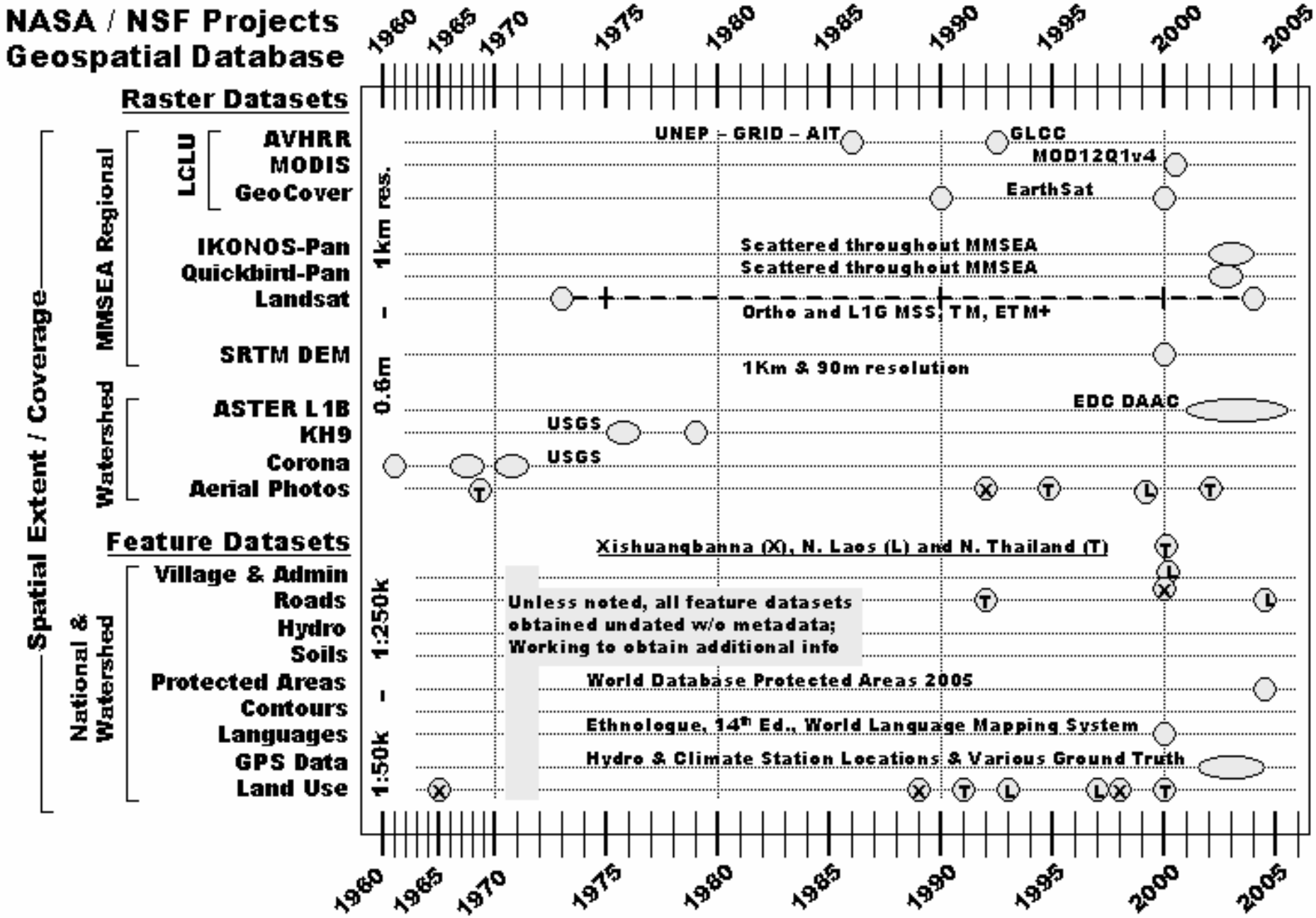
Multi-disciplinary, field and modeling approach in involving four teams: (1) LCLU Team; (2) Field Hydrology Team; (3) Watershed Modeling Team; and (4) Regional Climate Modeling Team




Conceptual model of interaction of proposed research components

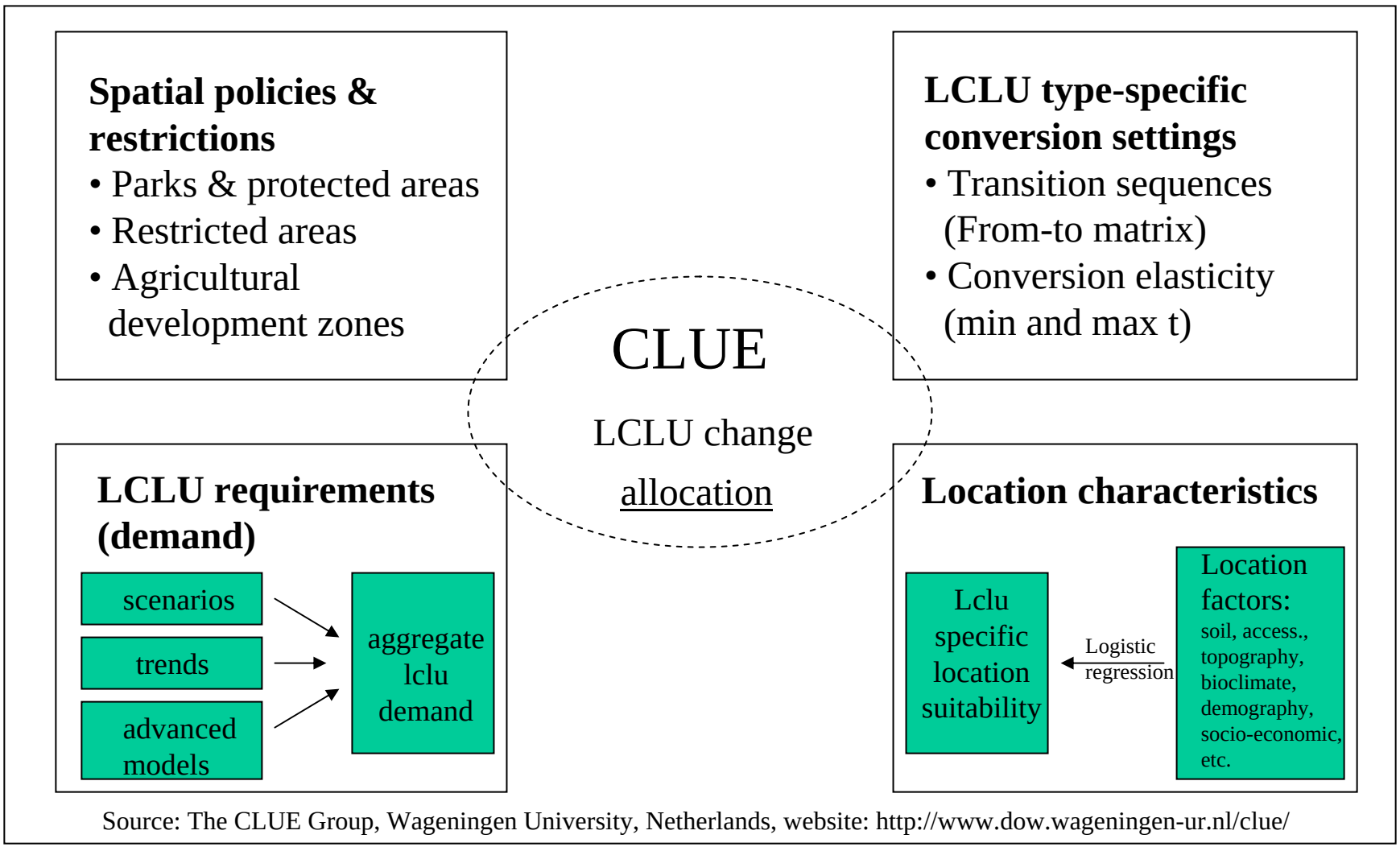

# Goals and Progress

1. To develop a comprehensive, high-resolution database of recent and current land cover in MMSEA and to develop scenarios of LCLUC in the region to 2025 and 2050 to be used as data layers in a regional climate change model.


NASA / NSF Projects
Geospatial Database
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Raster Datasets
Spatial Extent / Coverage
MMSEA Regional
LCLU
AVHRR
MODIS
GeoCover
IKONOS-Pan
Quickbird-Pan
Landsat
SRTM DEM
Watershed
ASTER L1B
KH9
Corona
Aerial Photos
1km res.
0.6m
UNEP – GRID – AIT
GLCC
MOD12Q1v4
EarthSat
Scattered throughout MMSEA
Scattered throughout MMSEA
Ortho and L1G MSS, TM, ETM+
1Km & 90m resolution
EDC DAAC
USGS
USGS
Feature Datasets
National & Watershed
Village & Admin
Roads
Hydro
Soils
Protected Areas
Contours
Languages
GPS Data
Land Use
1:250k
1:50k
Xishuangbanna (X), N. Laos (L) and N. Thailand (T)
Unless noted, all feature datasets obtained undated w/o metadata; Working to obtain additional info
World Database Protected Areas 2005
Ethnologue, 14th Ed., World Language Mapping System
Hydro & Climate Station Locations & Various Ground Truth

# MMSEA Land Cover / Land Use Simulations

- Changing Land Use and its Effects (CLUE) modeling framework




Source: The CLUE Group, Wageningen University, Netherlands, website: http://www.dow.wageningen-ur.nl/clue/

# MMSEA Land Cover / Land Use Simulations

• **Data Requirements** (Raw data cleaned, vector > raster, 1km res. GRIDs cut to 6 different regions, GRIDs converted to ASCII)

- Initial LC (MODIS-based year 2001)

- Masks and Protected Areas (WDPA)

- Socio-economic (income, GDP, malnutrition rate, illiteracy, etc.)

- Demographic (population density (*dynamic variable*))

- Bioclimatic (subset of bioclimate variables from WorldClim)

- Geographic (distance to road, river, market ('to road' is *dynamic variable*))

- Topographic (elevation, slope, aspect)

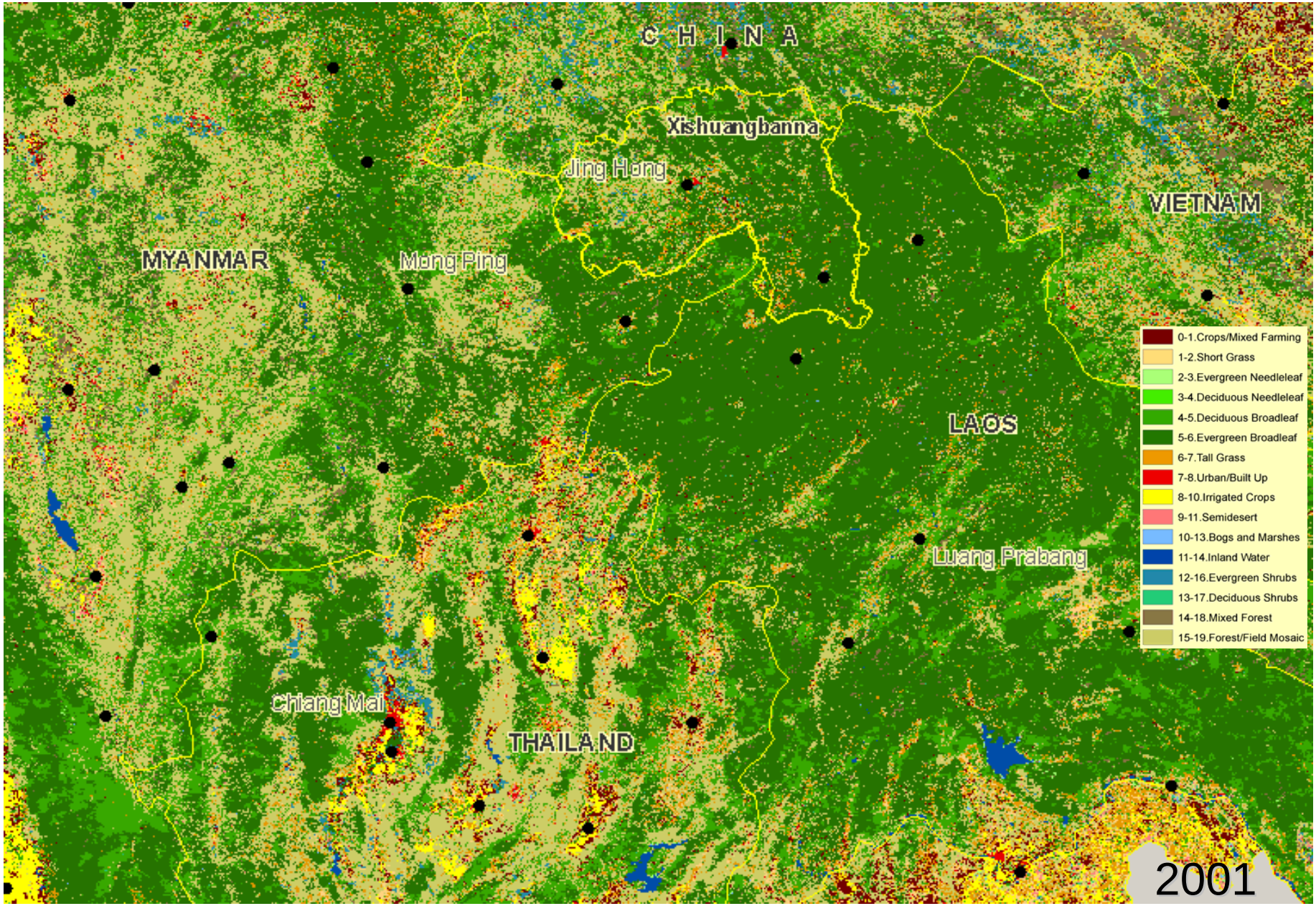
- Soils/Geomorphology (soil type, soil degradation, landform)

# MMSEA Land Cover / Land Use Simulations

- Overall MMSEA **Results** Increase Decrease Little/No change

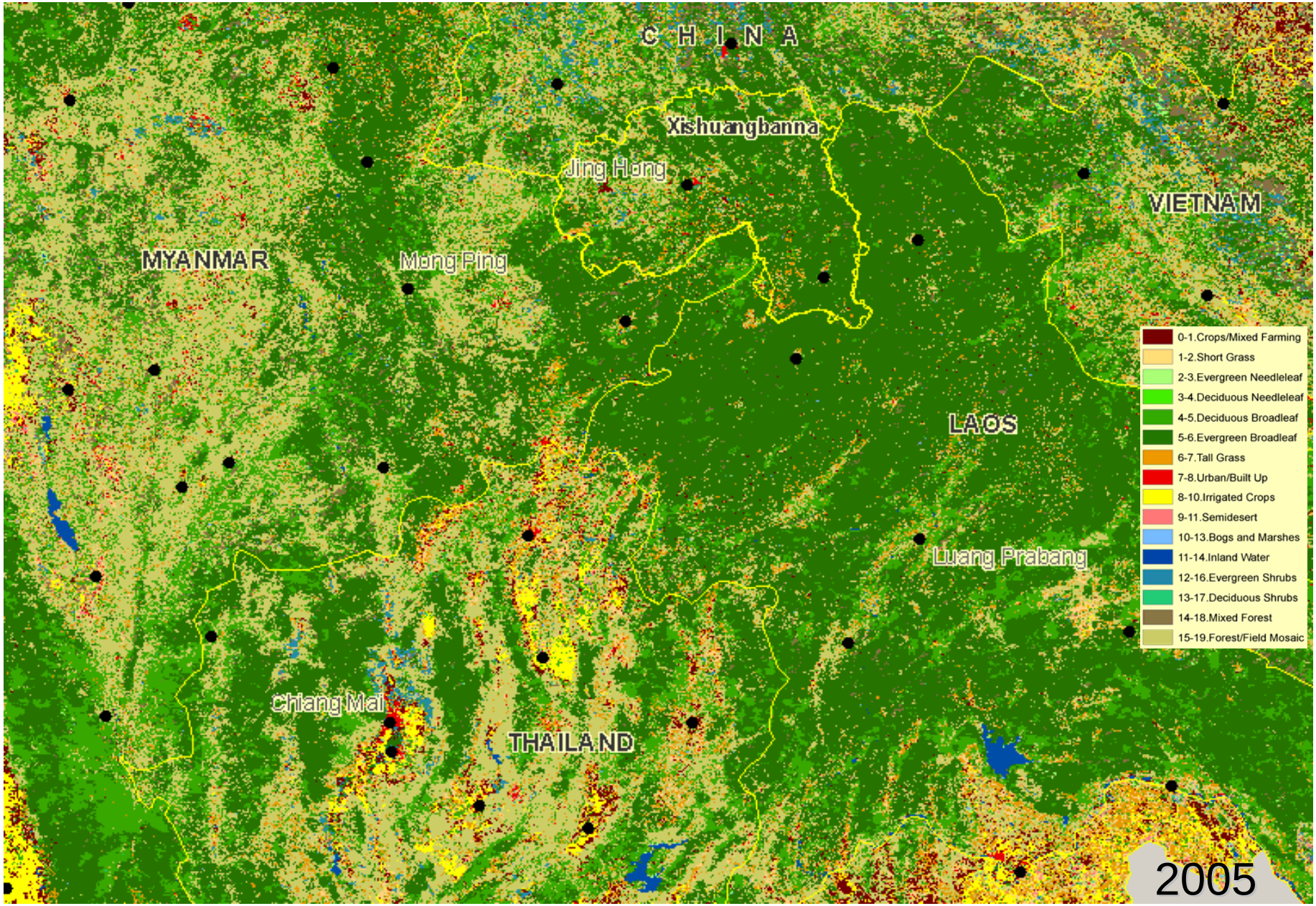
| MMSEA Model Region | Observed | | Simulation | | Simulation | |
|---|---|---|---|---|---|---|
| | 2001 | | 2025 | | 2050 | |
| LC Type | cells | % | cells | % | cells | % |
| Crops, Mixed Farming | 63816 | 3.69 | 103528 | 5.98 | 106182 | 6.13 |
| Short Grass | 51726 | 2.99 | 50654 | 2.93 | 59014 | 3.41 |
| Evergreen Needleleaf Trees | 5344 | 0.31 | 7411 | 0.43 | 5460 | 0.32 |
| Deciduous Needleleaf Trees | 25 | 0.00 | 18 | 0.00 | 18 | 0.00 |
| Deciduous Broadleaf Trees | 221978 | 12.82 | 246451 | 14.23 | 264610 | 15.28 |
| Evergreen Broadleaf Trees | 633363 | 36.58 | 582185 | 33.63 | 568824 | 32.85 |
| Tall Grass | 98737 | 5.70 | 93998 | 5.43 | 91185 | 5.27 |
| Desert | 11910 | 0.69 | 20683 | 1.19 | 39947 | 2.31 |
| Tundra | N/A | N/A | N/A | N/A | N/A | N/A |
| Irrigated Crops | 165063 | 9.53 | 174793 | 10.10 | 175123 | 10.11 |
| Semidesert | 17236 | 1.00 | 12638 | 0.73 | 12638 | 0.73 |
| Ice Caps and Glaciers | N/A | N/A | N/A | N/A | N/A | N/A |
| Bogs and Marshes | 1904 | 0.11 | 1904 | 0.11 | 1904 | 0.11 |
| Inland Water | 11105 | 0.64 | 11105 | 0.64 | 11105 | 0.64 |
| Ocean | 677 | 0.04 | 677 | 0.04 | 677 | 0.04 |
| Evergreen Shrubs | 39867 | 2.30 | 55781 | 3.22 | 68046 | 3.93 |
| Deciduous Shrubs | 10527 | 0.61 | 11663 | 0.67 | 11663 | 0.67 |
| Mixed Forest | 88824 | 5.13 | 77472 | 4.47 | 67414 | 3.89 |
| Forest/Field Mosaic | 309230 | 17.86 | 280372 | 16.19 | 247523 | 14.30 |
| Total | 1731333 | 100.00 | 1731333 | 100.00 | 1731333 | 100.00 |

# LCLUC Simulations 2001 – 2050



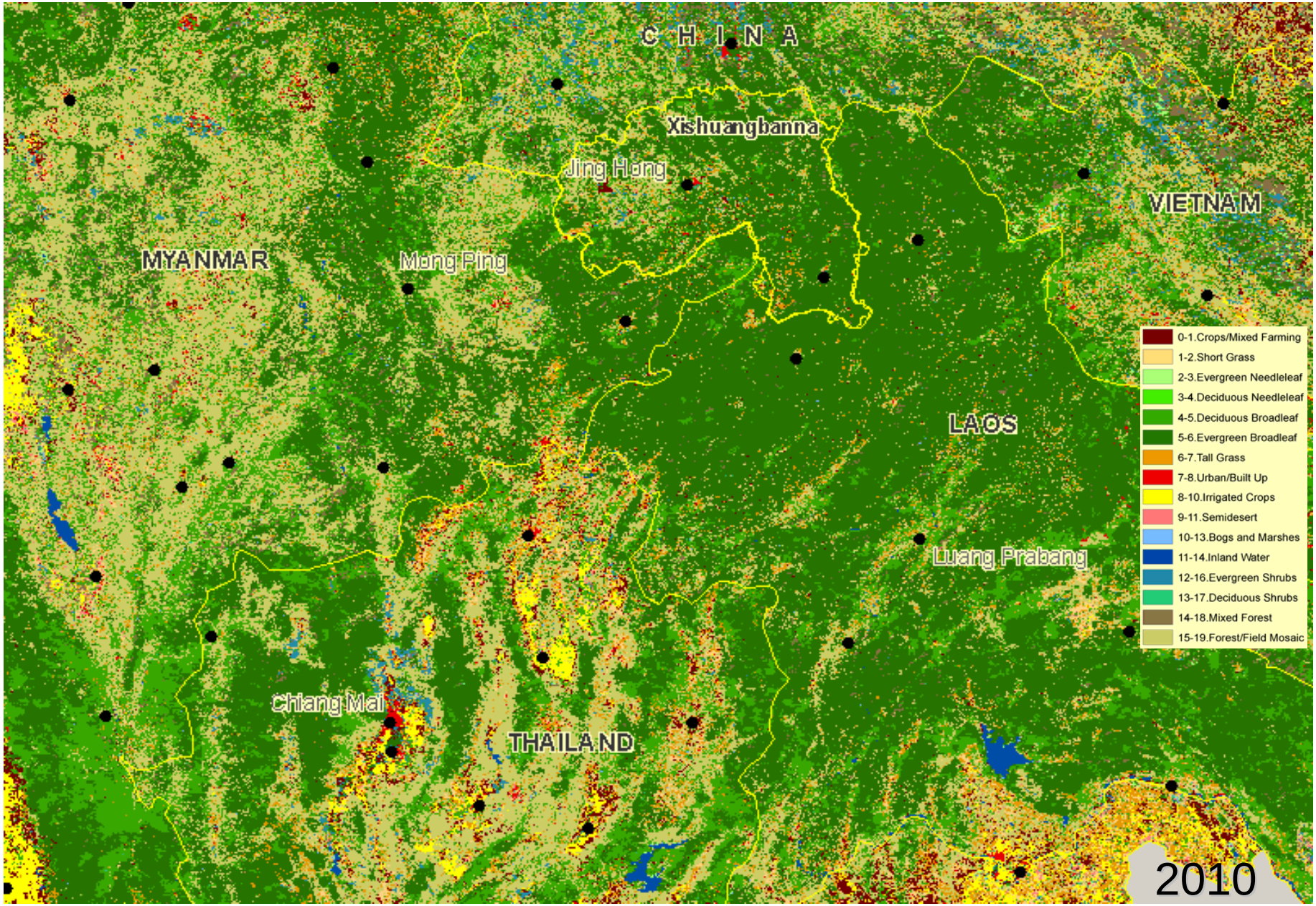

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050




Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050

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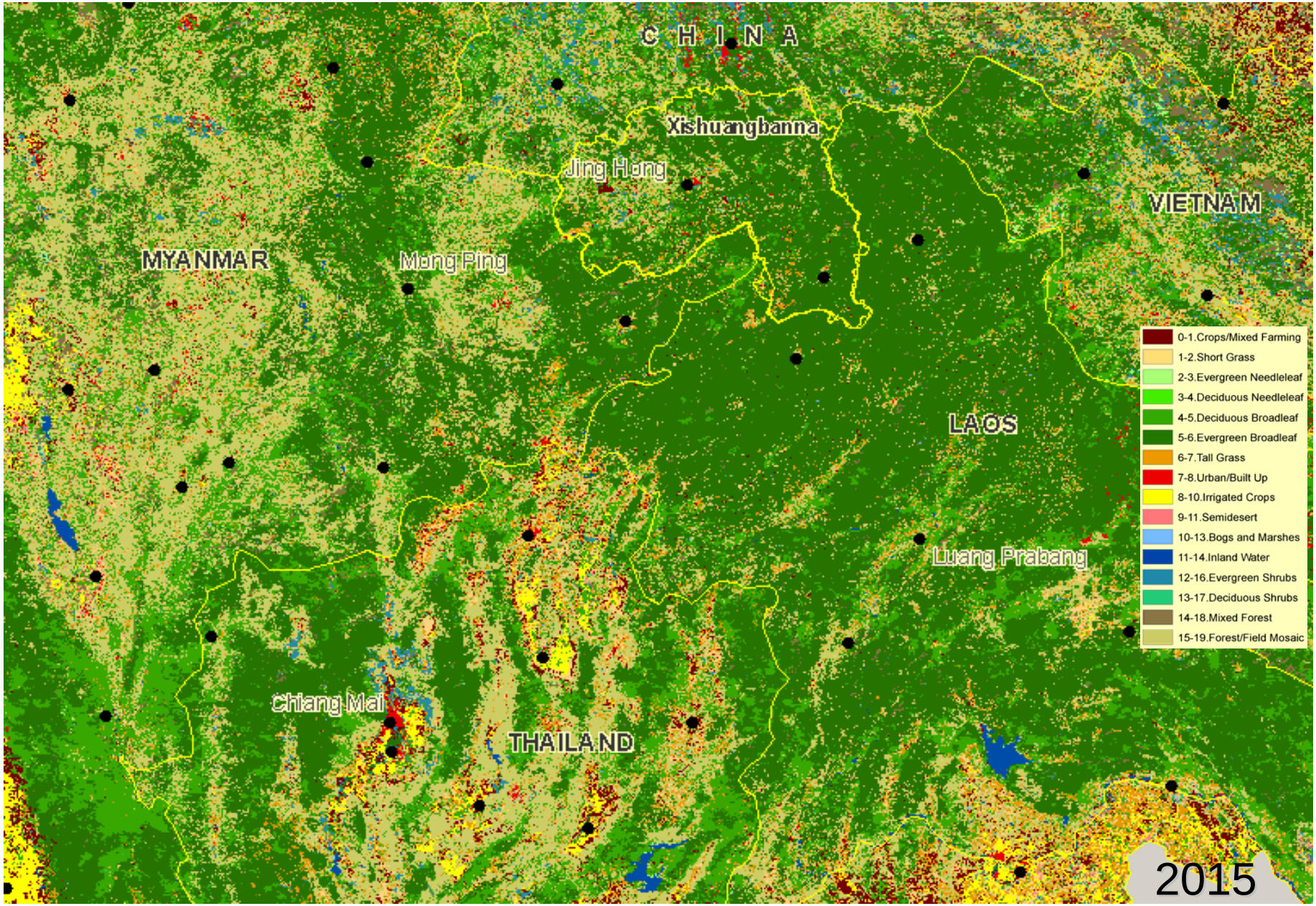
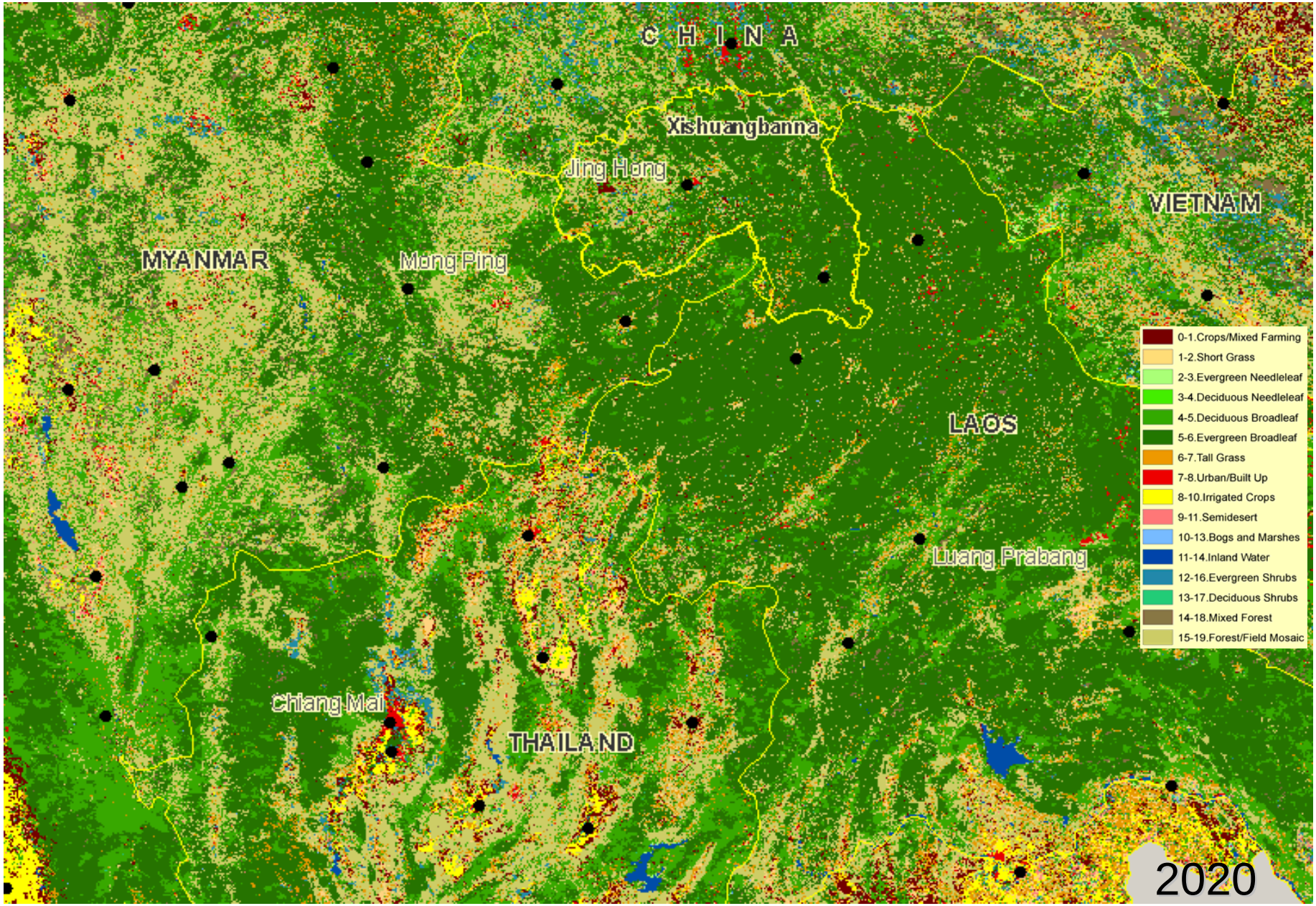


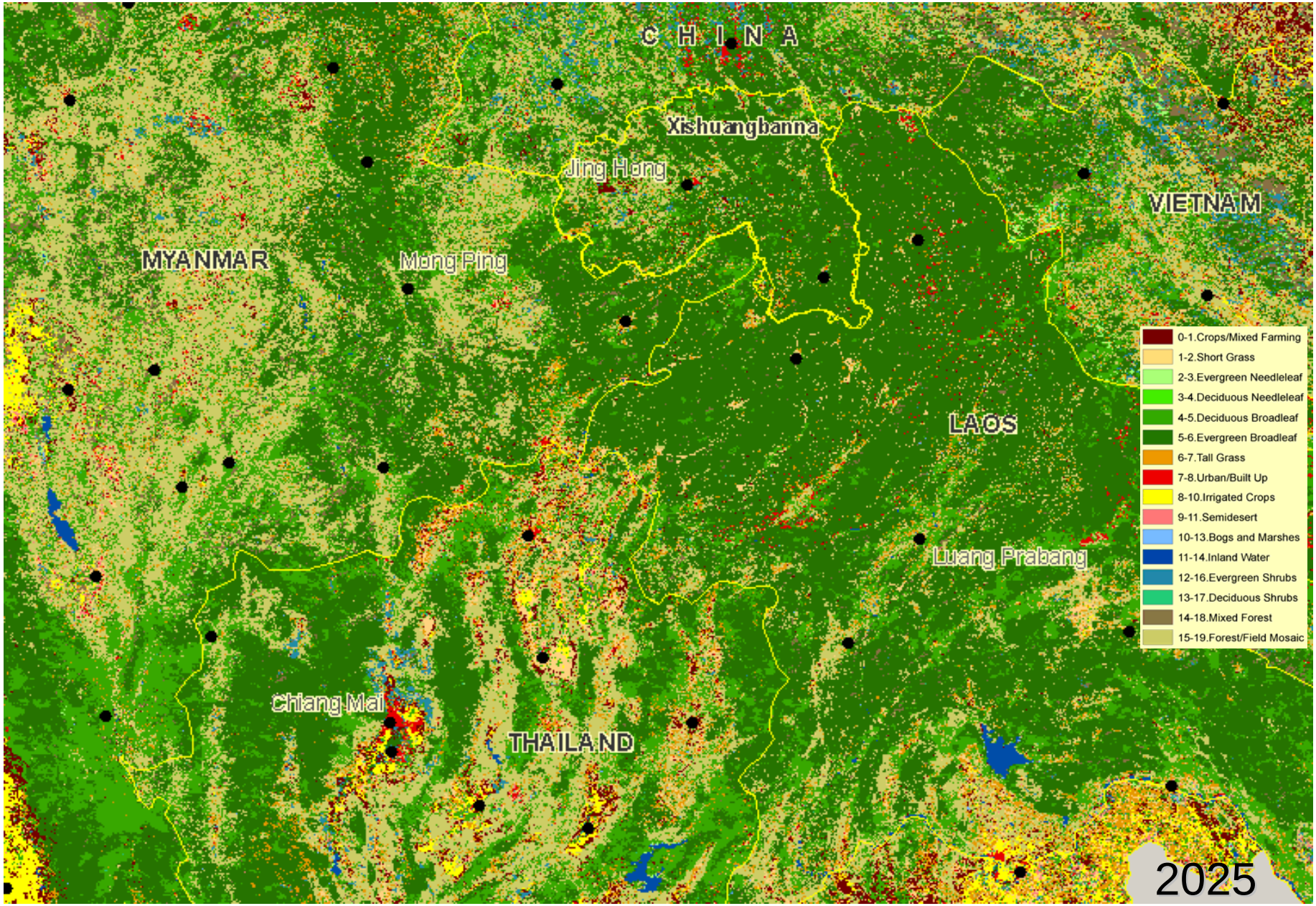

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



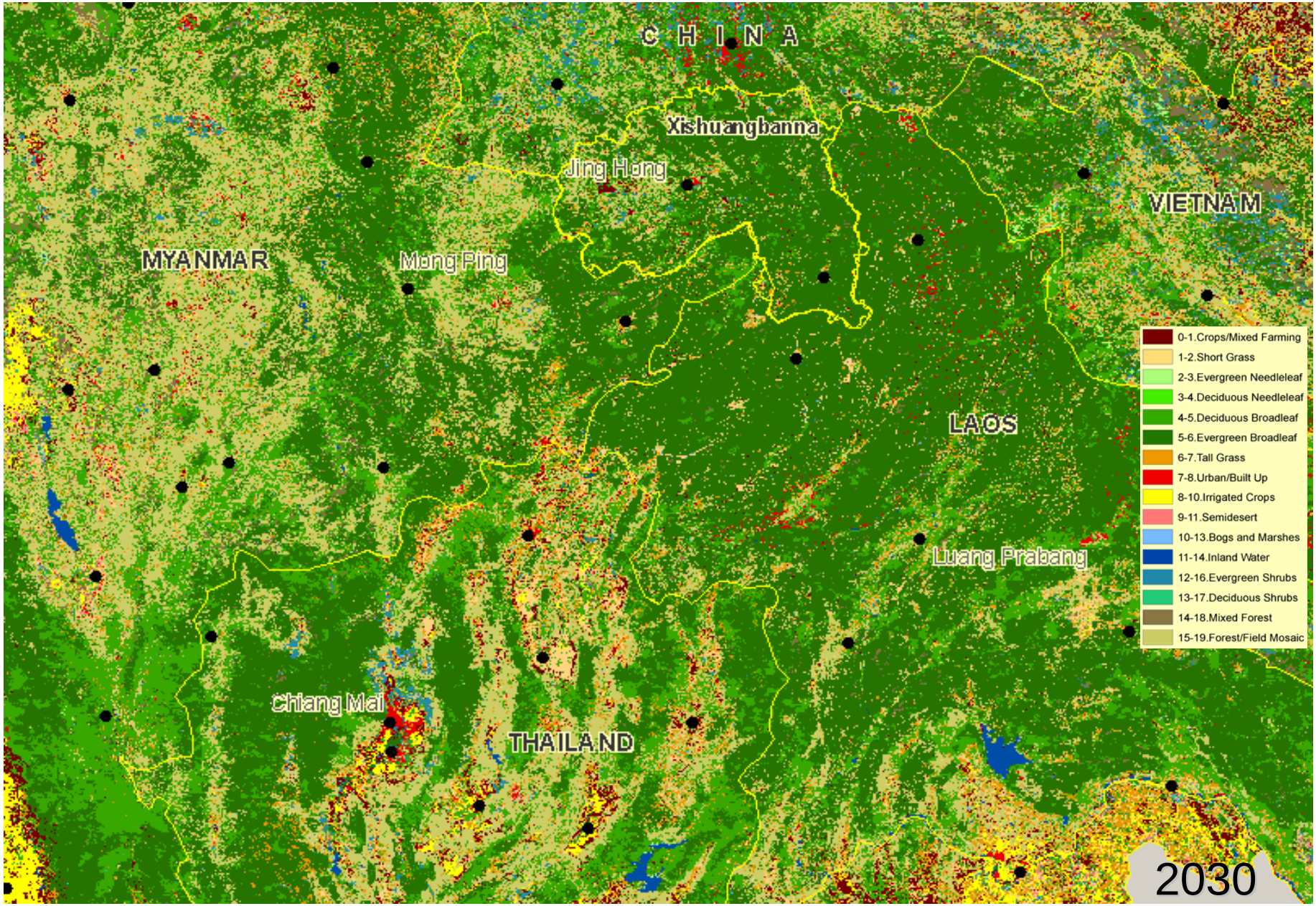

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



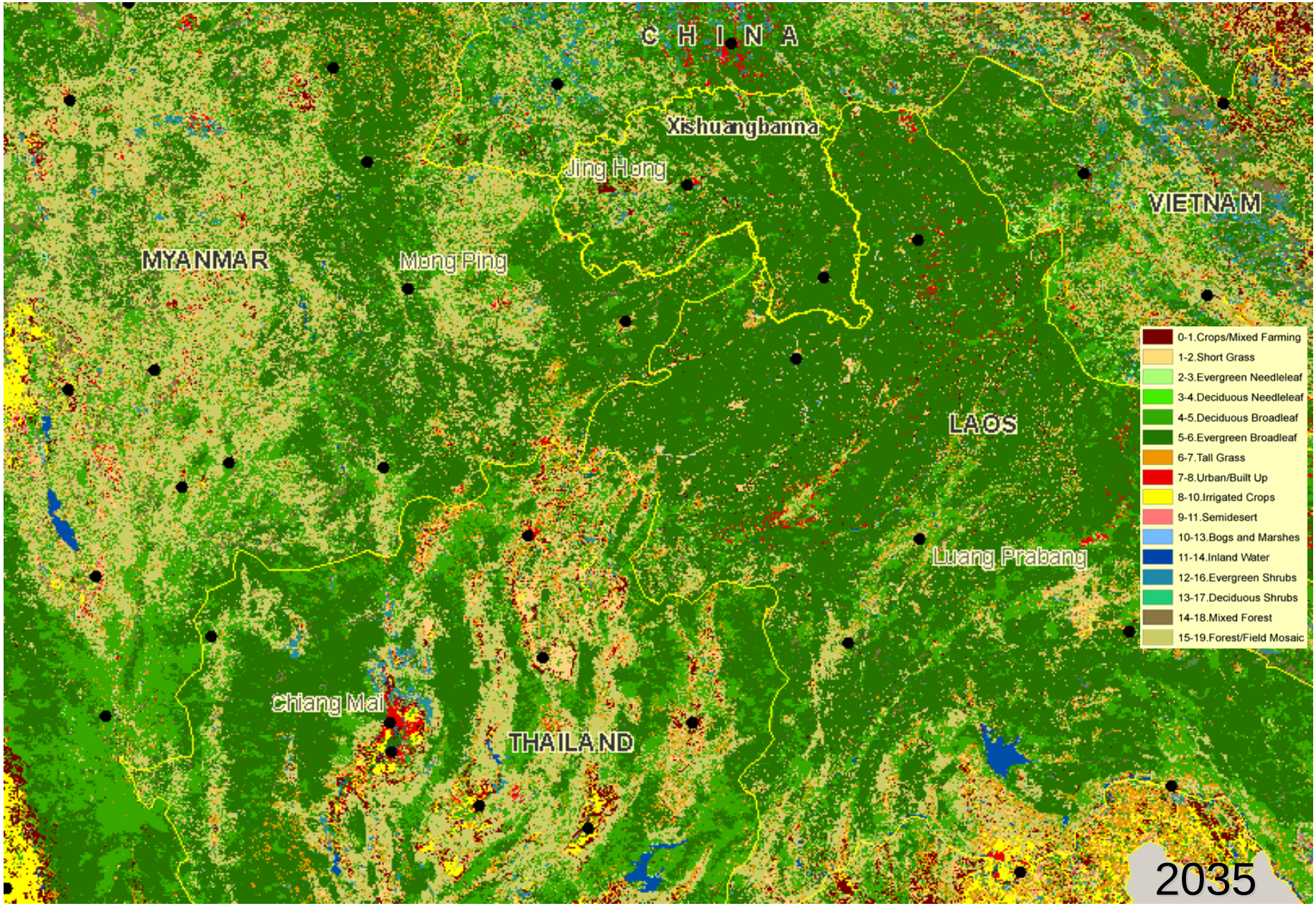

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



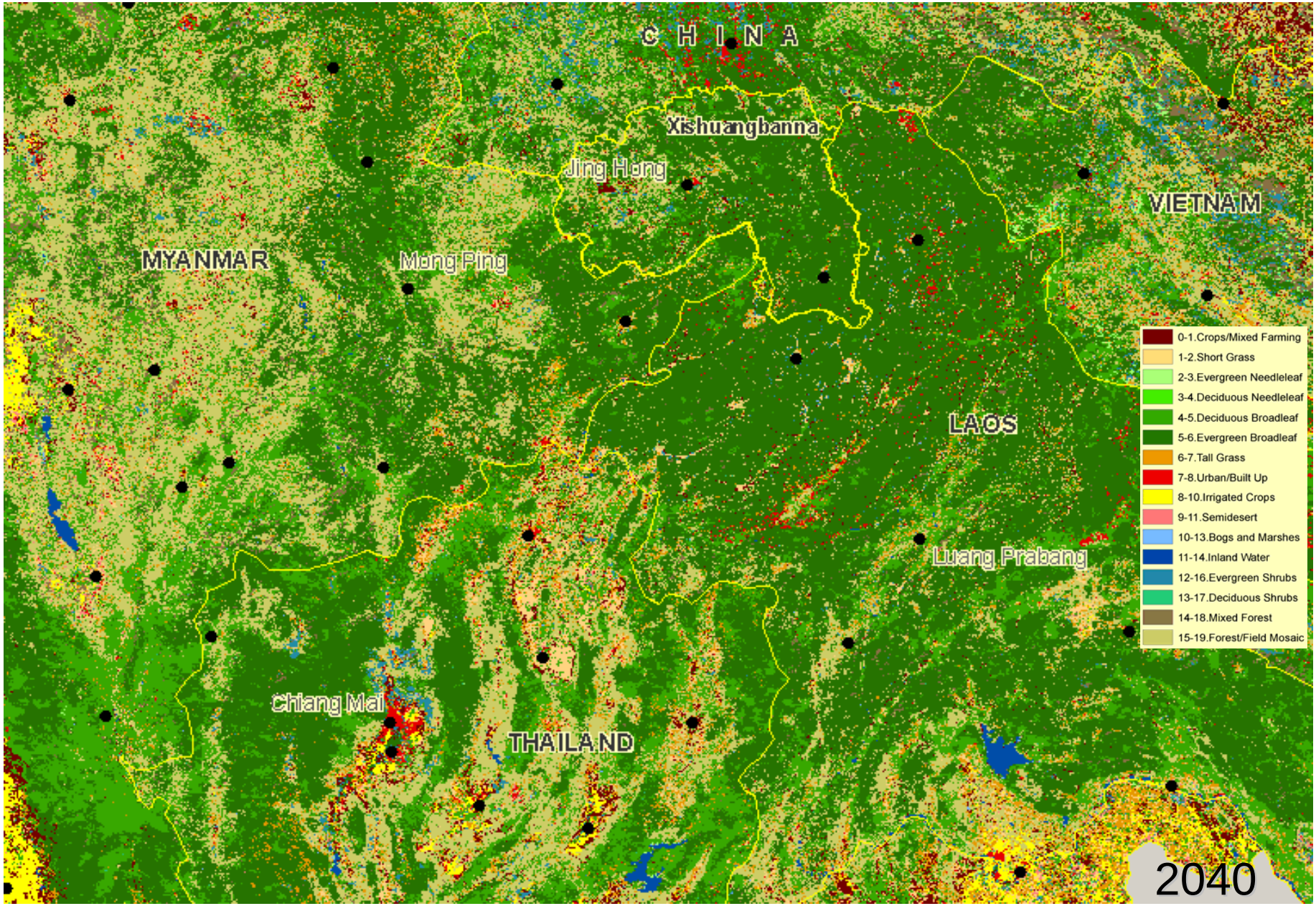

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



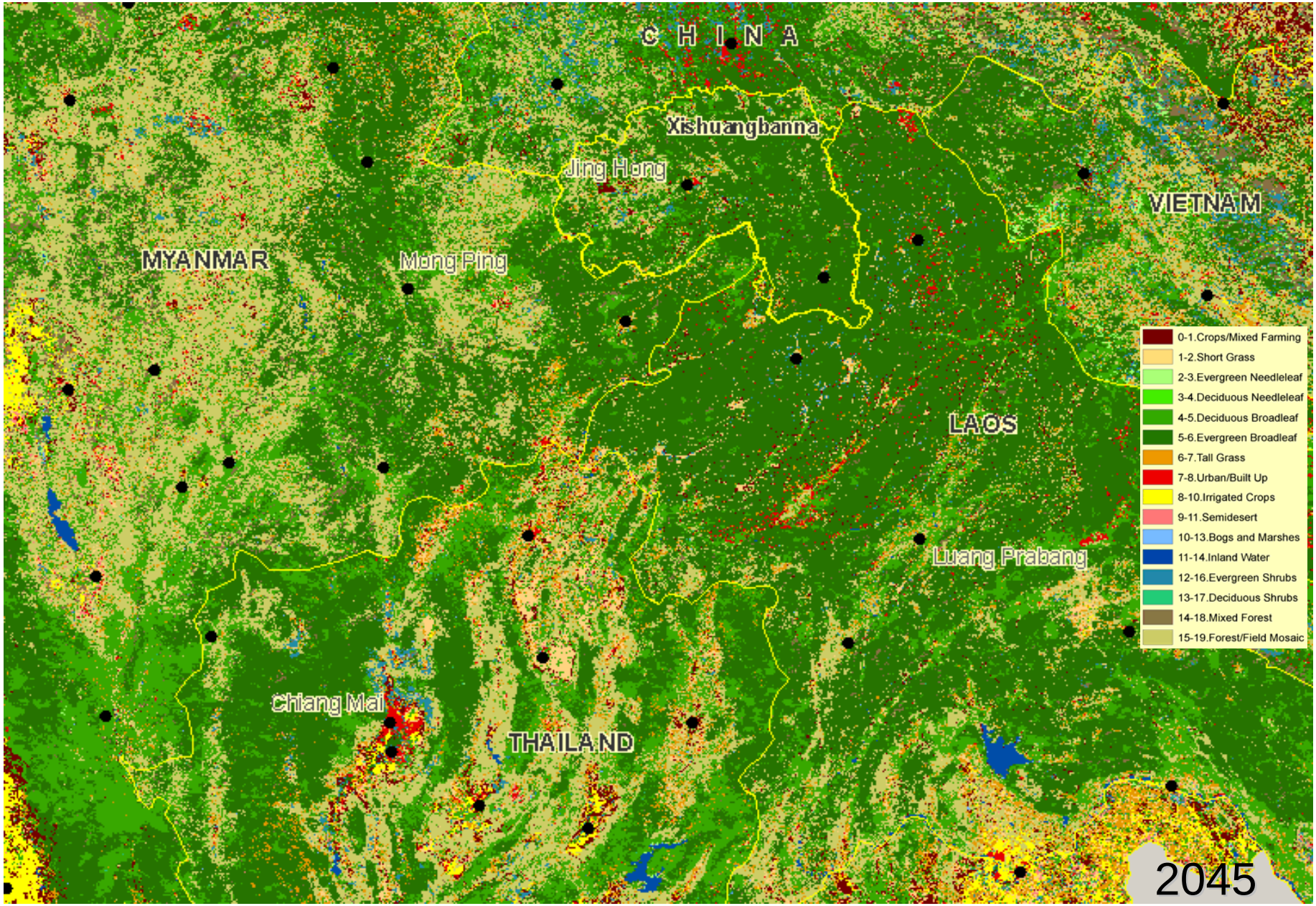

6 Model use annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



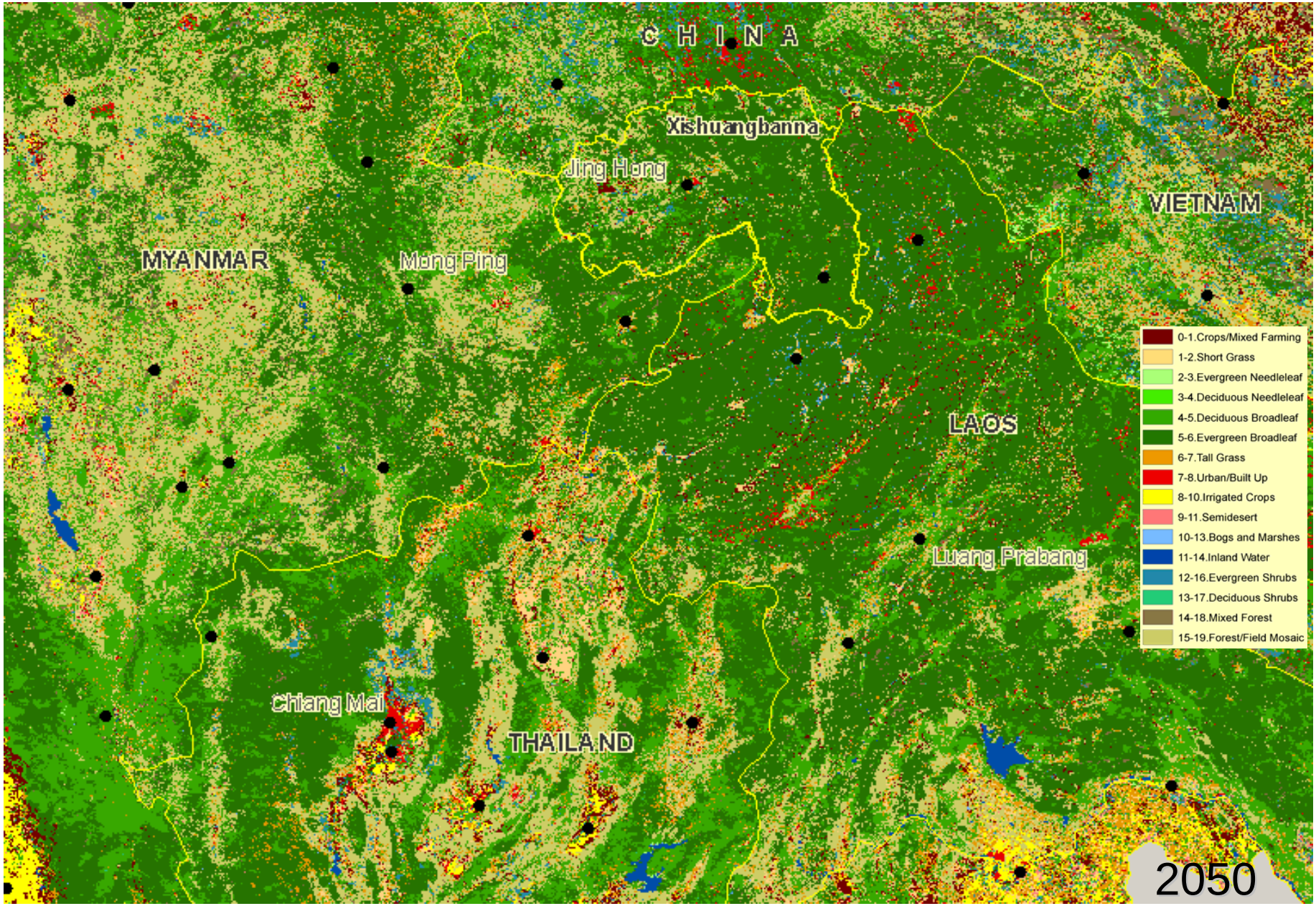

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050



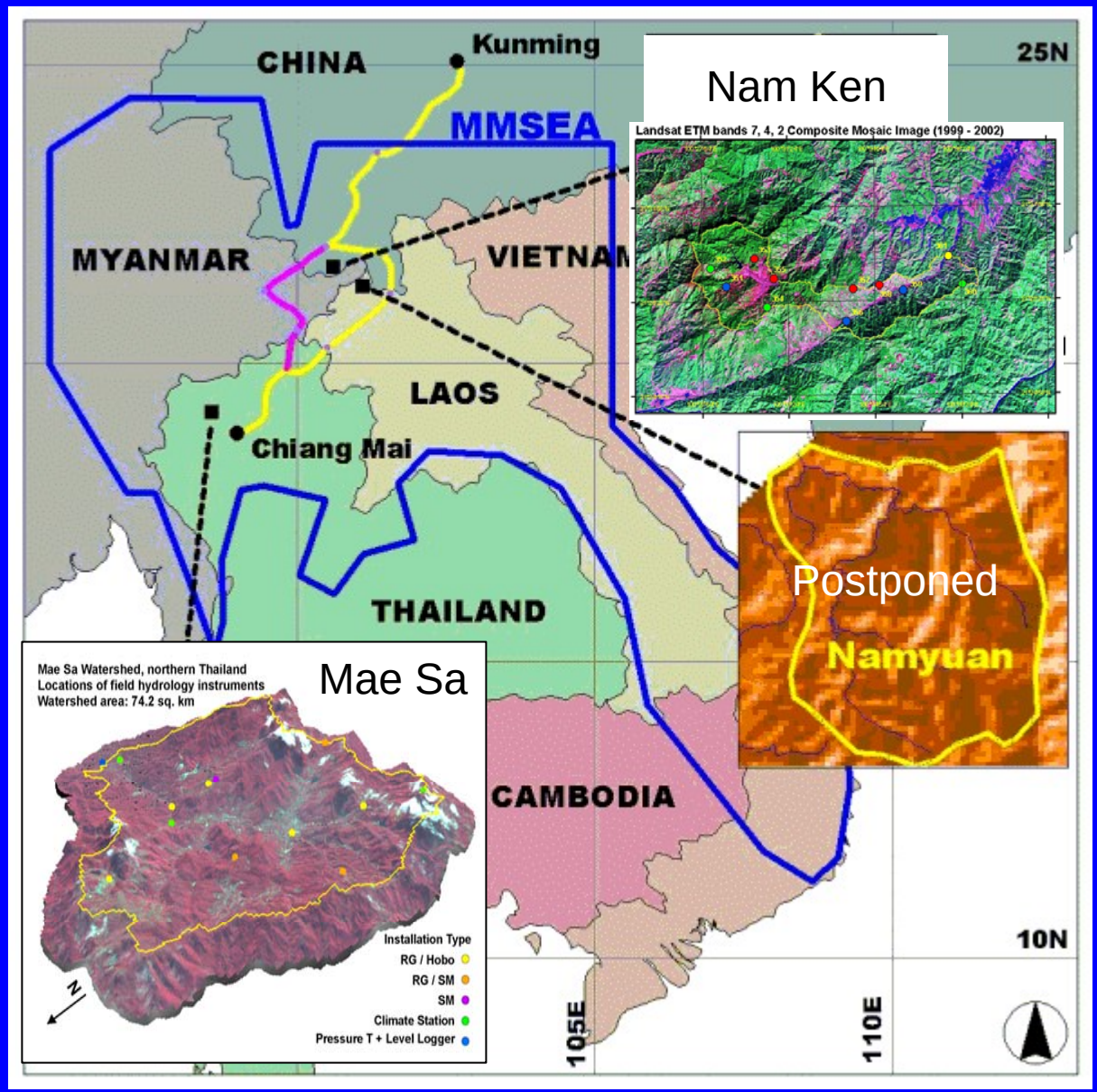

Model uses annual time steps; 5yr interval outputs shown here

# LCLUC Simulations 2001 – 2050




Model uses annual time steps; 5yr interval outputs shown here


2. To make field measurements of key hydrological variables within two representative watersheds for the purposes of calibrating and validating hydrological and climatological models for the region.


CHINA
Kunming
25N
MMSEA
Nam Ken
Landsat ETM bands 7, 4, 2 Composite Mosaic Image (1999 - 2002)
MYANMAR
VIETNAM
LAOS
Chiang Mai
THAILAND
Postponed
Namyuan
Mae Sa Watershed, northern Thailand
Locations of field hydrology instruments
Watershed area: 74.2 sq. km
Mae Sa
CAMBODIA
Installation Type
RG / Hobo
RG / SM
SM
Climate Station
Pressure T + Level Logger
N
10N
105E
110E

–Se
(no
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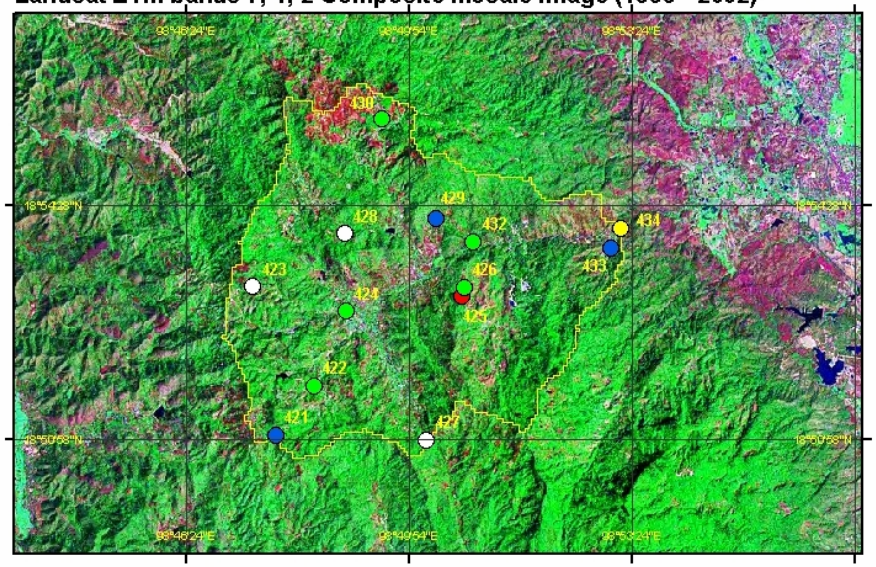
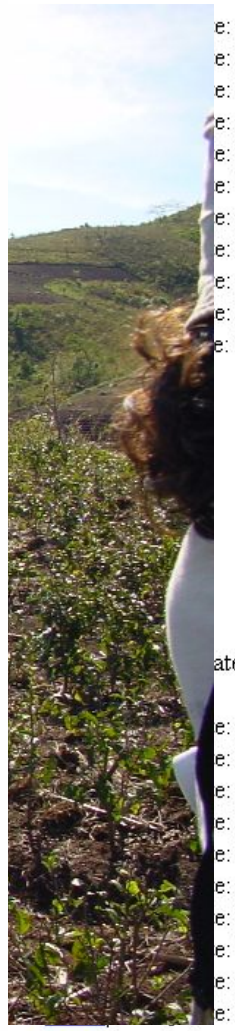
CHINA

map

**Landsat ETM bands 7, 4, 2 Composite Mosaic Image (1999 - 2002)**




last update: 041124



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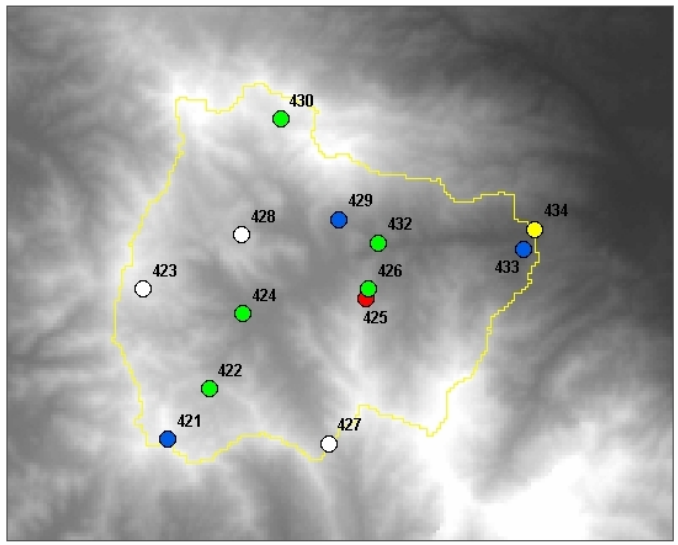
## Mae Sa Watershed Station Locations and Types

Kilometers

0 2.5 5 10




**Type**

- RG/Hobo
- RG/SM
- SM
- climate station
- pressure T + level loggers

**th_wshd90m_f.img**

**Value**

High : 1688

Low : 0

ate: 041124

e: 041124
e: 041124
e: 041124
e: 041124
e: 041124
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notes | last update: 041124
notes | last update: 041124
notes | last update: 041124

**SRTM 90m Resolution DEM**

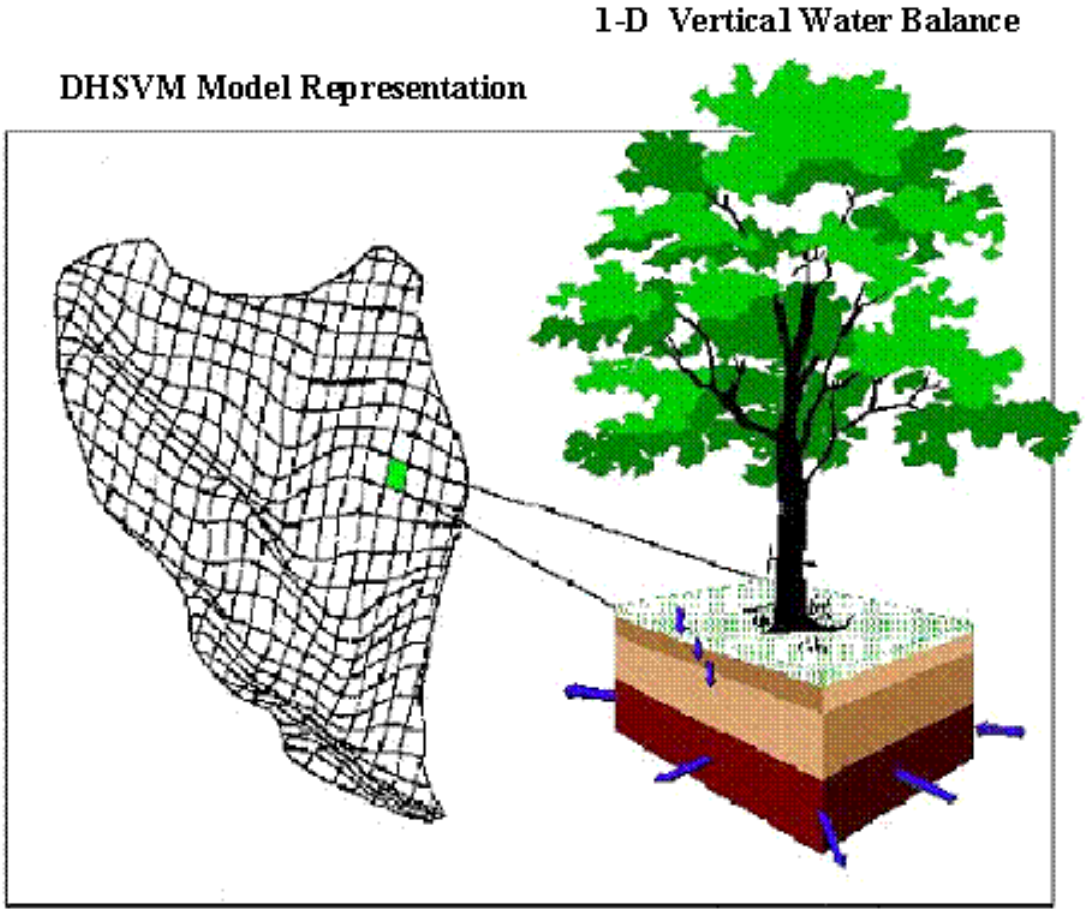
Station visit notes [2004] [2005] [2006] | last update: 041124

Progress Report


3. To model hydrological processes within each study watershed to establish the role of land-cover change in altering watershed function.

# DHSVM: Hydrology – Vegetation model

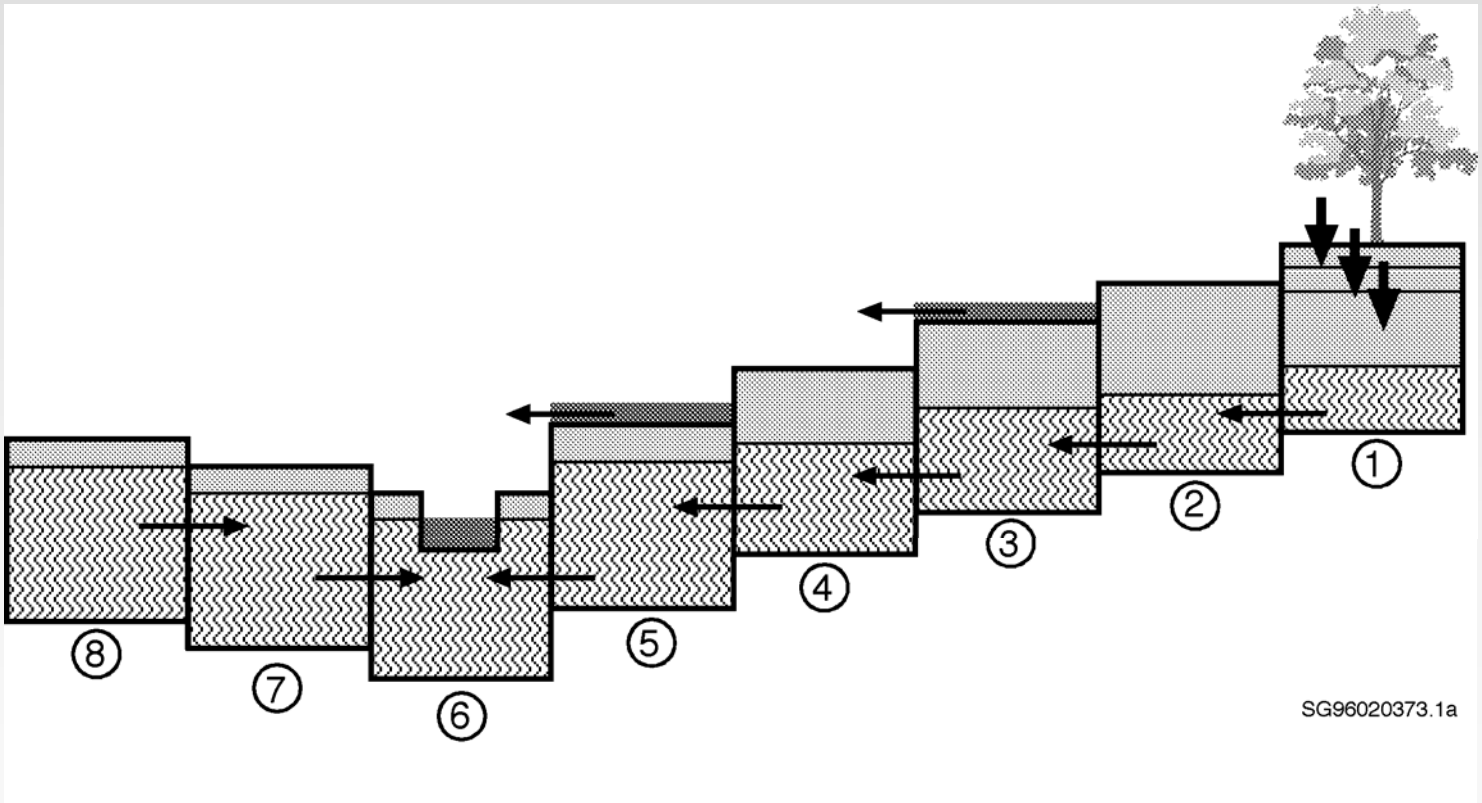
## Distributed Hydrology Soil Vegetation Model




- Overstory / Understory
- 3 layers of rooting zone
- Saturated subsurface flow

# DHSVM

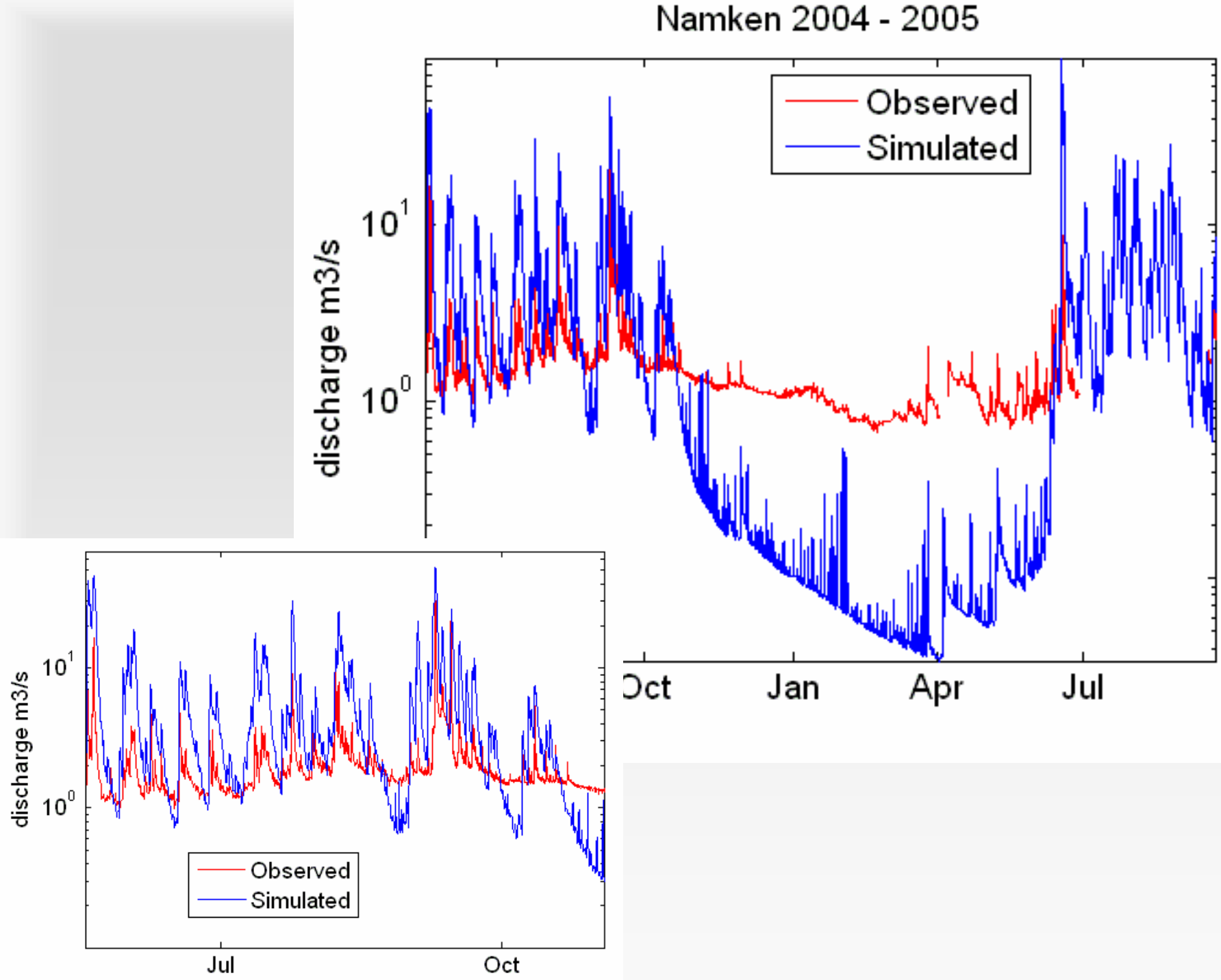
- Unsaturated flow → Darcy (Unit gradient)
- Lower root zone → Water table
- 3-D surface, subsurface & saturated flow



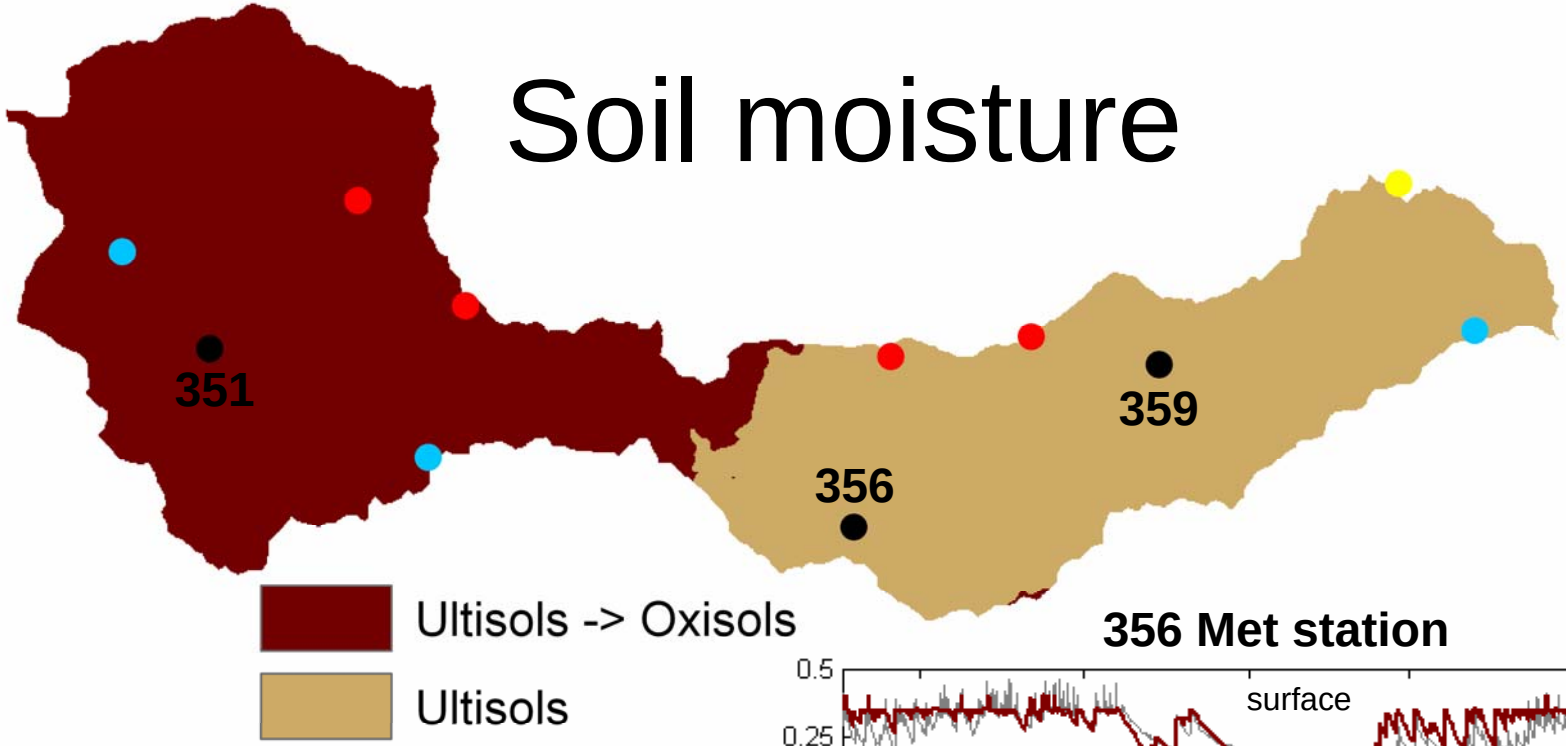
# Initial runs

- Measured and Literature parameters
- No calibration done

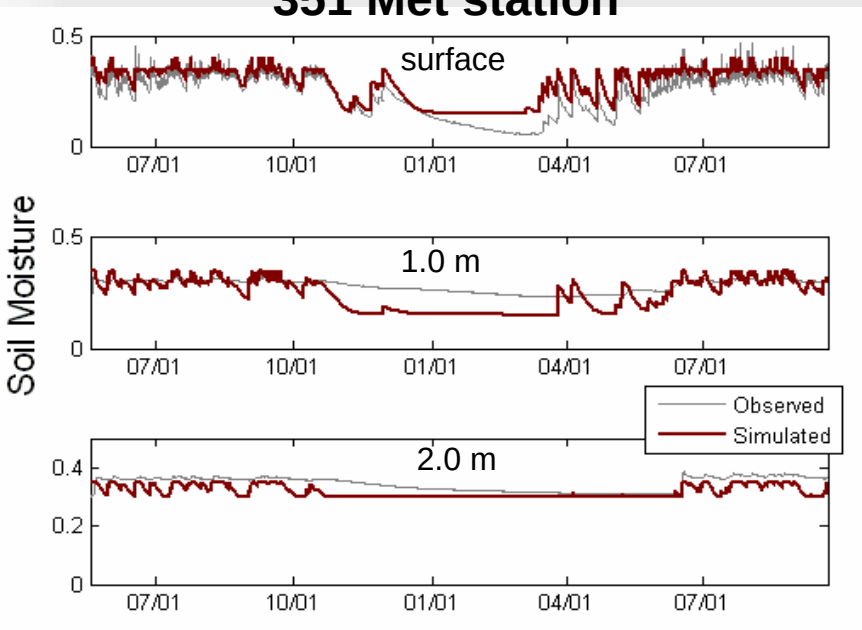
- Comparisons with:
  - Streamflow observations
  - Soil moisture observations


Namken 2004 - 2005
Observed
Simulated
discharge m3/s
$10^1$
$10^0$
Oct
Jan
Apr
Jul
discharge m3/s
$10^1$
$10^0$
Observed
Simulated
Jul
Oct

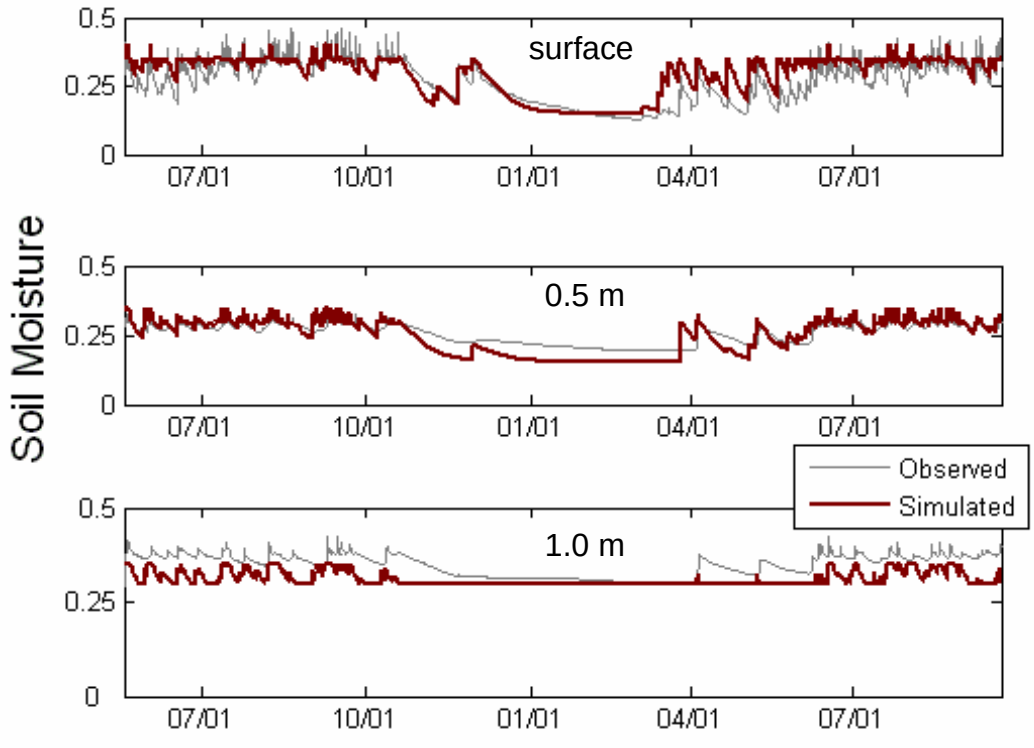
# Soil moisture




## 351 Met station



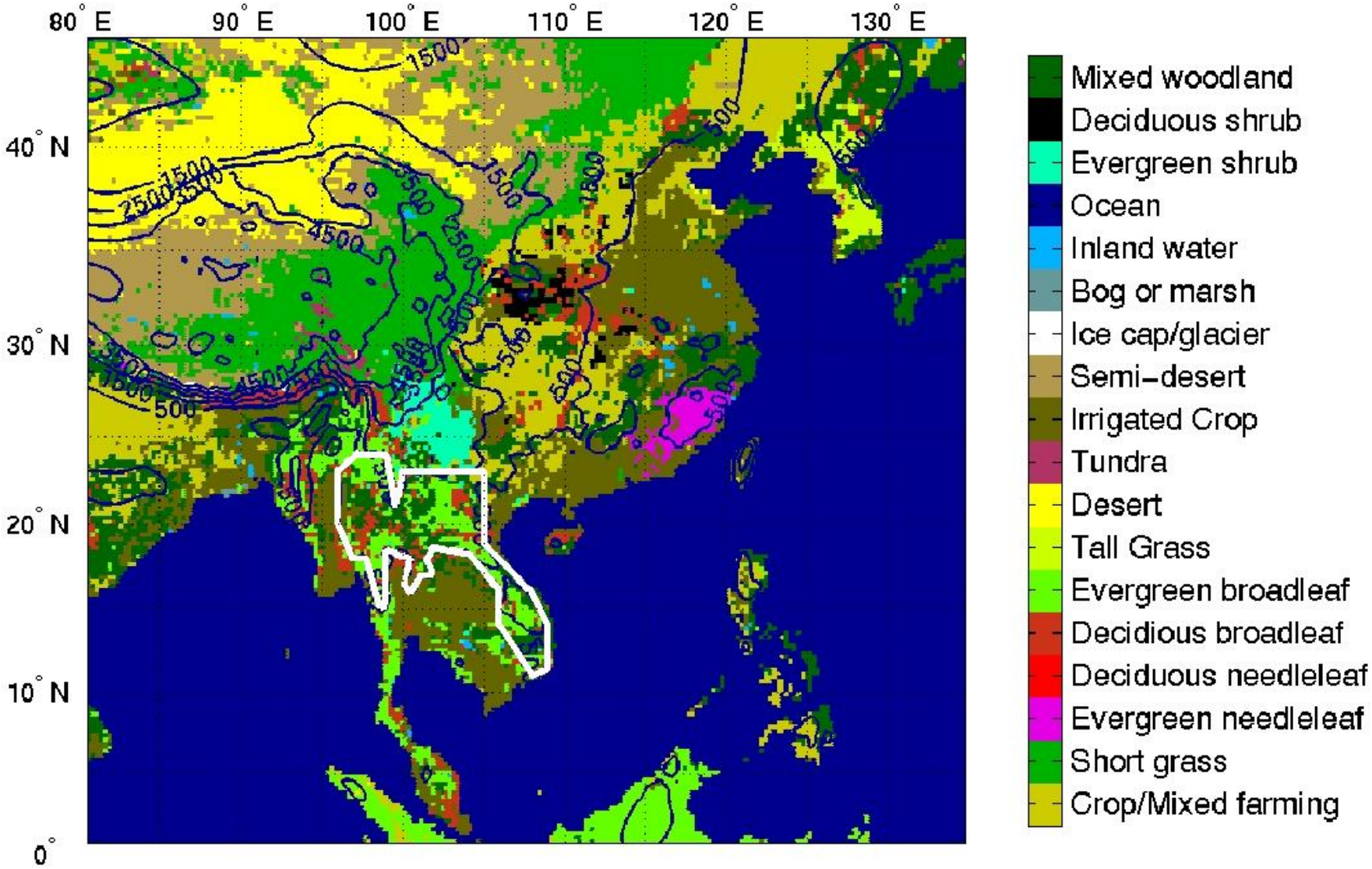

## 356 Met station




4. To determine what are the separate and combined effects of LCLUC and global warming on the regional and local hydrology?

# Climate simulations …

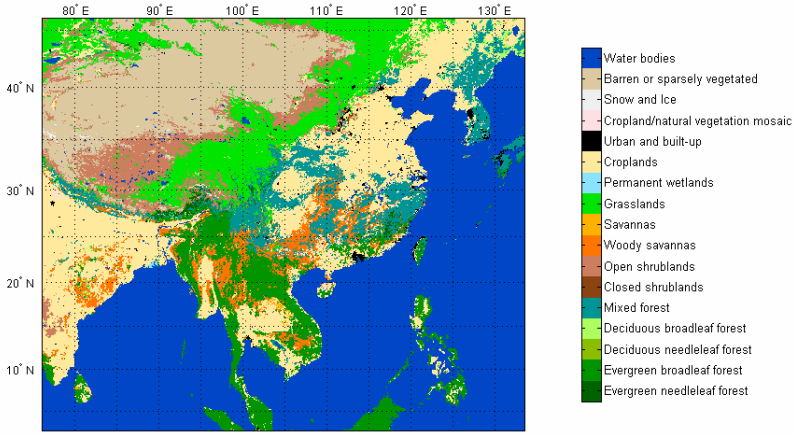
- Present climate (1998-2002; NCEP/NCAR) with present LCLU
- Present climate (1998-2002; NCEP/NCAR) with **2025 LCLU**
- Present climate (1998-2002; NCEP/NCAR) with **2050 LCLU**
- Control climate (PCM 2045-55; Present CO2) with present LCLU
- Control climate (PCM 2045-55; Present CO2) with **2050 LCLU**
- Projected 2050 climate (PCM 2045-55; SRES A2 CO2) with present LCLU
- Projected 2050 climate (PCM 2045-55; SRES A2 CO2) with **2050 LCLU**



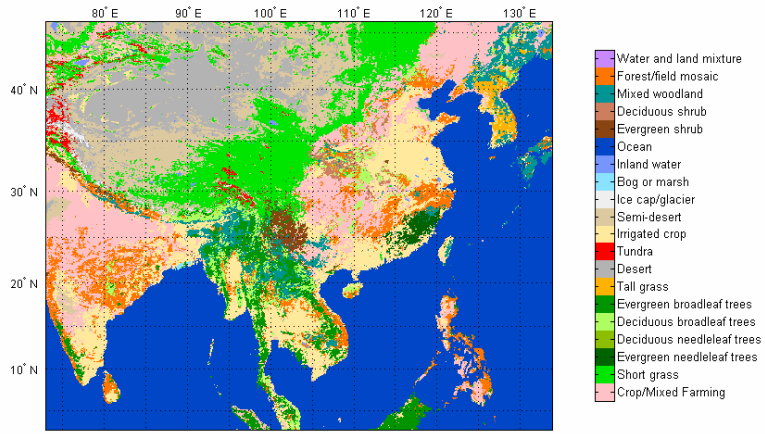

Domain of IPRC regional climate model w/ land cover and elevation

# Land Cover/Vegetation Map

## MODIS-IGBP

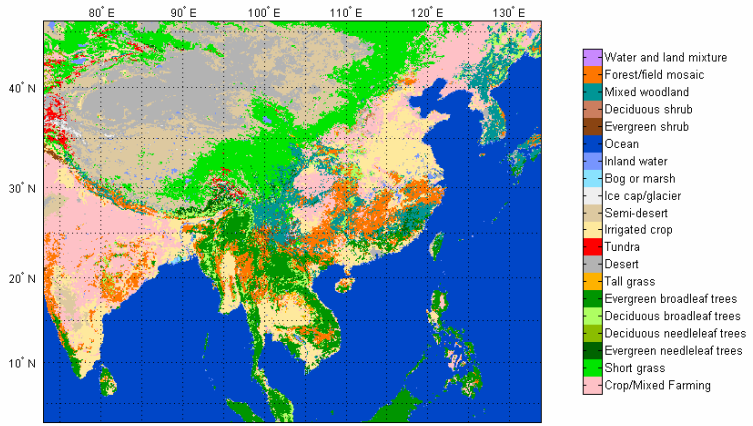



## AVHRR-BATS



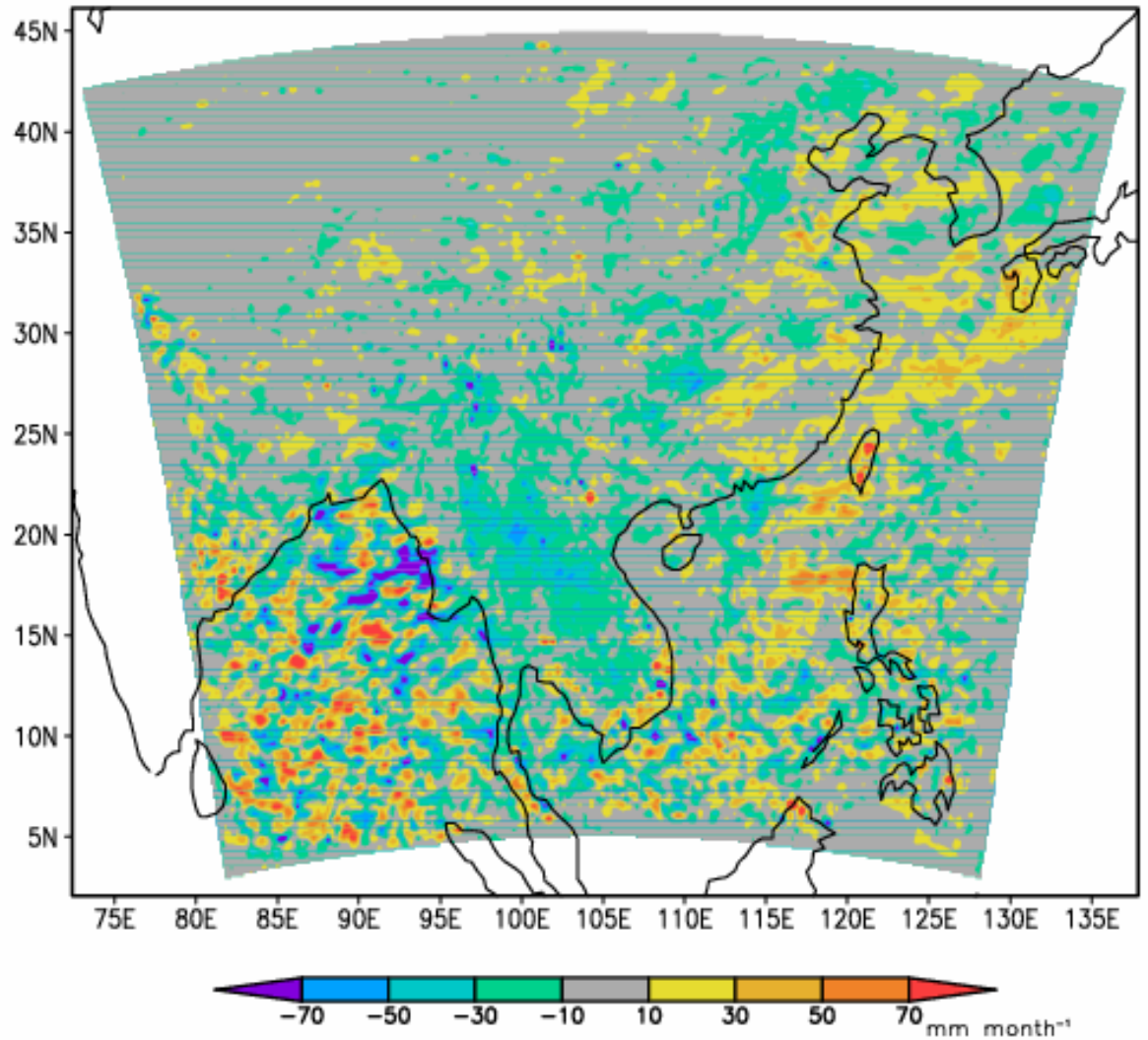

- **MODIS-IGBP obtained at 0.008333 degree**
- **Upscaled to 0.08333 degree (~9.26 km) using dominant landscape approach**
- **IGBP vegetation classes were then translated to corresponding BATS classes**
  - **Incorporated some attributes from AVHRR-BATS when MODIS-IGBP class was too broad (“Grassland” in IGBP could be translated to “Short grass” or “Tall grass” in BATS)**

## MODIS-BATS

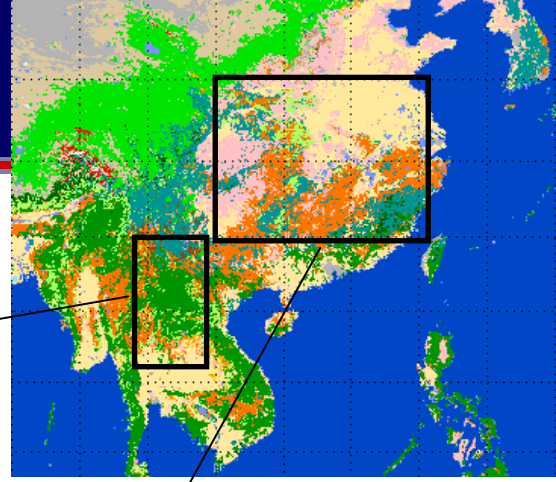


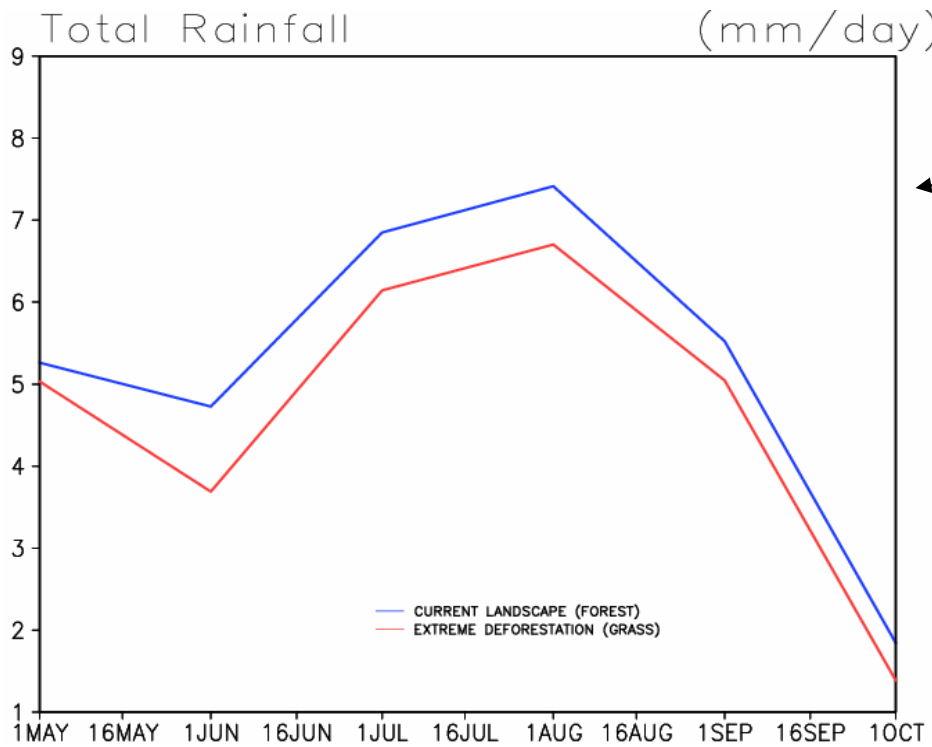
# Ensemble Difference in JJA Precipitation

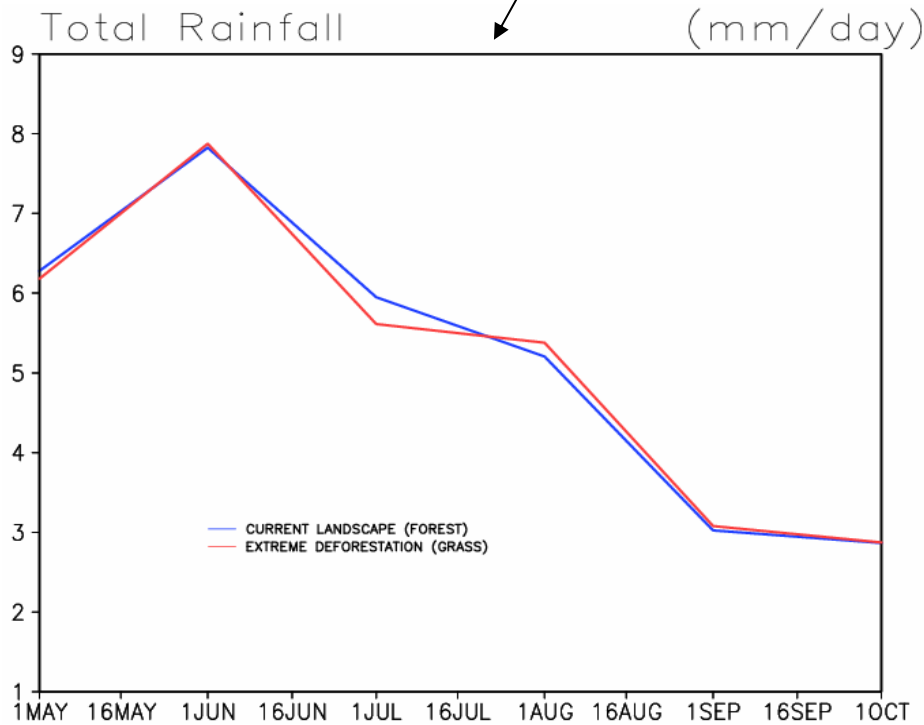
**Extreme deforestation (grass) – Current landscape (forest)**



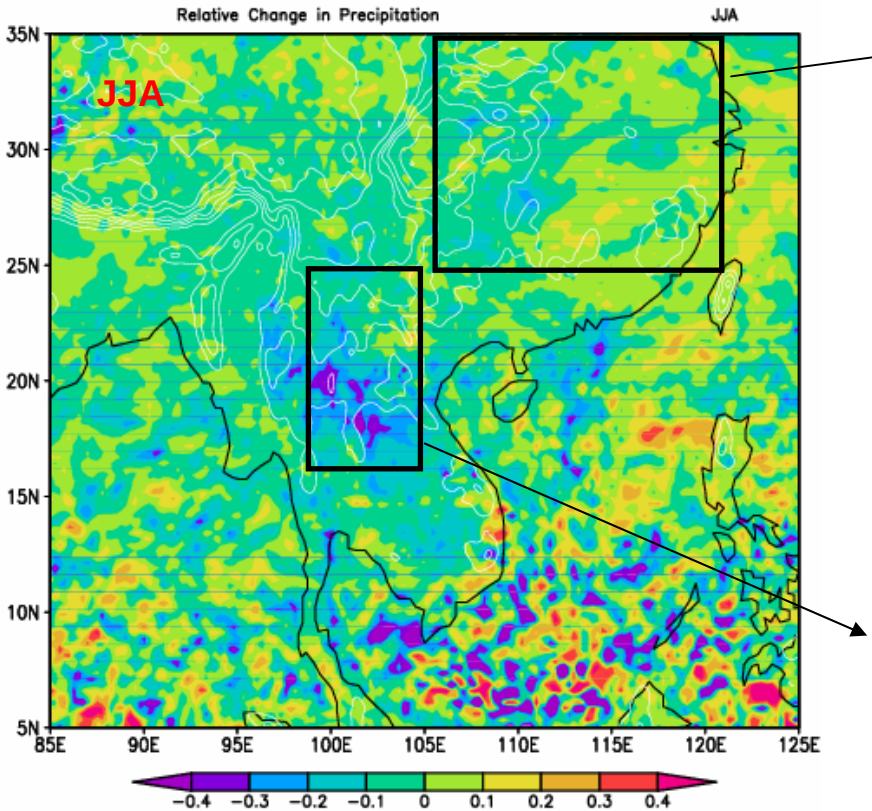
# Change in Precipitation

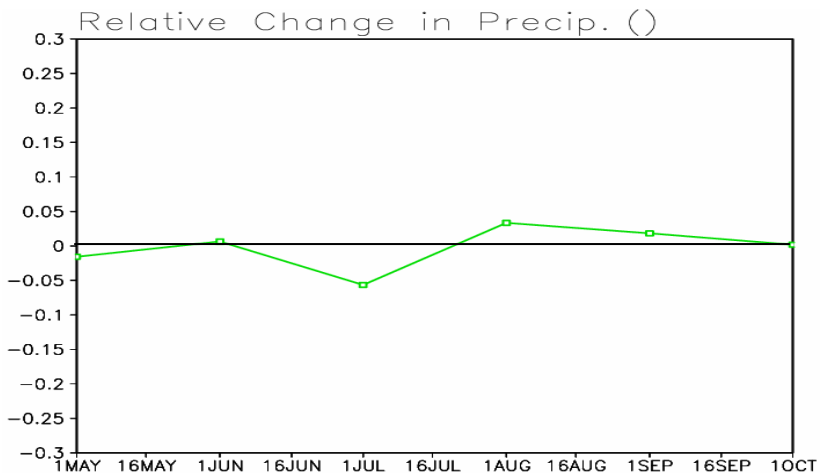


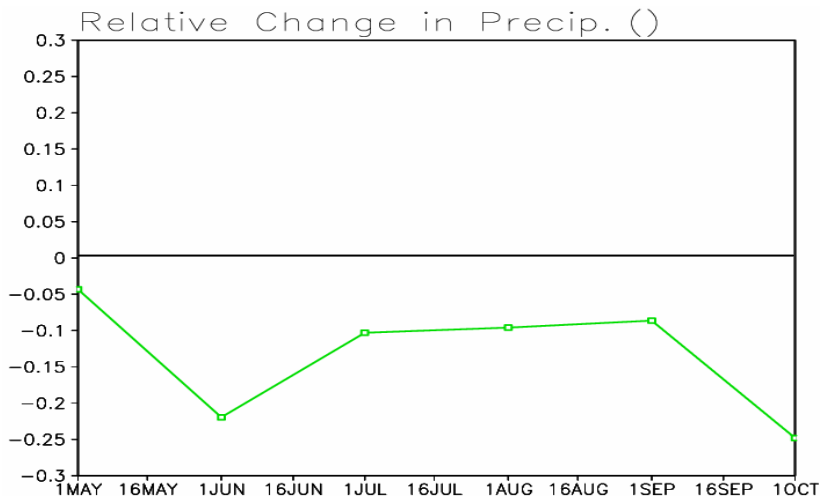


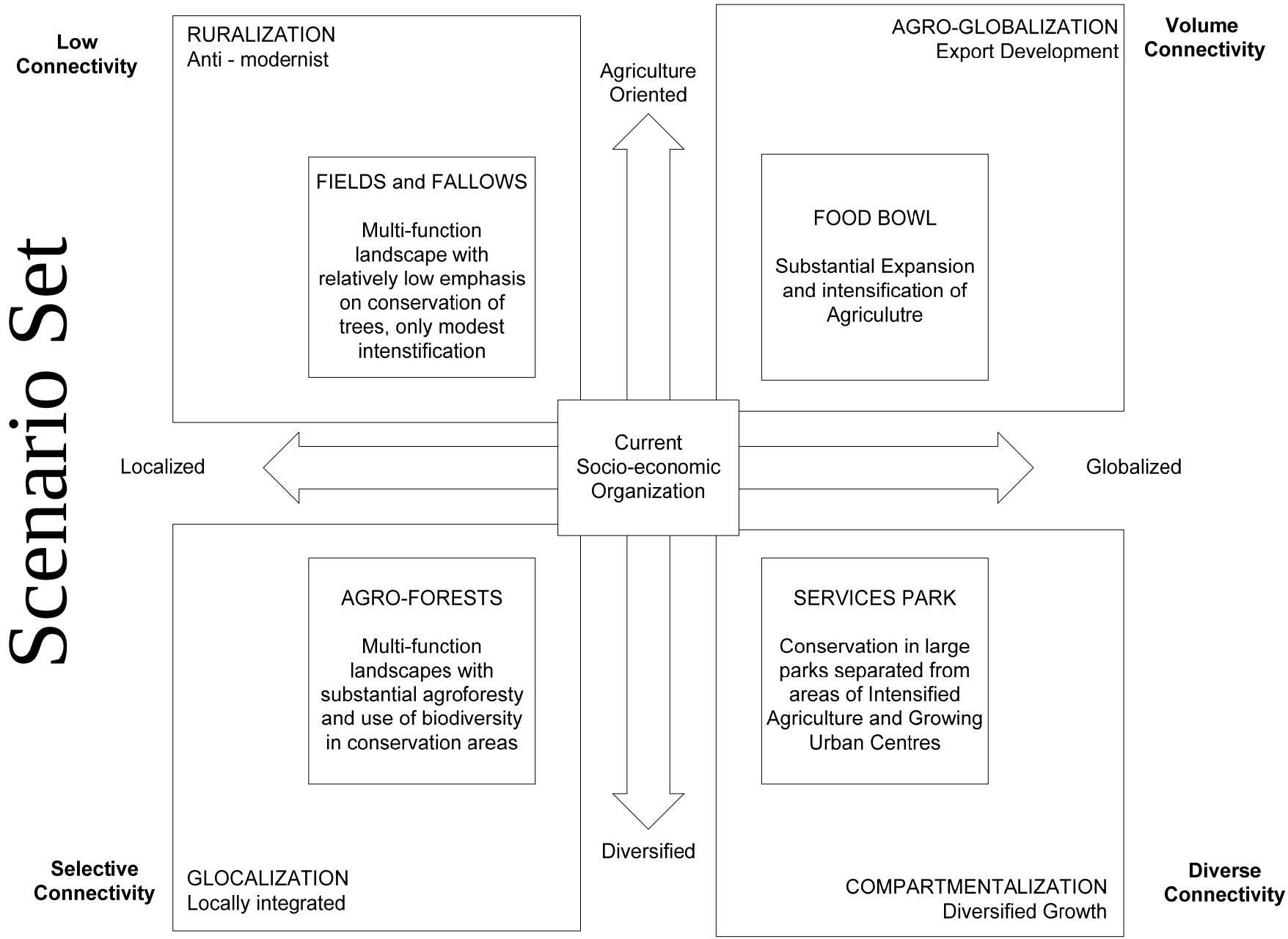
# Relative Change in Precipitation




5. To use climate model output to drive simulations of the watershed model to predict the effects of both land-cover and climatic change, including feedbacks, on MMSEA hydrology.




**Scenario sets can be logically defined by combination of key axes of uncertainties**

# Future steps


- Continue to obtain field climate/hydrological data and soil, vegetation, and physical parameters for forcing, parameter setting, and calibration of watershed and climate models
- Simulate hydrological processes in study watershed under various land cover scenarios using distributed model DHSVM
- Simulate climate and hydrology of East-SE Asia region for present and future land cover and present and future global climate scenarios
- Use regional climate output to drive simulations of hydrological processes in study watersheds under future land-cover and climate conditions


# Conclusions

- Research is progressing nicely after 2 years of work but we have not reached any conclusions yet
- No publications yet
- Data available at:

  http://research.eastwestcenter.org/mmsea/data.htm

  http://webdata.soc.hawaii.edu/hydrology/projects/res_NASA/data.htm