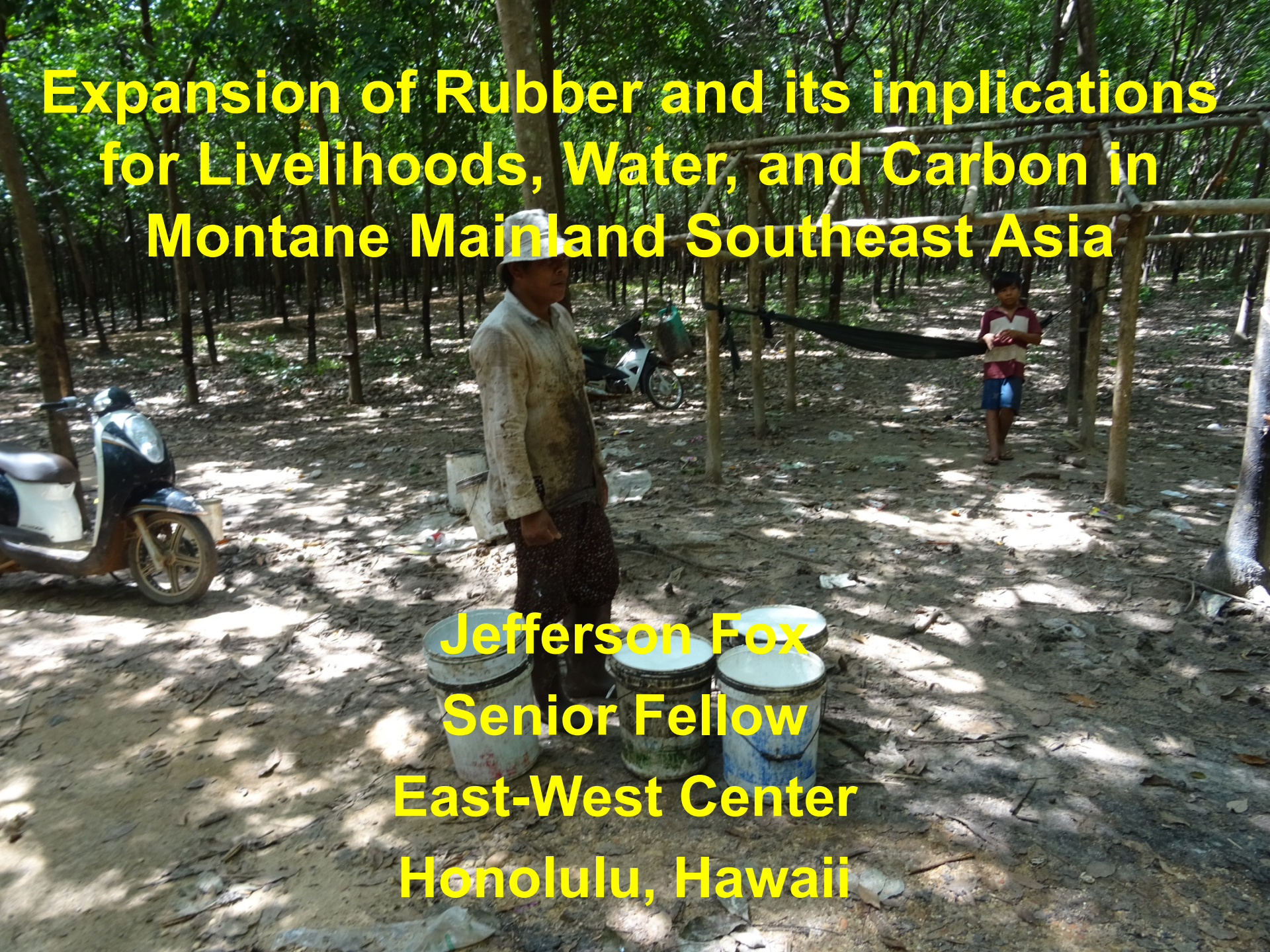


Expansion of Rubber and its implications for Livelihoods, Water, and Carbon in Montane Mainland Southeast Asia



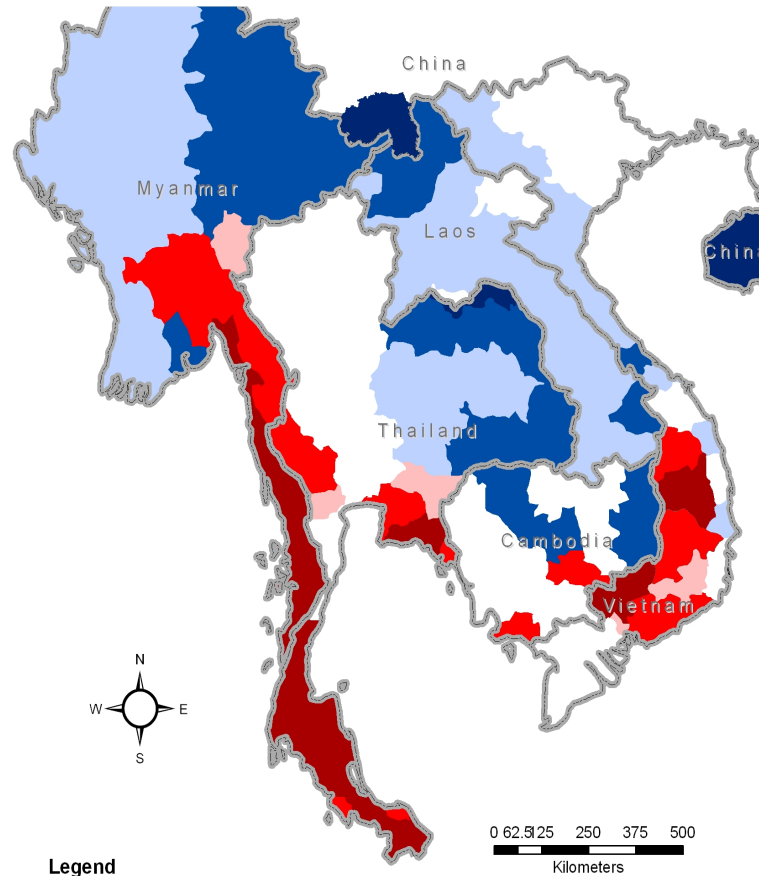
Jefferson Fox
Senior Fellow
East-West Center
Honolulu, Hawaii



Outline of Talk

- Introduction—rapid land-use and land-cover change (LCLUC) in the uplands of Mainland Southeast Asia;
- Mapping change—loss of forests and growth of tree crops (primarily rubber);
- Drivers of change—national policies and demand
- Implications for livelihoods—income and labor;
- Implications for water and carbon
- Summary—take home points.

Historical and recent rubber-growing regions



Legend

Country boundary

Old rubber

- Area over 50,000 ha
- Area between 10,000 to 50,000 ha
- Area less than 10,000 ha

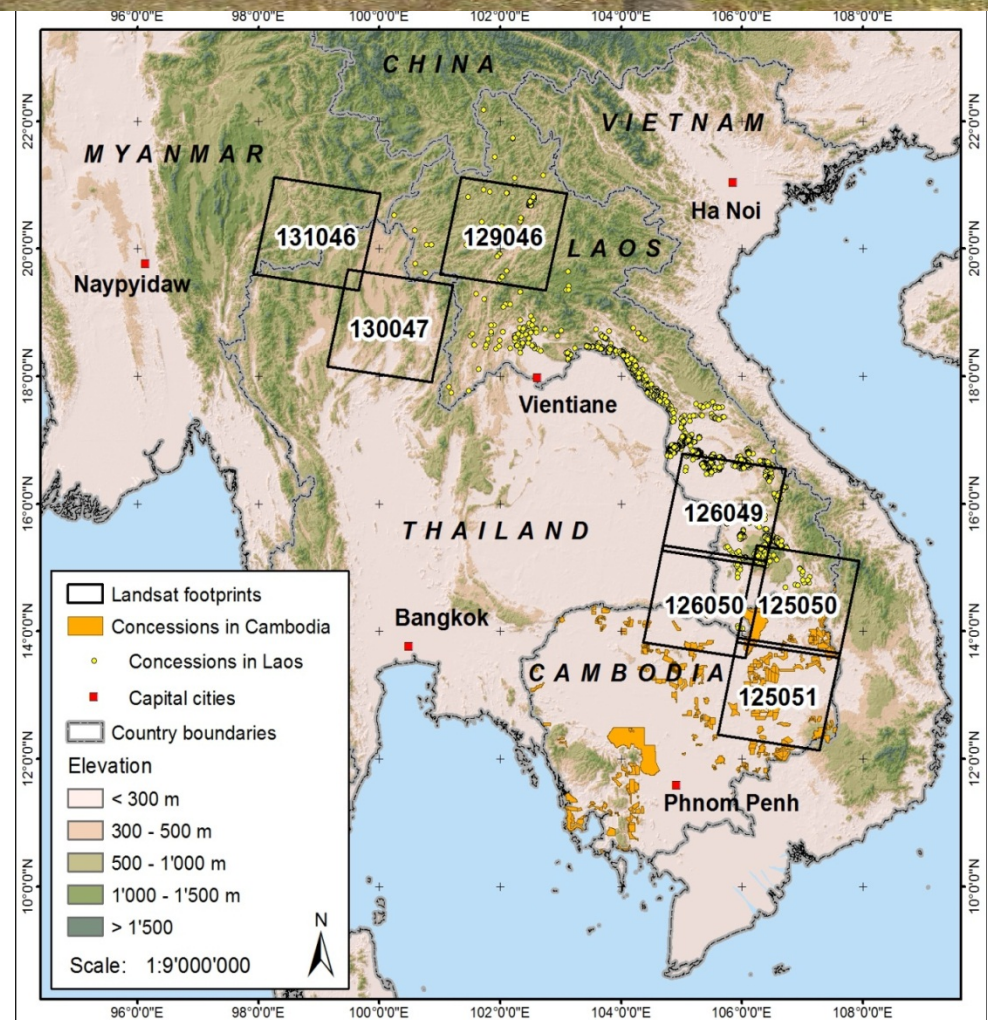
Young rubber

- Area over 50,000 ha
- Area between 10,000 to 50,000 ha
- Area less than 10,000 ha
- No rubber

Li and Fox 2010

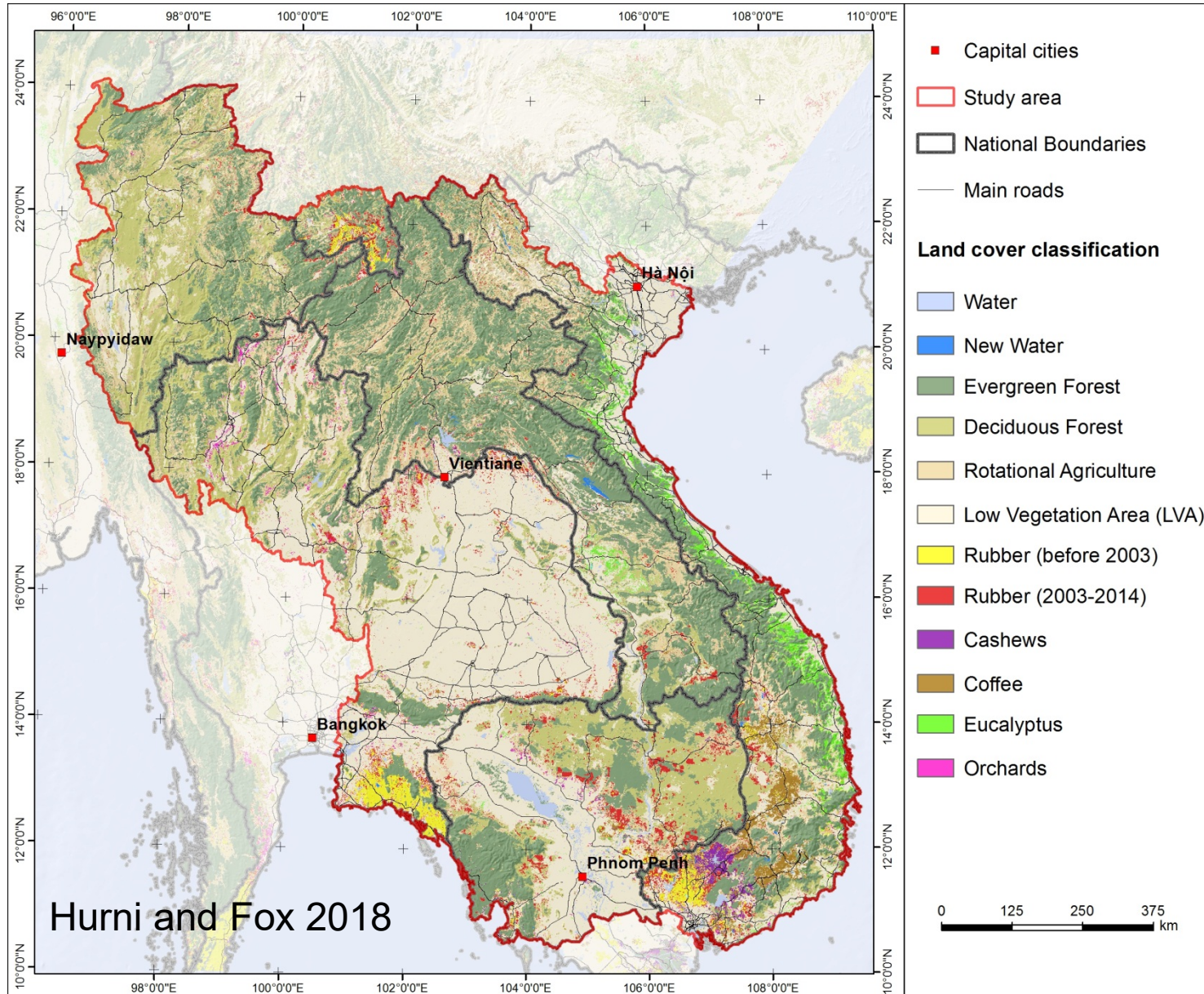
Landat Footprints we classified

Used dense-time stack of Landsat images to classify change in these 7 footprints between 2003 and 2014



Hurni, Fox et al. 2017

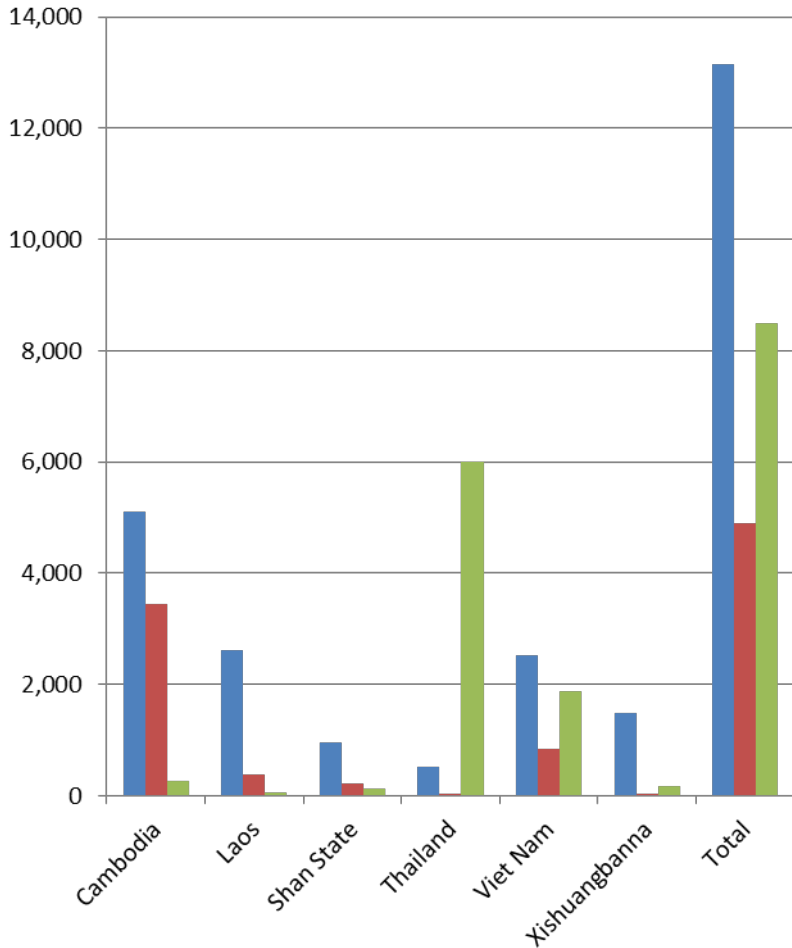
MODIS map of LC in 2014 and changes in rubber between 2003 and 2014



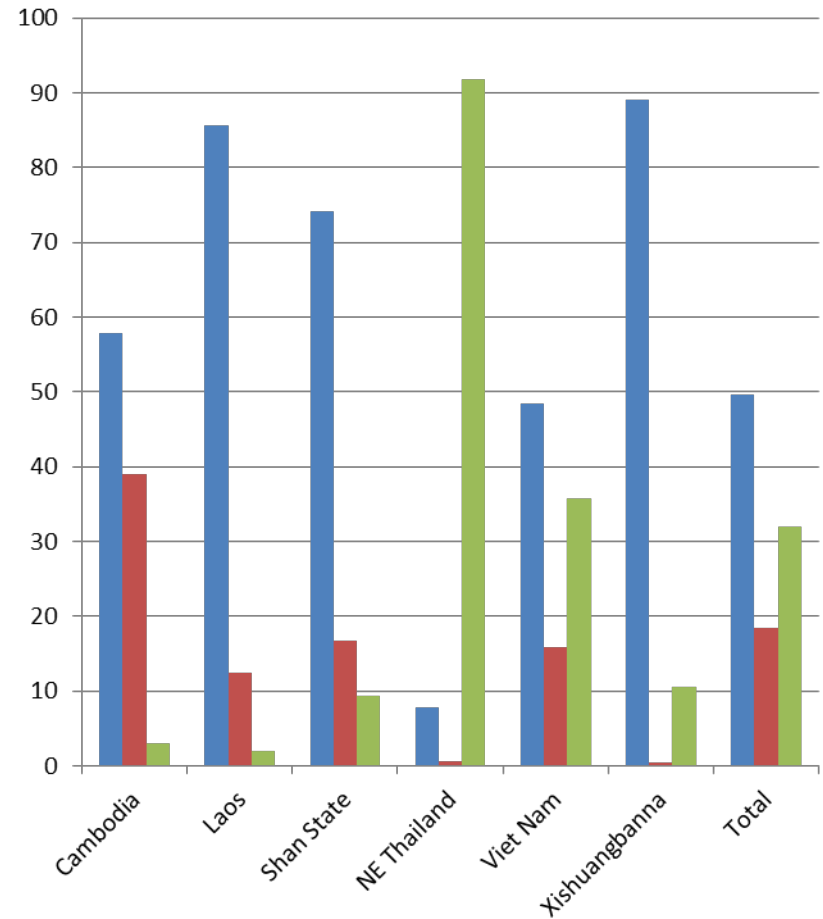
Land cover types (2014)

	Cambodia	Laos	Thailand	Viet Nam	Xishuangbanna	Total
Km2	Area (% total)	Area (% total)	Area(% total)	Area (% total)	Area (% total)	Area (% total)
Evergreen Forest	39,925 (22.92%)	125,692 (55.2%)	44,400 (13.65%)	69,297 (31.83%)	12,334 (41.71%)	337,709 (29.52%)
Deciduous Forest	43,144 (24.77%)	15,338 (6.74%)	41,689 (12.81%)	9,212 (4.22%)	3,596 (12.16 %)	169,367 (14.8%)
Rotational Agriculture	10,859 (6.23%)	55,921 (24.56%)	25,606 (7.87%)	30,512 (13.97%)	6,227 (21.06%)	168,924 (14.76%)
Low Vegetation Area	68,098 (39.09%)	24,830 (10.9%)	193,754 (59.55%)	68,479 (31.35%)	2,657 (8.99%)	382,277 (33.41%)
Rubber	9,744 (5.59%)	3,338 (1.47%)	14,642 (4.50%)	10,748 (4.92%)	3,681 (12.45%)	43,497 (3.8%)
Cashews	647 (0.37%)	226 (0.1%)	197 (0.06%)	3,666 (1.68%)	94 (0.32%)	4,854 (0.42%)
Coffee	813 (0.47%)	342 (0.15%)	725 (0.22%)	11,482 (5.26%)	461 (1.56%)	14,213 (1.24%)
Eucalyptus	324 (0.19%)	1,497 (0.66%)	300 (0.09%)	13,843 (6.34%)	77 (0.26%)	16,156 (1.41%)
Orchards	645 (0.37%)	538 (0.24%)	4,052 (1.25%)	1,163 (0.53%)	440 (1.49%)	7,088 (0.62%)
All Tree Crops	12,175 (6.99%)	5,940 (2.61%)	19,916 (6.12%)	40,902 (18.83%)	4,753 (16.07%)	85,808 (7.5%)

Land cover converted to rubber 2003 to 2014



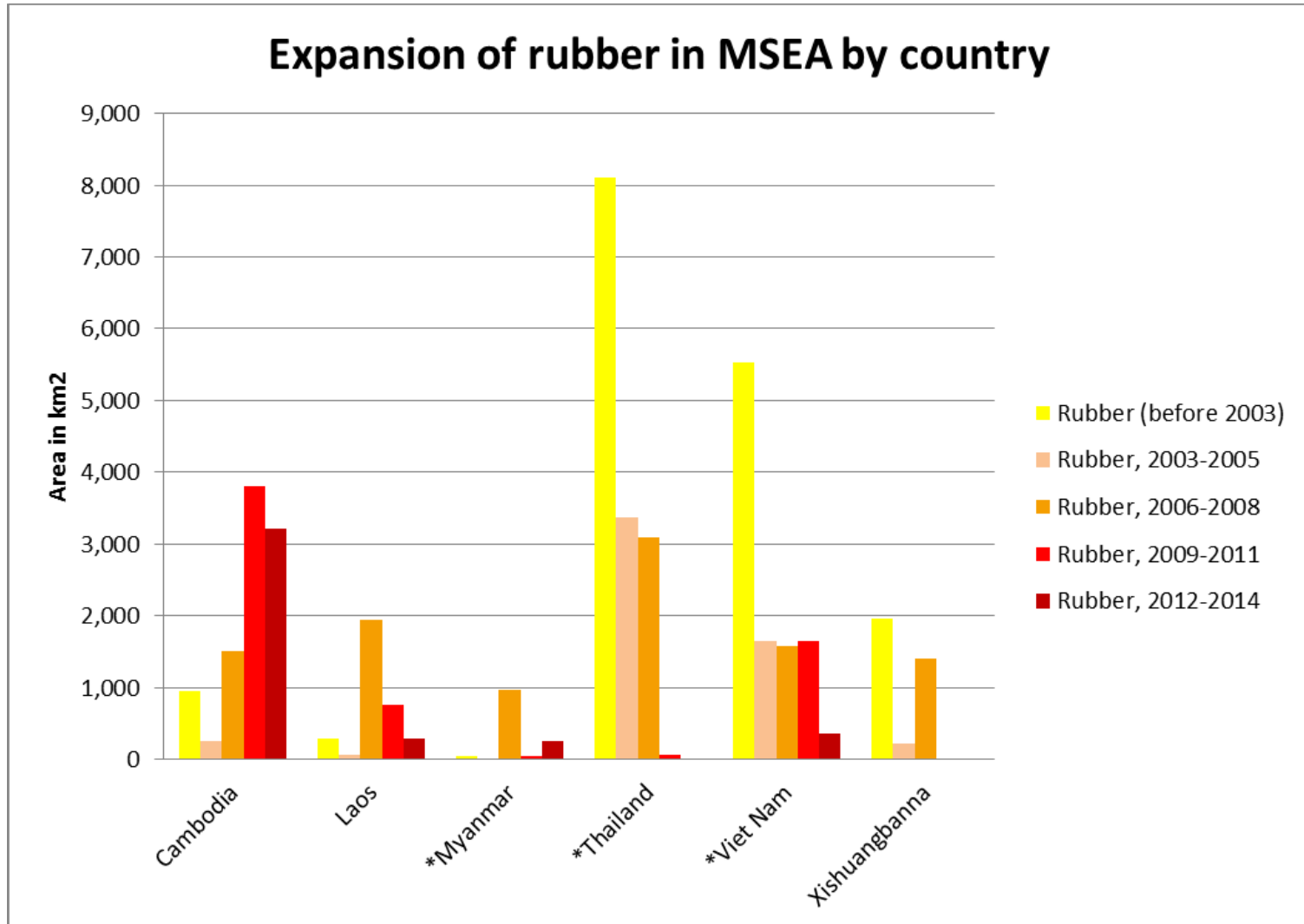
Rubber area in Km2 since 2003



Rubber in % of total rubber since 2003

Blue = Evergreen Forest; Red = Deciduous Forest; Green = Low Vegetation Area

Expansion of rubber 2003 to 2014



Summary of LCLU Changes

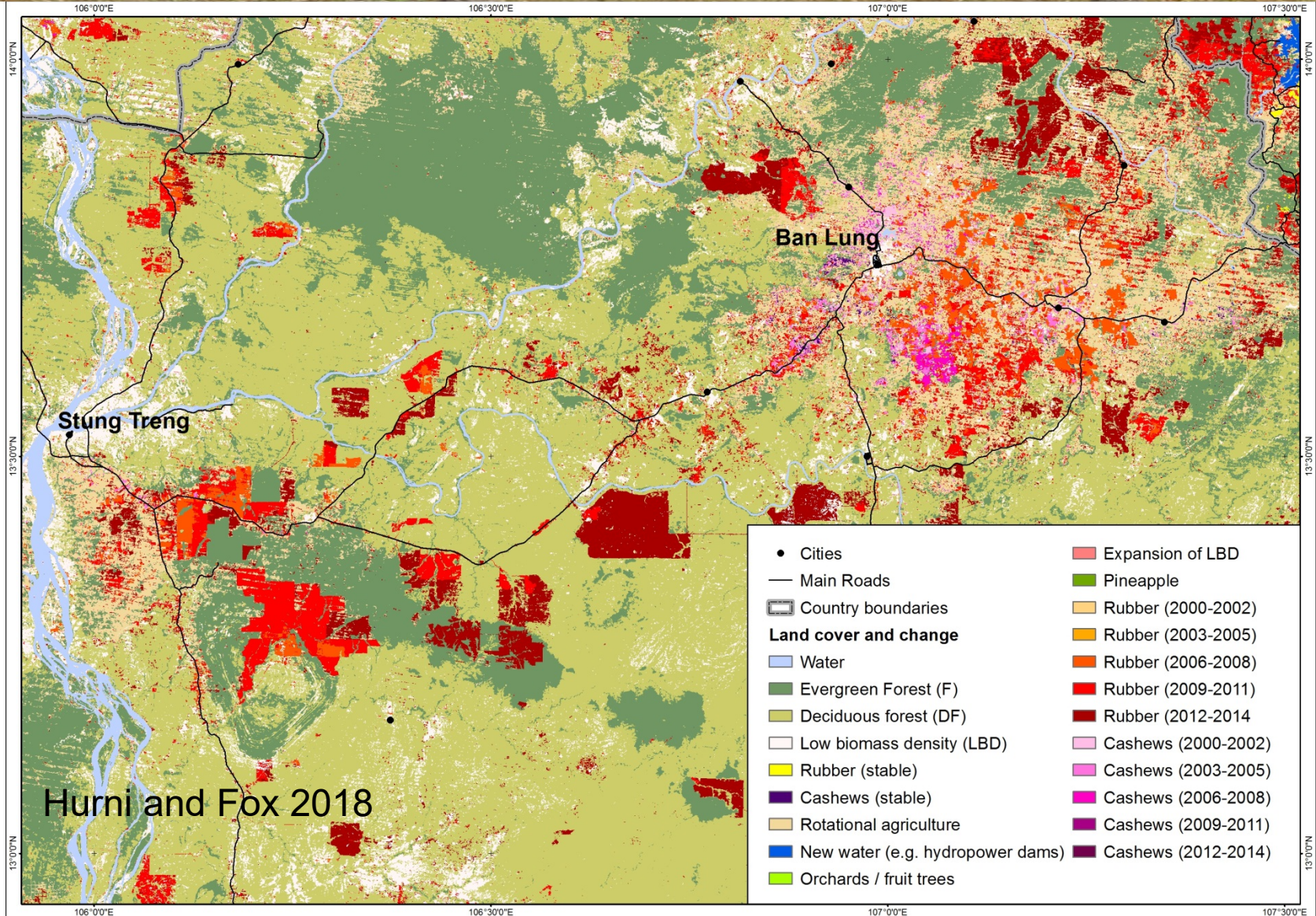
- 44,000 sq km of rubber have been planted since 2003;
- 50% of rubber is planted on former evergreen forest land;
- 18% on deciduous forest land;
- 32% on low vegetation area;
- Tree crops occupy about 8% of the landscape (half of that is rubber).

Landat Footprints we classified

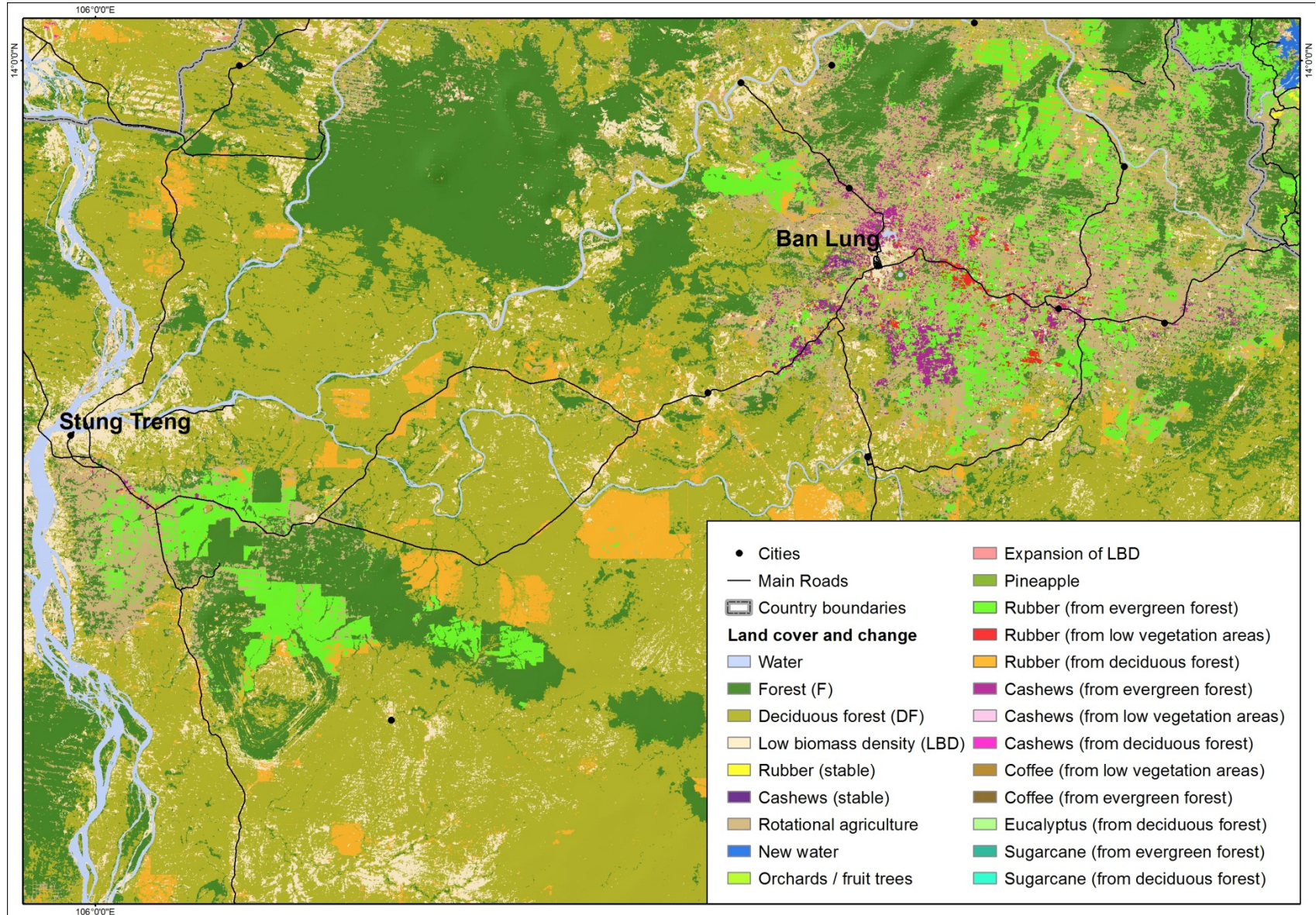
These footprints overlap with study sites and inventories of agricultural concessions (represented by yellow dots in Laos and orange polygons in Cambodia).



Landsat Classification: Year of land conversion



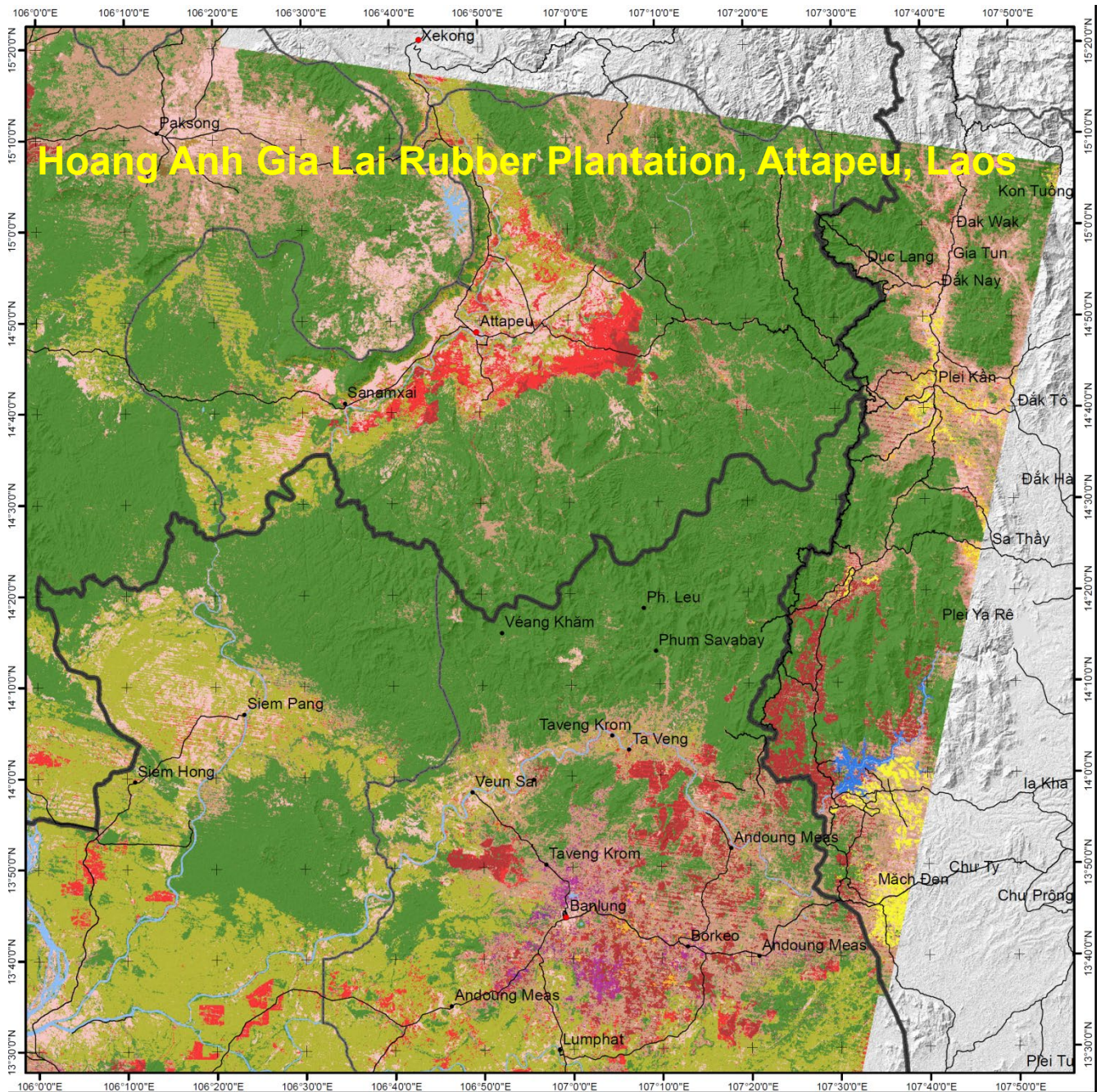
Landsat Classification: From—to conversion





National Policy as a driver of change: Laos

- Land law of 2003 and the 2009 Decree 135/PM Articles 2 and 4 established that national land could be granted as concessions for activities that “pay land concession fees, cost for national resources (royalties), tax, customs fees and other fees as specified in the [land] law.”
- Unofficial ‘Turning land into capital’ policy seeks to transform unproductive land systems and practices into intensive and efficient cash crop and industrial plantations.
 - Investors provide state revenues, wage labor, infrastructure, technical expertise, new technology, and increased production (Dwyer 2013).



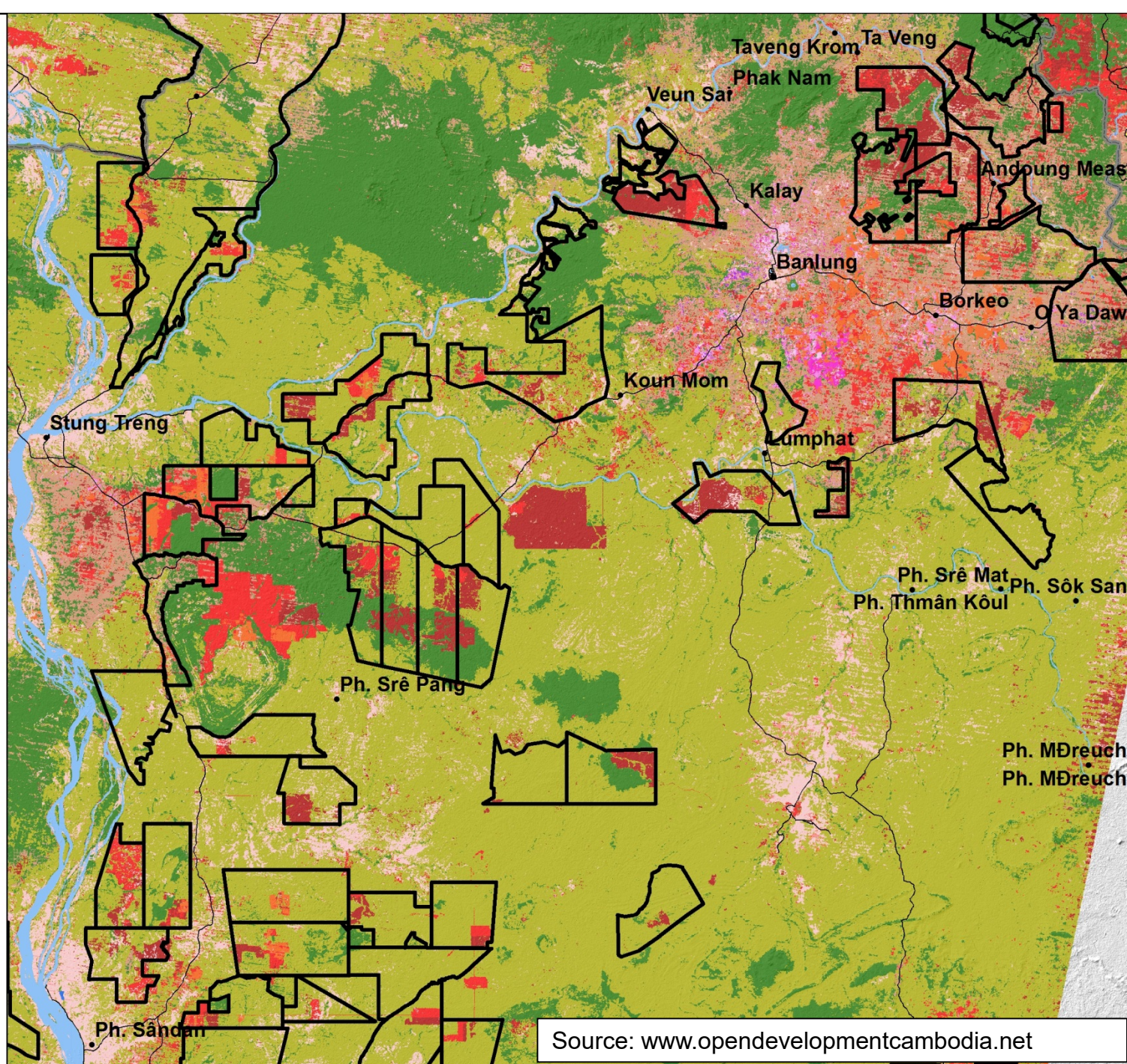
Hoang Anh Gia Lai Rubber Plantation, Attapeu, Laos



Cambodia: National Policy as a driver of change

- Land law of 2001 developed a flexible and powerful doctrine of state land ownership, particularly when it comes to the allocation of concessions;
- Concessions can take two forms: economic land concessions (ELCs), aimed at cultivating large-scale investment, and social land concessions (SLCs) aimed at alleviating landlessness through provision of surplus state land.

- Water
- Forest (F)
- Deciduous forest (DF)
- Low biomass density (LBD)
- Rubber (stable)
- Cashews (stable)
- Rotational agriculture
- New water (e.g. hydropower dams)
- Expansion of LBD
- Rubber (2000-2002, from F)
- Rubber (2000-2002, from LBD)
- Rubber (2003-2005, from F)
- Rubber (2003-2005, from DF)
- Rubber (2003-2005, from LBD)
- Rubber (2006-2008, from F)
- Rubber (2006-2008, from DF)
- Rubber (2006-2008, from LBD)
- Rubber (2009-2011, from F)
- Rubber (2009-2011, from DF)
- Rubber (2009-2011, from LBD)
- Rubber (2012-2014, from F)
- Rubber (2012-2014, from DF)
- Cashews (2000-2002, from F)
- Cashews (2003-2005, from F)
- Cashews (2003-2005, from LBD)
- Cashews (2006-2008, from F)
- Cashews (2006-2008, from DF)
- Cashews (2006-2008, from LBD)
- Cashews (2009-2011, from F)
- Cashews (2012-2014, from F)
- Coffee (2002, from LBD)
- Coffee (2007, from F)
- Eucalyptus (2006-2008, from DF)
- Eucalyptus (2009-2011, from DF)
- Eucalyptus (2012-2014, from DF)
- Sugarcane (2006-2008, from F)
- Sugarcane (2006-2008, from DF)
- Sugarcane (2009-2011, from DF)

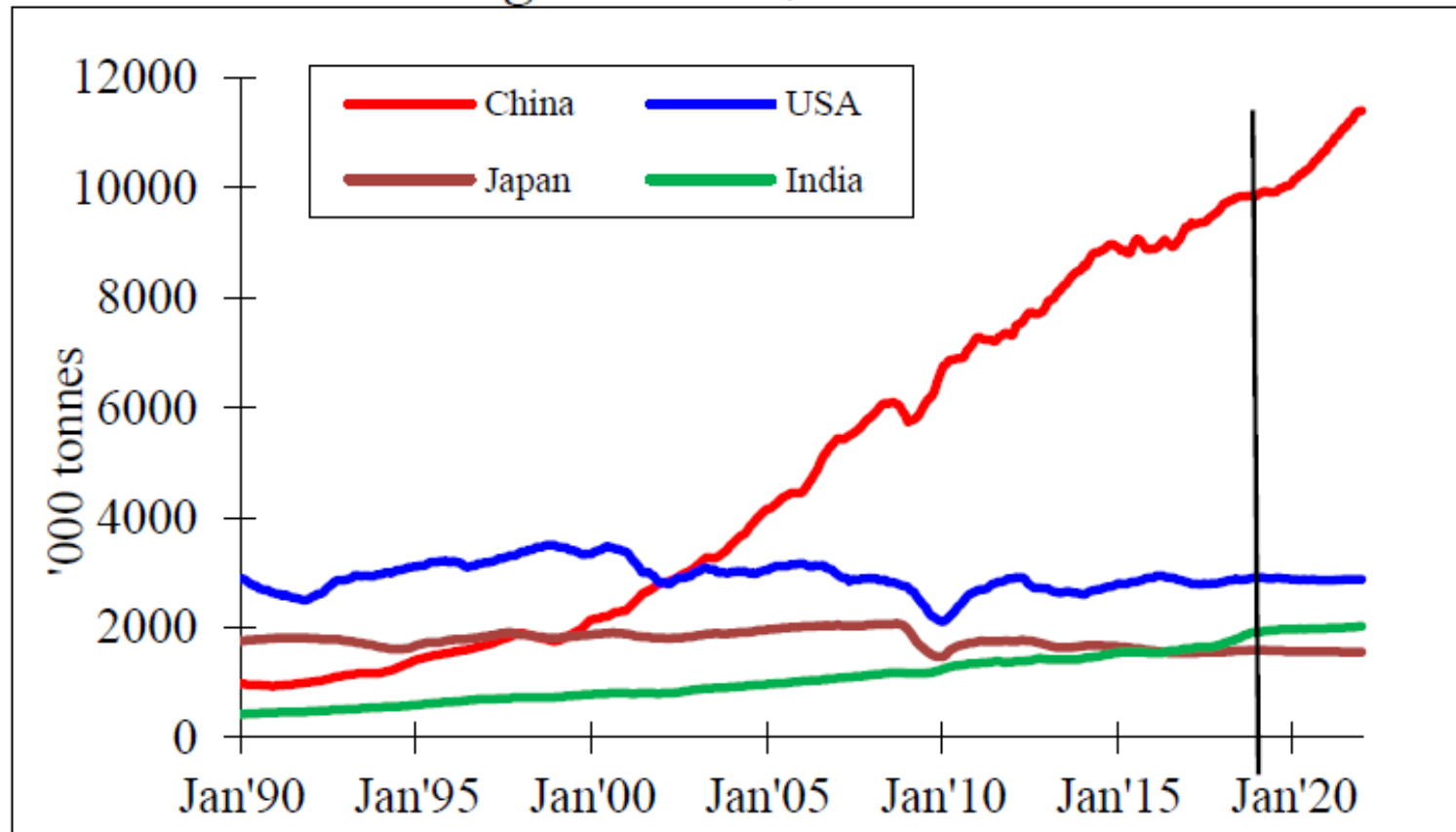


Source: www.opendevdevelopmentcambodia.net

Summary: National policy as a driver of change

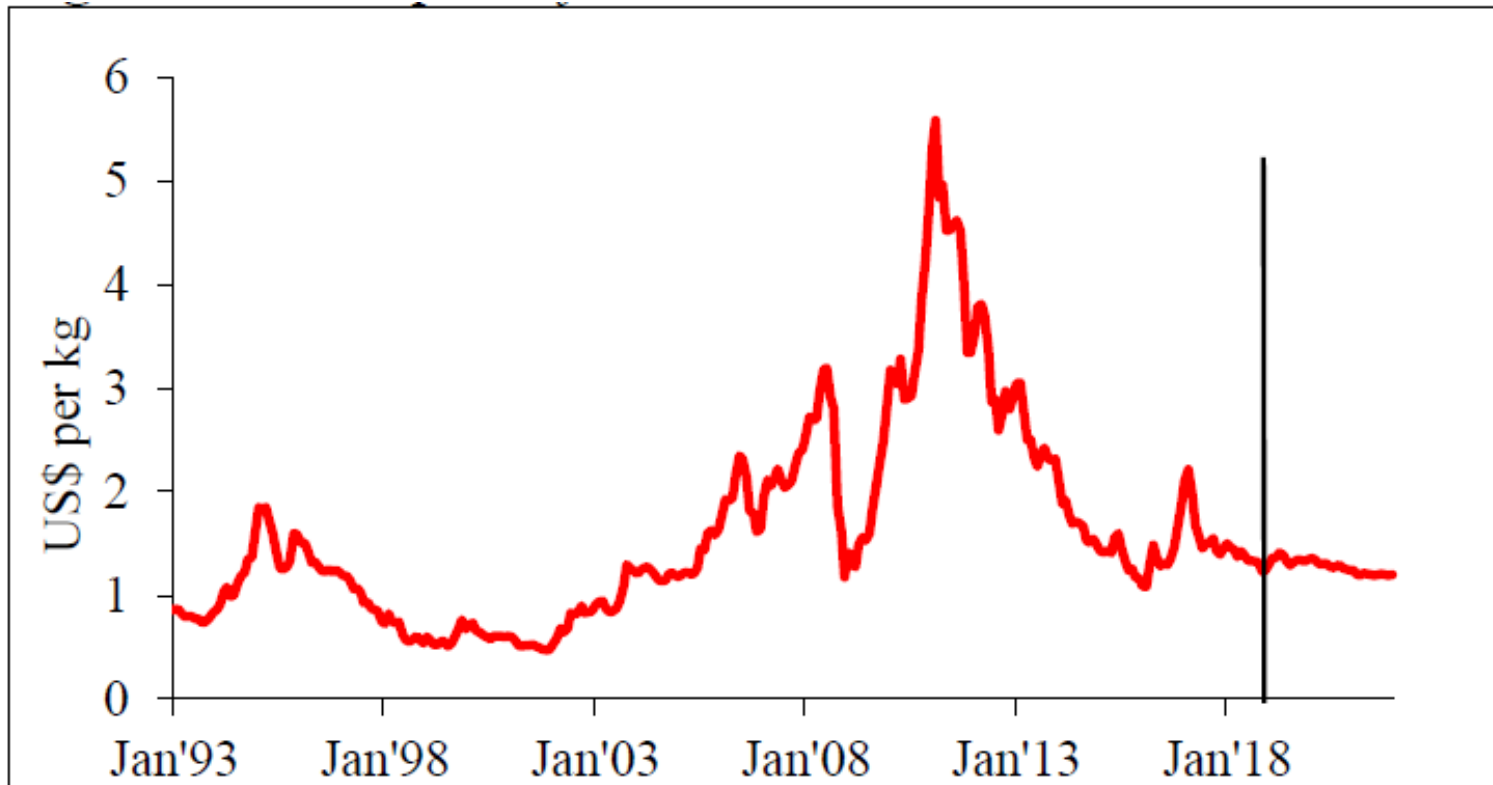
- In **Laos and Cambodia** the governments promote foreign investments in the **industrial plantations** as a win-win solution:
 - to alleviate poverty in remote rural areas;
 - to generate income from export commodities;
 - Give land rights to concessionaires;
 - Investors provide state revenues, wage labor, infrastructure, technical expertise, new technology, and increased production.
- But also:
 - farmers losing access to land, overlapping and unclear land designation, lack of alternative income sources for remote villagers.

Demand for rubber as a driver of change



The Rubber Economist Quarterly Report. First Quarter 2019 report

NR price forecast to 2021



The Rubber Economist Quarterly Report. First Quarter 2019 report



Rubber prices and plantations

- Some firms are going bankrupt—largest is Hoang Anh Gia Lai Rubber Plantation in Attapeu Province, Laos. Group is seeking to sell half their 40,000 ha estate to Chinese investors;
- 3 companies we interviewed in Cambodia are managing but hurting. All are tapping less rubber than they could.



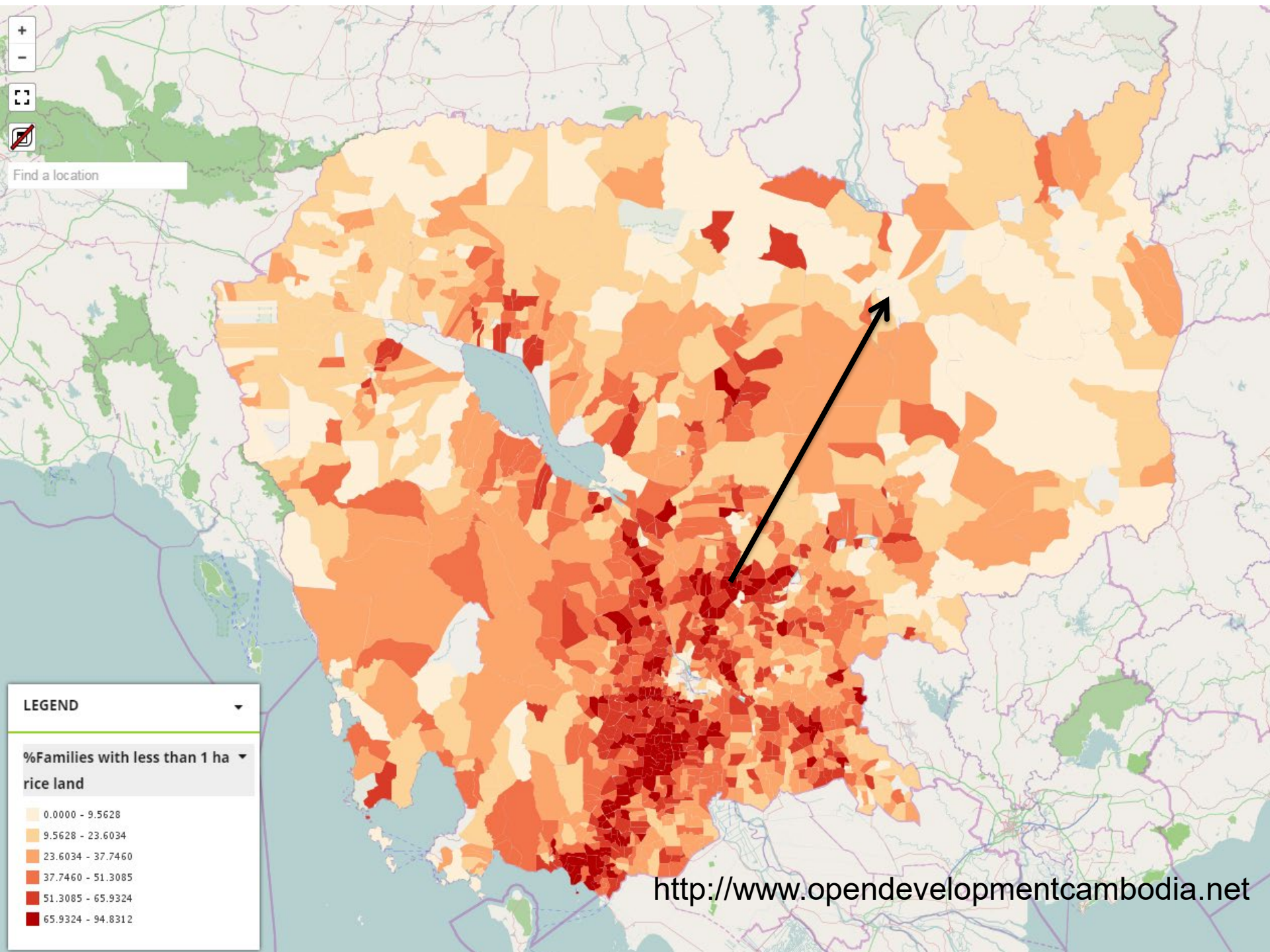
Summary: NR price and production

- Cambodia has 321,000 ha of rubber planted since 2012 that are just beginning to be tapped now (78% of region's total).
- Plantations in Cambodia are required to continue planting until they reach their size limit—despite low prices.
- Small holders and plantations are struggling to remain economically viable.
- Rubber Economist (First Quarter 2019) predicts rubber prices will remain stable through 2021.



Cambodia: Domestic Labor

- In Cambodia workers from Stung Treng and Ratanakiri Province Cambodia, Khmer workers from the south have come to tap rubber.
- Seek to describe:
 - Number of migrants and impacts on LC;
 - Livelihoods of tappers;
 - Future Availability of labor;



Find a location

LEGEND

%Families with less than 1 ha
rice land

- 0.0000 - 9.5628
- 9.5628 - 23.6034
- 23.6034 - 37.7460
- 37.7460 - 51.3085
- 51.3085 - 65.9324
- 65.9324 - 94.8312

<http://www.opendevdevelopmentcambodia.net>

Impact of Migrants

- The impact of large migrant populations on the landscape is not limited to the area of the plantation but will affect the larger landscape through shops and food outlets, schools, medical facilities, and other infrastructure.





Implications for Land and Livelihoods

- In Thailand, China and Vietnam where the governments provides support to smallholders, there is evidence that rubber farming improves livelihoods:
 - risks associated = food security, disease, pests, weather, etc., but in short-term many people have done well economically
- In Cambodia, Laos, and Myanmar where the governments do not provide support to smallholders, rubber farming can result in worsening livelihoods:
 - Local farmers losing access to land, becoming laborers on plantations owned by others, coercion, disputes over terms and wages, overlapping and unclear land designation, lack of alternative income sources for remote villagers.

Summary: Socioeconomic impacts of rubber

- Indigenous households lose access to land and are forced to relocate on to more marginal land;
- These households neither chose to be tappers nor are they sought out by rubber companies to be tappers;
- Tappers make a reasonably good income but the hours make it a young person's job;
- Labor is becoming a scarce resource and will eventually become more problematic than access to land;
- Rubber plantations are struggling with low prices.

What are the implications of rubber for water and carbon

- What are the hydrological **consequences of conversion** of land to rubber plantations in non-historical rubber growing areas?
- What are the **rates of ET in rubber** stands, and how does it compare with other land-cover types in the region?
- To what extent are **dry-season basin water storage** affected by water use of rubber?

Instruments and Observations

Micrometeorological instruments installed at two rubber (*Hevea brasiliensis*) plantations to measure water, energy, and carbon exchange

Som Sanuk, Nong Khai, NE Thailand
Trees planted in 1992
Tower installed February 2009



CRRI, Kampong Cham, Cambodia
Trees planted in 2004
Tower Installed September 2009



Tower Instrumentation

Cambodia Rubber Research Institute

Kampong Cham, Cambodia

3 dimensional sonic anemometer (CSAT3, Campbell Scientific)

•Wind speed and direction (05106, RM young)

4 component radiation (NR01, Hukseflux)

infrared gas analyzer (LI-7500, Licor)

PAR sensor (LI-190, Licor)

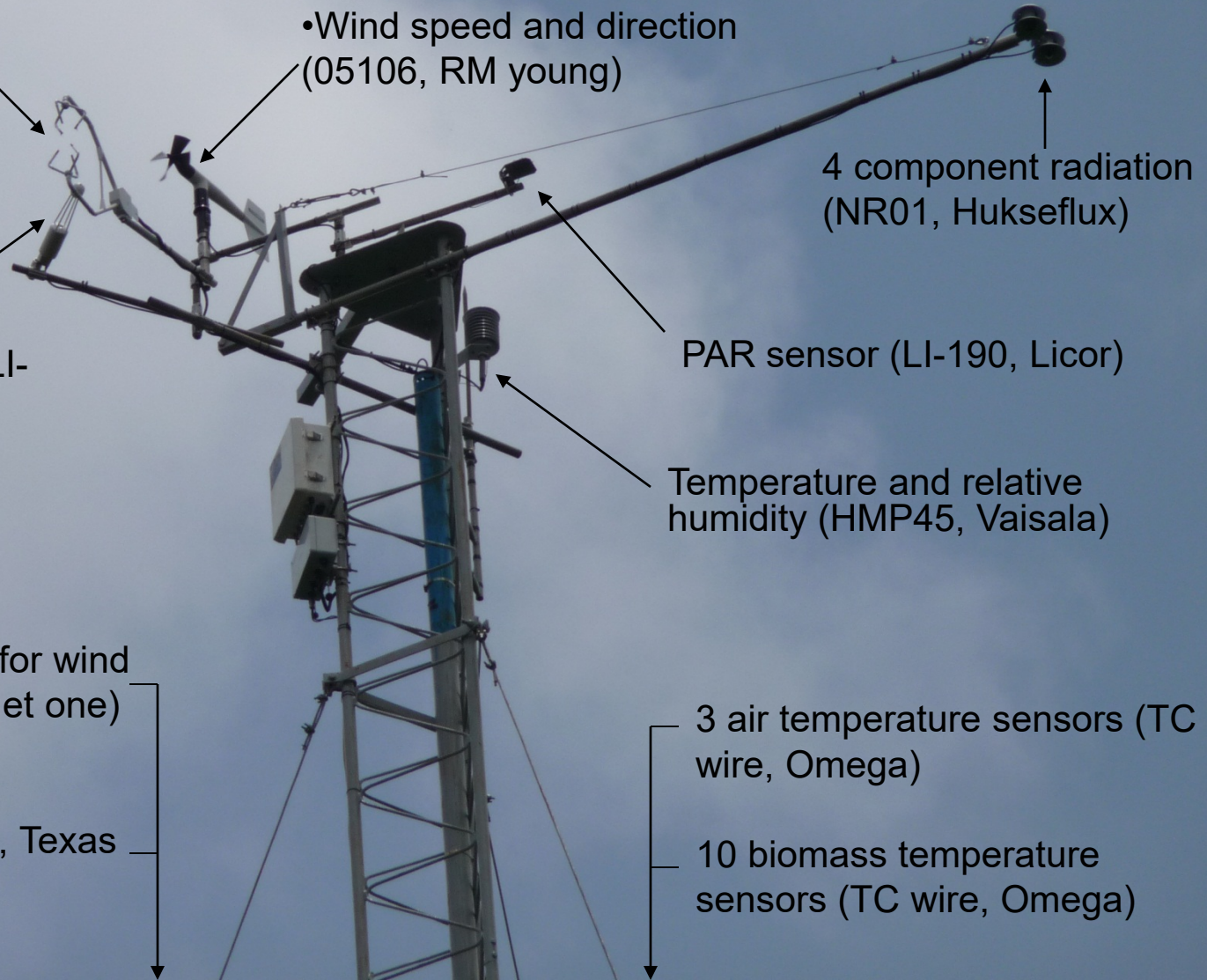
Temperature and relative humidity (HMP45, Vaisala)

3 wind speed sensors for wind height profile (014A, Met one)

3 air temperature sensors (TC wire, Omega)

2 Rain gauges (TI-525, Texas Instruments)

10 biomass temperature sensors (TC wire, Omega)

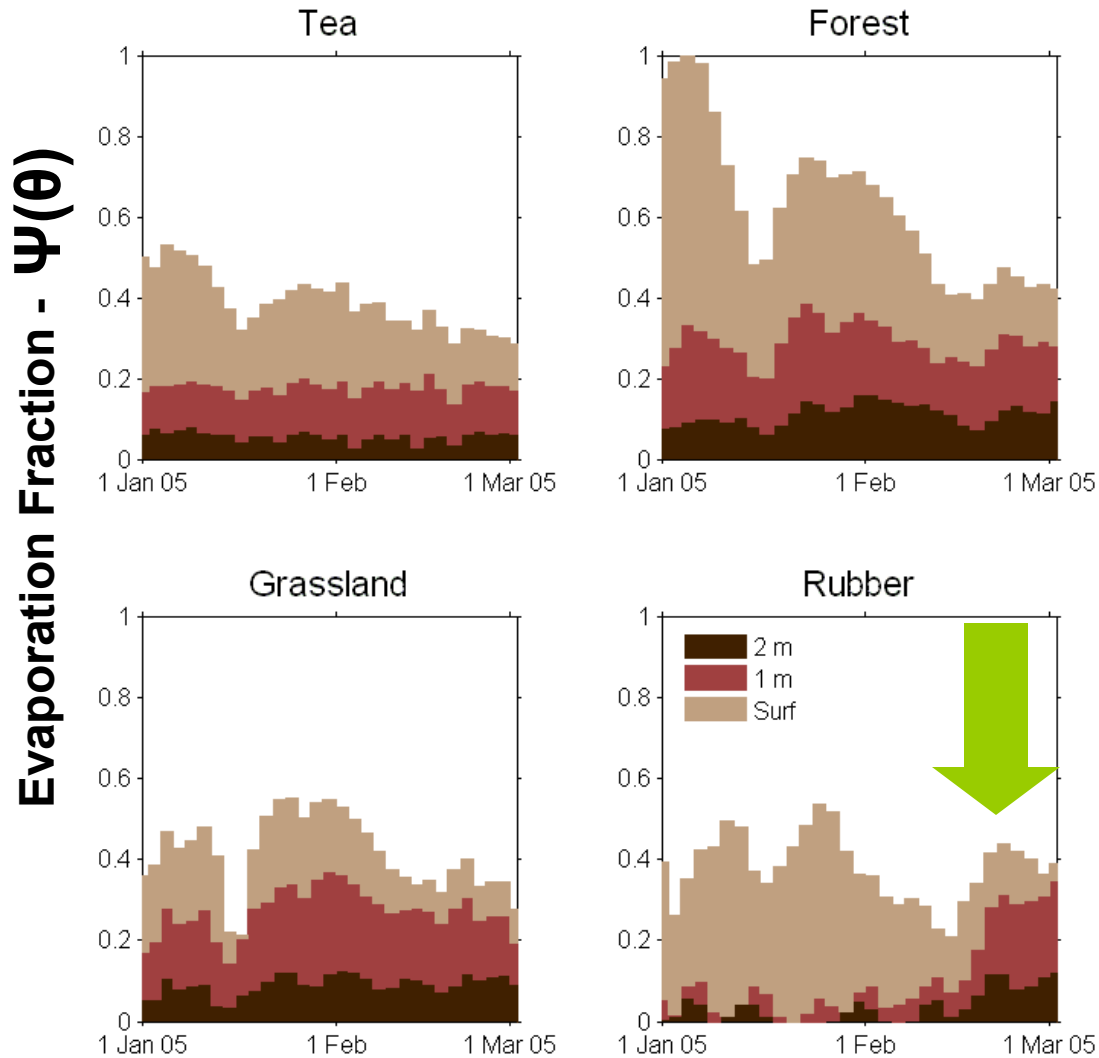


Underground sensors

- **2 soil temperature sensors** (20 cm TC probes, Campbell Scientific)
- **4 soil heat flux plates** (HFP01, Hukseflux)
- **5 TDR soil moisture probes** – 30 cm (CS616, Campbell Scientific)
 - 4 cm horizontal
 - 30 cm vertical
 - 1 m vertical
 - 2 m vertical
 - 3 m vertical
- **5 ADR soil moisture sensors** (Theta Probe, DeltaT)
 - in 2 stands (2001 and 2004)
 - 5, 10, 20, 30, and 50 cm all horizontal



Soil water extraction



2005

Negligible precipitation

Slide adapted from Guardiola-Claramonte (2007)



Summary

- Rubber ET is higher than forest ET
- Seasonal cycle significantly changed with lower Sep-Jan ET and higher Mar-Jul ET
- Question:
 - What effect does the altered annual cycle have on basin water storage and river discharge at the start of rain season?



Regional Scale Results

- We modeled LCLUC to 2050
Evergreen broadleaf trees → Deciduous broadleaf trees (Forest → Rubber and Cashews)
- Under 2050 LCLUC scenario → changes in precipitation over MMSEA, the Indochina Peninsula, and eastern China are usually less than 10%.
- Global warming-related effects will have a greater impact on precipitation than our predicted changes in land cover.

Carbon Values (MgC/Ha)

	Above Ground	Below Ground	SOC	Total
Forests	112-376	10-38	36-92	158-536
Fallow (11-25)	24-60	13		60-300
Fallow (5-10)	28-74			60-300
Fallow (<5)	17-22	11	58	40-120
Oil palm	91	1.3	12	40-120
Rubber			15	60-300
Agroforests	95-165		19	60-300
Pasture	3.2			40-120

Implications of rubber for water and carbon



- In these marginal rubber growing areas, rubber will have an affect on water availability in the dry season;
- Our modeling work suggests that rubber will not affect regional precipitation patterns;
- The implications of rubber for carbon are less serious than other alternatives—oil palm and pasture.



Summary

- 4.4 m ha of rubber have been planted since 2003;
- 68% planted on former forest land;
- Tree crops occupy about 8% of the landscape (half of that is rubber).
- In Laos and Cambodia the governments promoted foreign investments in the rubber plantations.
- Investors provide state revenues, wage labor, infrastructure, technical expertise, new technology, and increased production.
- Farmers lose access to land, overlapping and unclear land designation, lack of alternative income sources for remote villagers.



Summary

- With low rubber prices, small holders and plantations are struggling to remain economically viable.
- In these marginal rubber growing areas, rubber will have an affect on water availability in the dry season;
- Rubber will not affect regional precipitation patterns;
- The implications of rubber for carbon are less serious than other alternatives—oil palm and pasture.

Thank You

