Archetypical Pathways of Direct and Indirect Land-Use Change Caused by Economic Land Concessions in Cambodia

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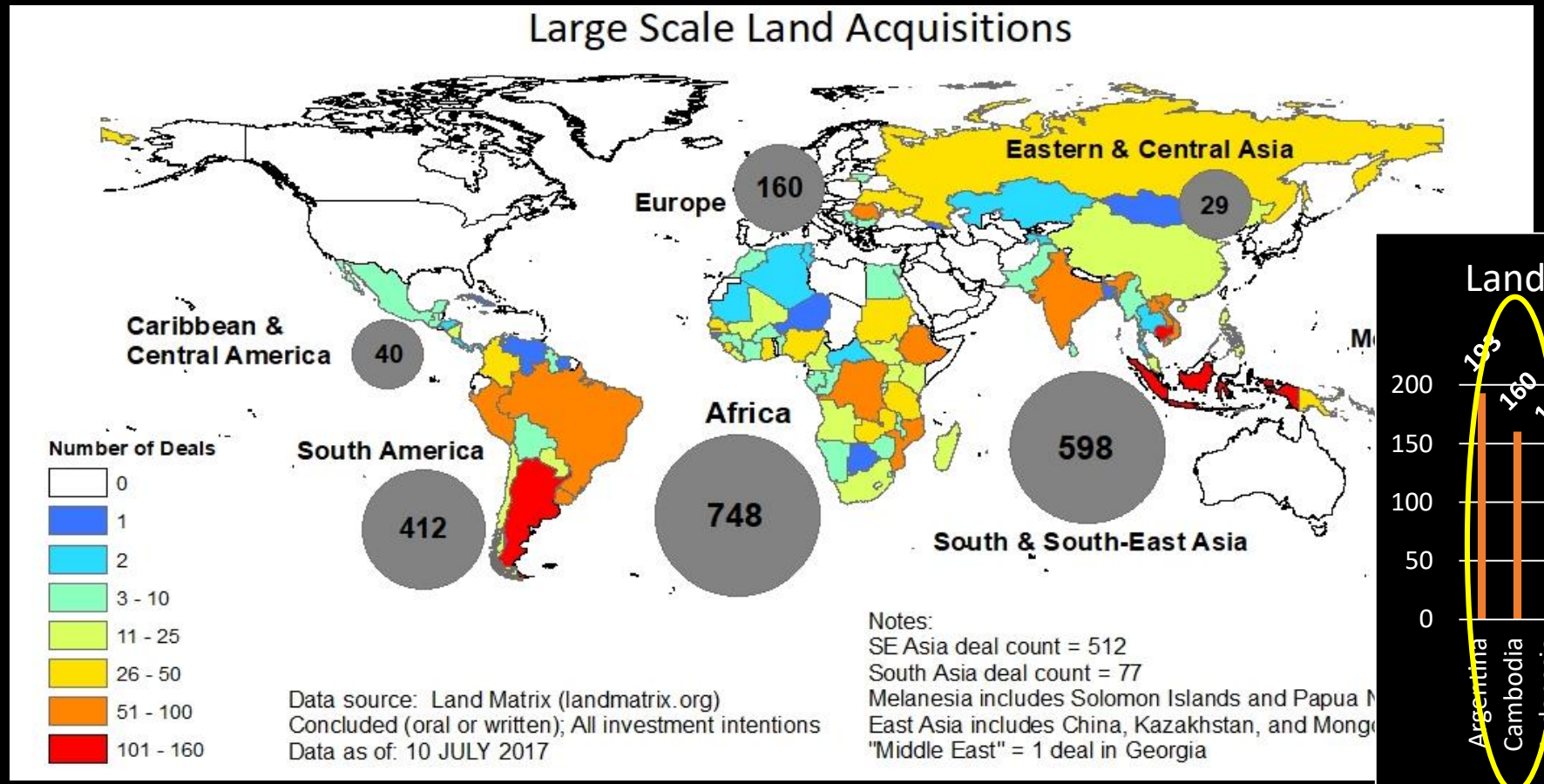
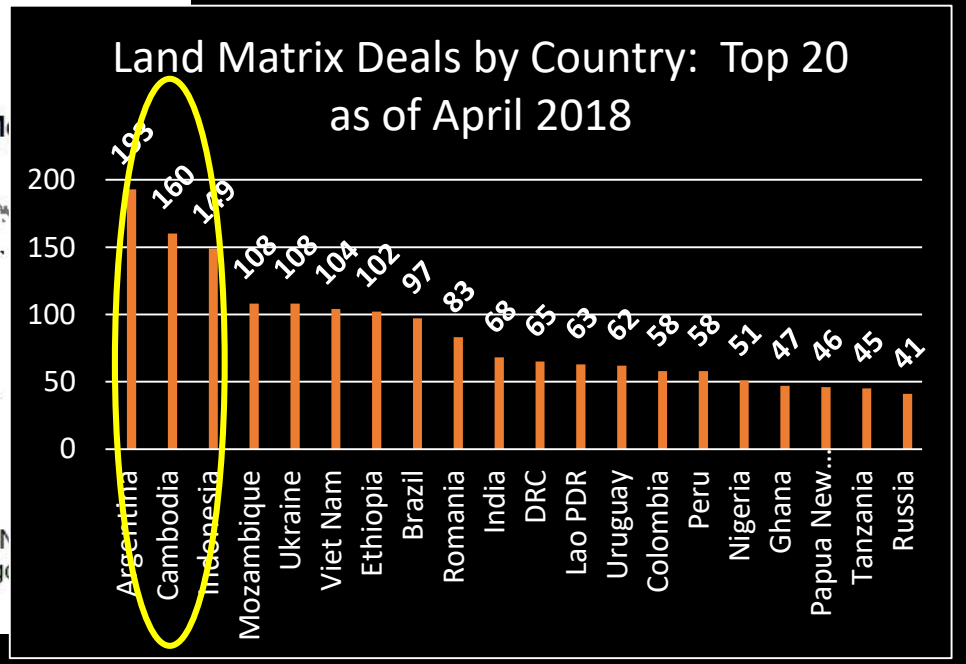
Economic Globalization and Land-Use Change

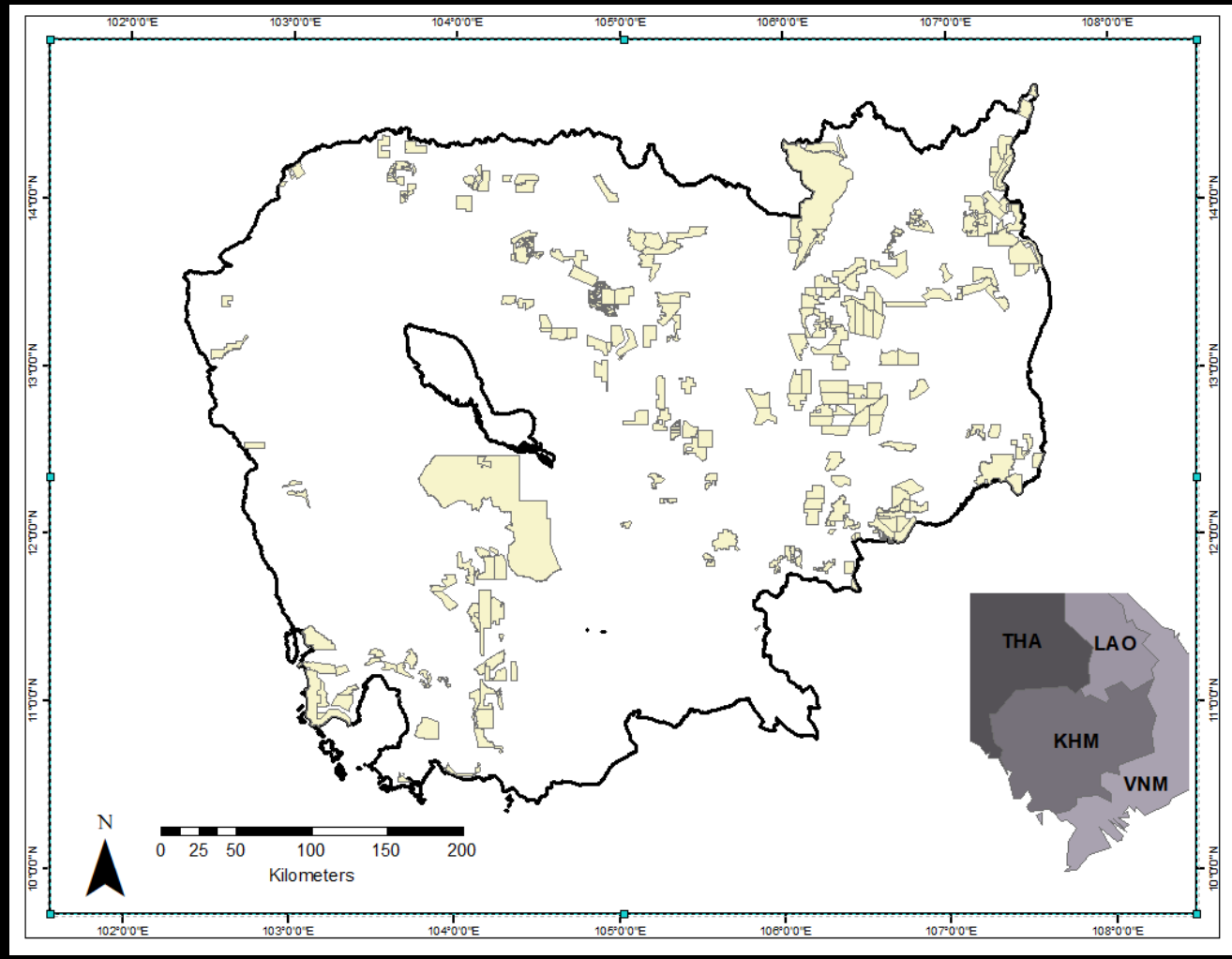
- Increase of large-scale land acquisitions (LSLAs) was observed in the previous two decades
- External investors (foreign and/or domestic) seeking to secure access to land to produce food, biofuels, and other agricultural commodities or for speculation.





Economic Globalization and Land-Use Change

- Cambodia in particular has been targeted
  - Economic Land Concessions (ELCs) cover 2.3 Mha (Open Dev. Cambodia)
  - ELC contribution to forest loss rose from 12.1% in 2001 to 27.0% in 2012 (Davis et al. 2015)

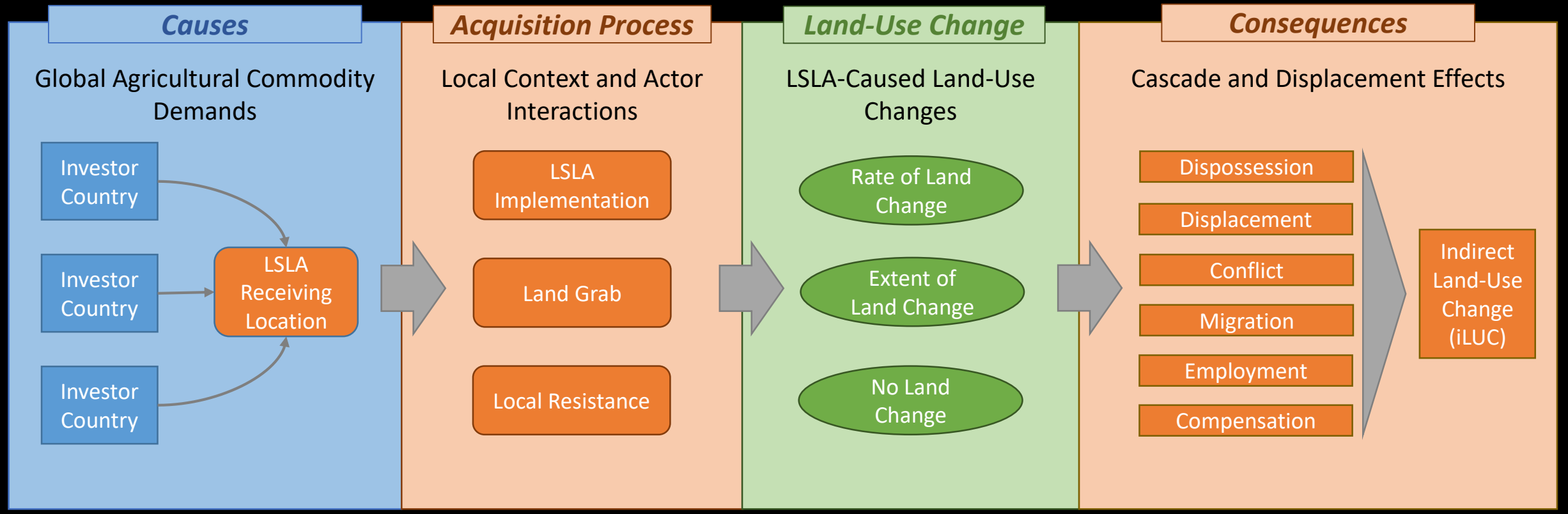


Knowledge Gaps

- Global to national-level; many local case studies
  - Descriptive generalizations or in-depth, context-dependent analyses
  - Systematic linking across scales has not been done
- Accounting for commodity-driven land-use changes is difficult
  - Disentangling direct and indirect land-use changes (LUC)
  - Focus on either environmental or social impacts, rarely integrated
- Basic question: How do global commodity signals in the form of LSLAs transform local landscapes and through what pathways?

Conceptual Framework: Commodity pathways (Meyfroidt 2015)

- Commodity-driven pathways for direct and indirect LUC caused by ELCs in Cambodia
  - Pathways: causal chains of events leading to specific outcomes



  - Archetypes: recurring 'building-blocks' of factors and/or processes that can be combined in various ways to simply describe or infer causal mechanisms from a population of cases

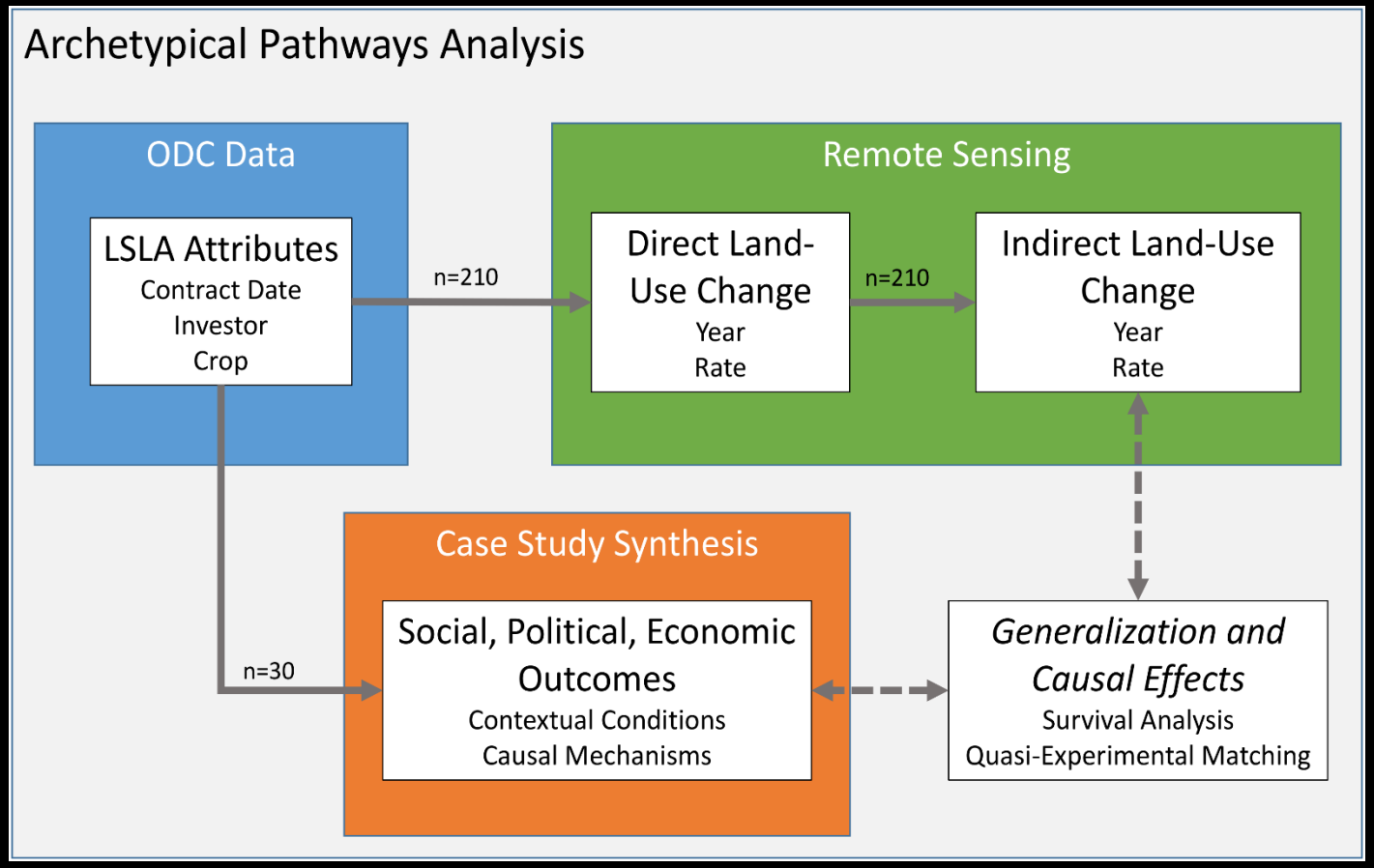
Objectives and Methods Overview

Disentangle and quantify forest loss caused by direct and indirect LUC

- How significant is iLUC?

Mixed methods triangulation and synthesis

- Remote sensing change detection
- Case-study synthesis
- Survival analysis
- Quasi-experimental matching

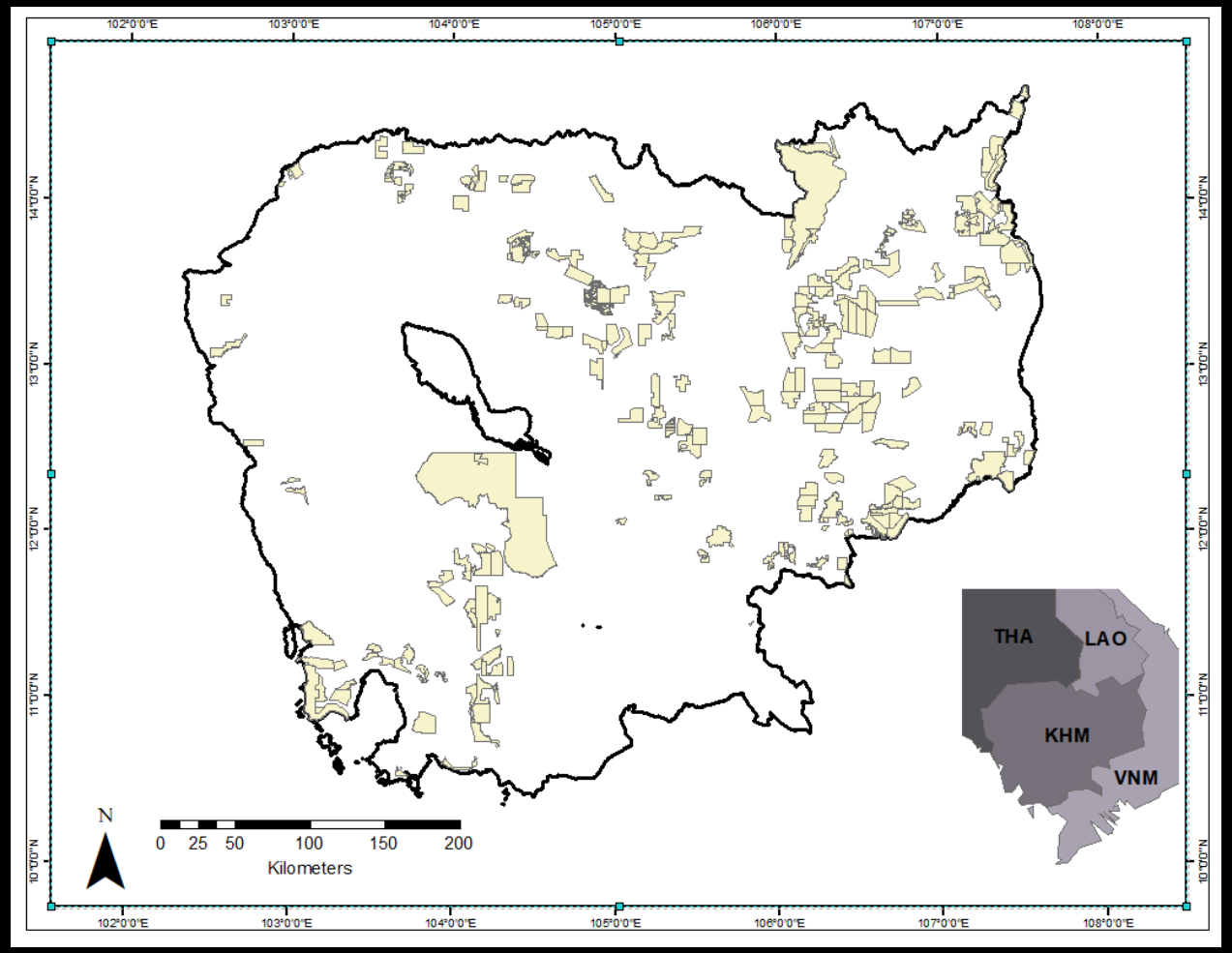


Methods: Economic Land Concessions

- Open Development Cambodia (ODC)
  - Consistent with Land Matrix criteria
  - From 2000-2012, 210 ELCs

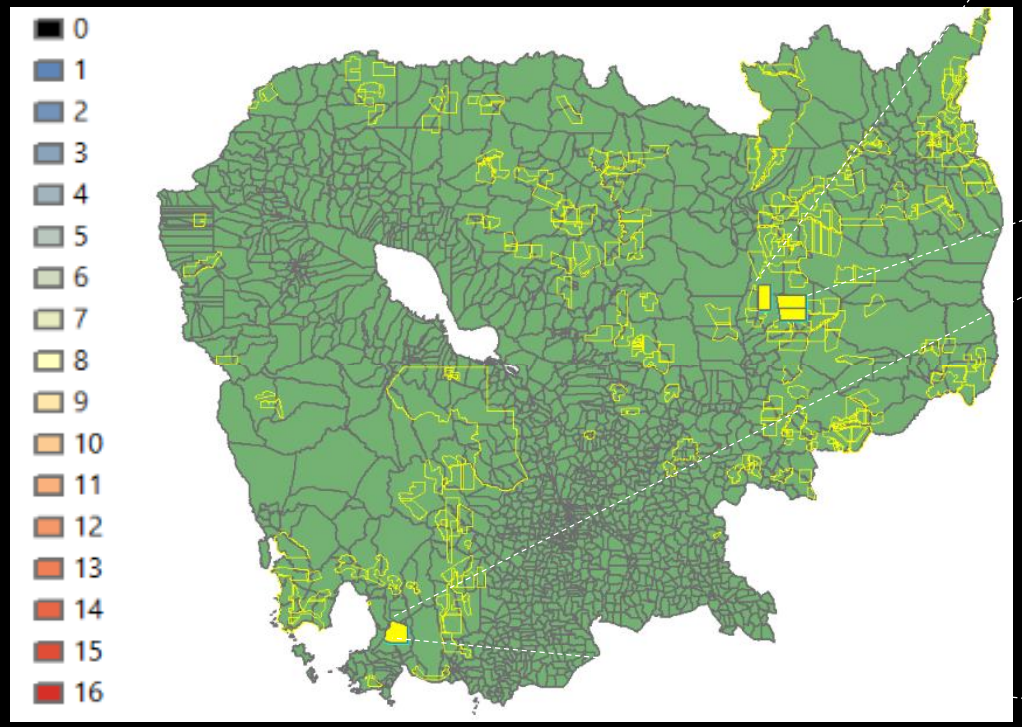
- Time-dependent variables
  - Population
  - Commodity prices

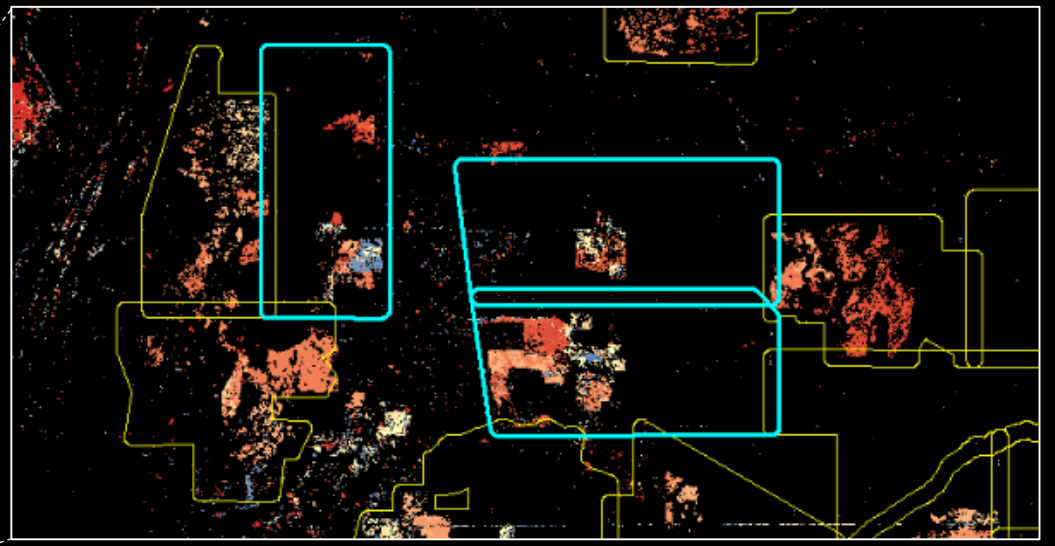
- Time-independent variables
  - Biophysical production conditions
  - Market accessibility
  - Social and land use (ODC)

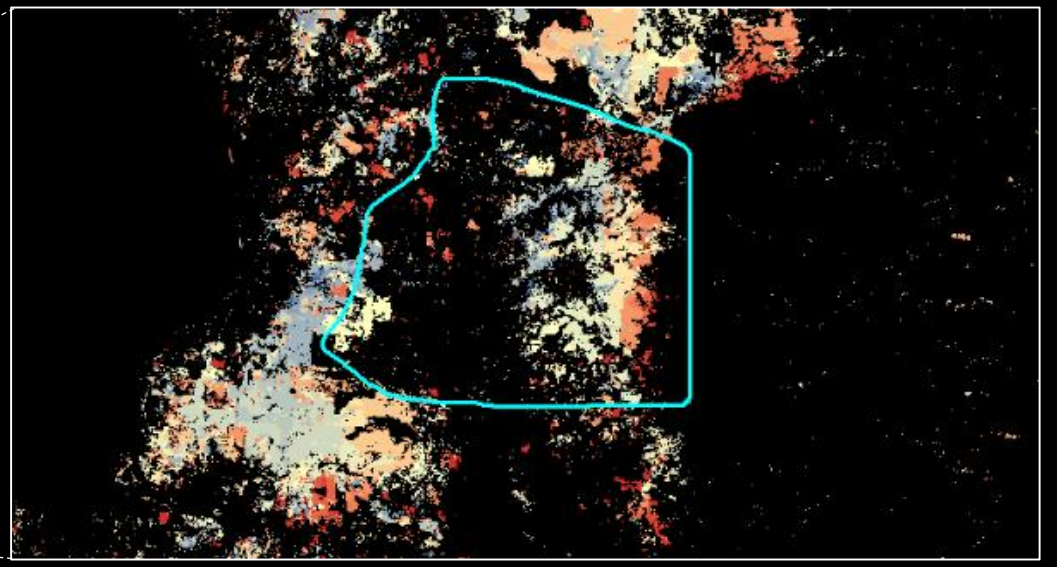


Methods: Forest Change Detection

- Hansen et al. (2013) global forest change product
- **Year of ≥ 10% forest loss** (total or annual) since ELC establishment or implementation year
- Direct LUC within 500m buffer of boundary
- Indirect LUC within containing commune







Methods: Qualitative Comparative Analysis (QCA)

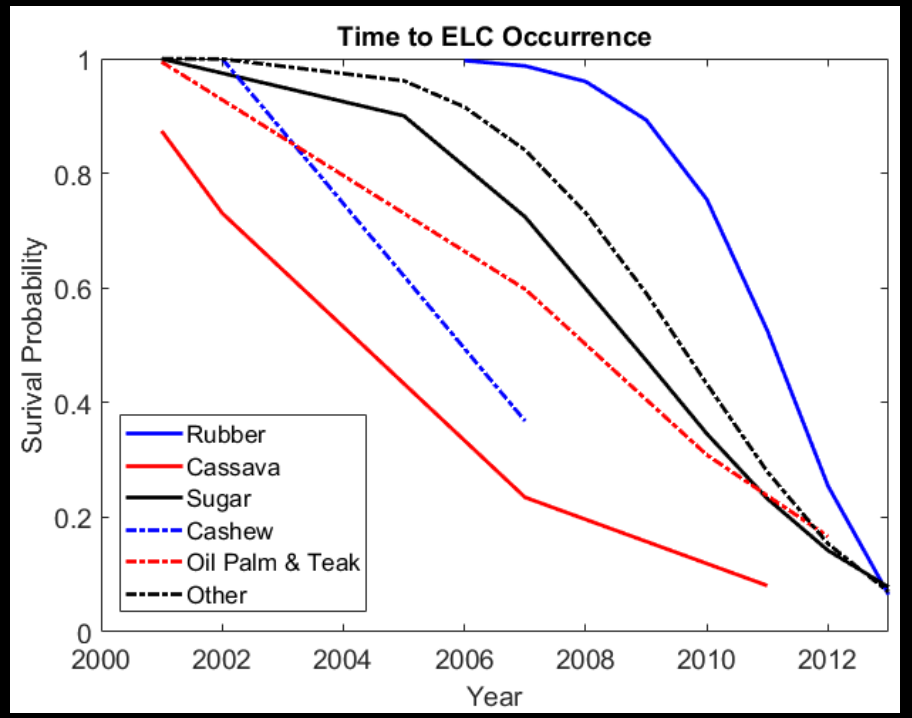
- Identify common acquisition processes leading to various socioeconomic and land-use change outcomes
  - Linking case studies to georeferenced ELC boundaries (Open Development Cambodia)
  - Included 30 cases from 18 articles
  - Coded for displacement, conflict, employment, compensation, migration, iLUC

Results: Causal configurations leading to (no) iLUC

1. Six casual configurations were identified as leading to iLUC: rapid LUC (≤ 3 years), rubber, displacement and conflict
2. Three causal configurations were associated with the absence of iLUC: rapid LUC and not rubber; gradual LUC, rubber, no displacement

Methods: Survival Analysis

- Estimate potential causal effects of local conditions and regional/global markets signals on the **timing** of ELC establishment and direct LUC within ELC boundaries
  - Probability of 'survival' (i.e., change of state) for each year and location
  - Establish initial causal factor, sequence of events



Results: Survival probability until ELC establishment, direct LUC

1. Rubber price - ELCs 43.7% more likely over time for specialized crops (e.g., rubber)
2. Cassava price - ELCs 33.2% less likely over time for multi-use crops (e.g., cassava)
3. Direct LUC 5% less likely with longer time since establishment

Methods: Propensity Score Matching

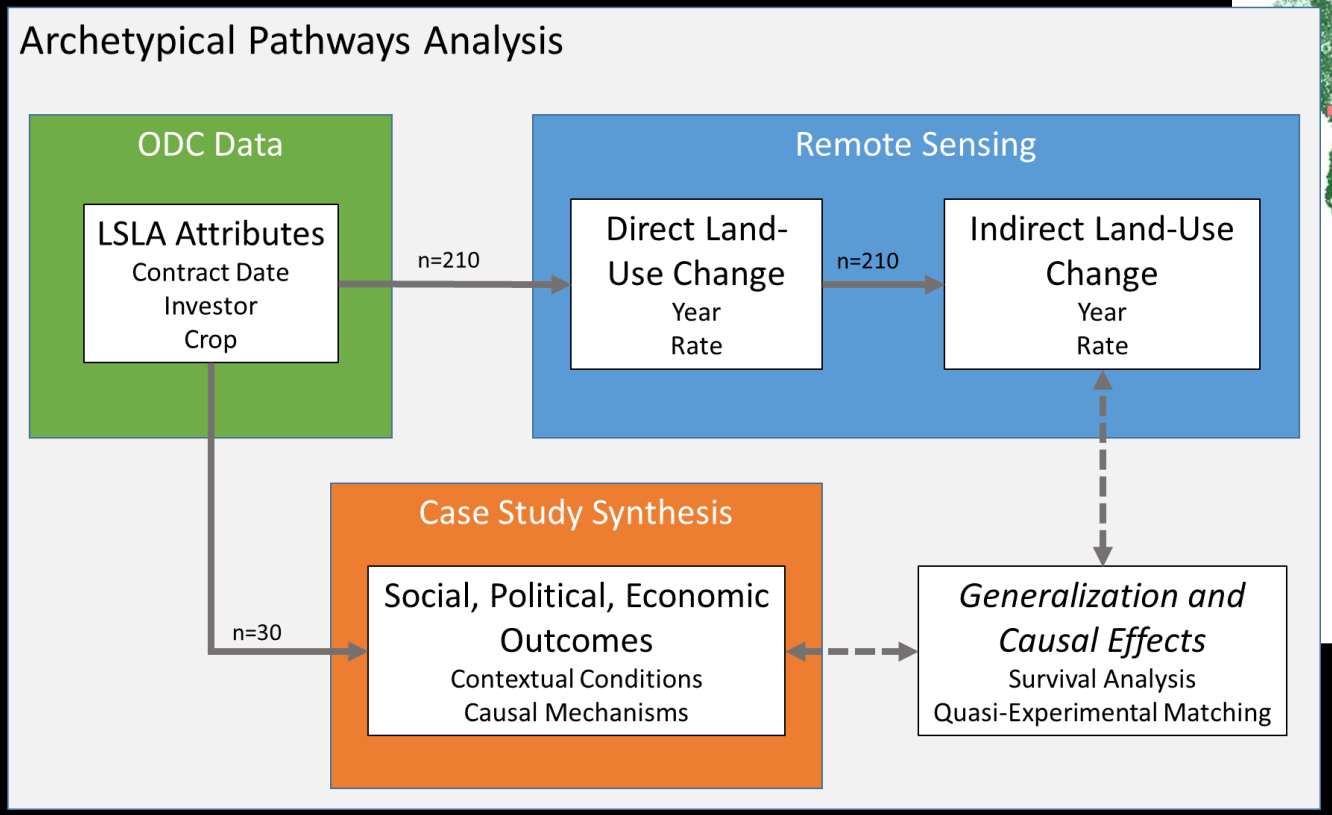
- Test for whether iLUC was higher in communes containing ELCs (treatment) than in those without (control)
  - Quasi-experimental matching using commune propensity score for threshold deforestation within ELC
  - Matched based on pop. density, % forest cover, market access, slope, rice ratio (median bias 5.83%)

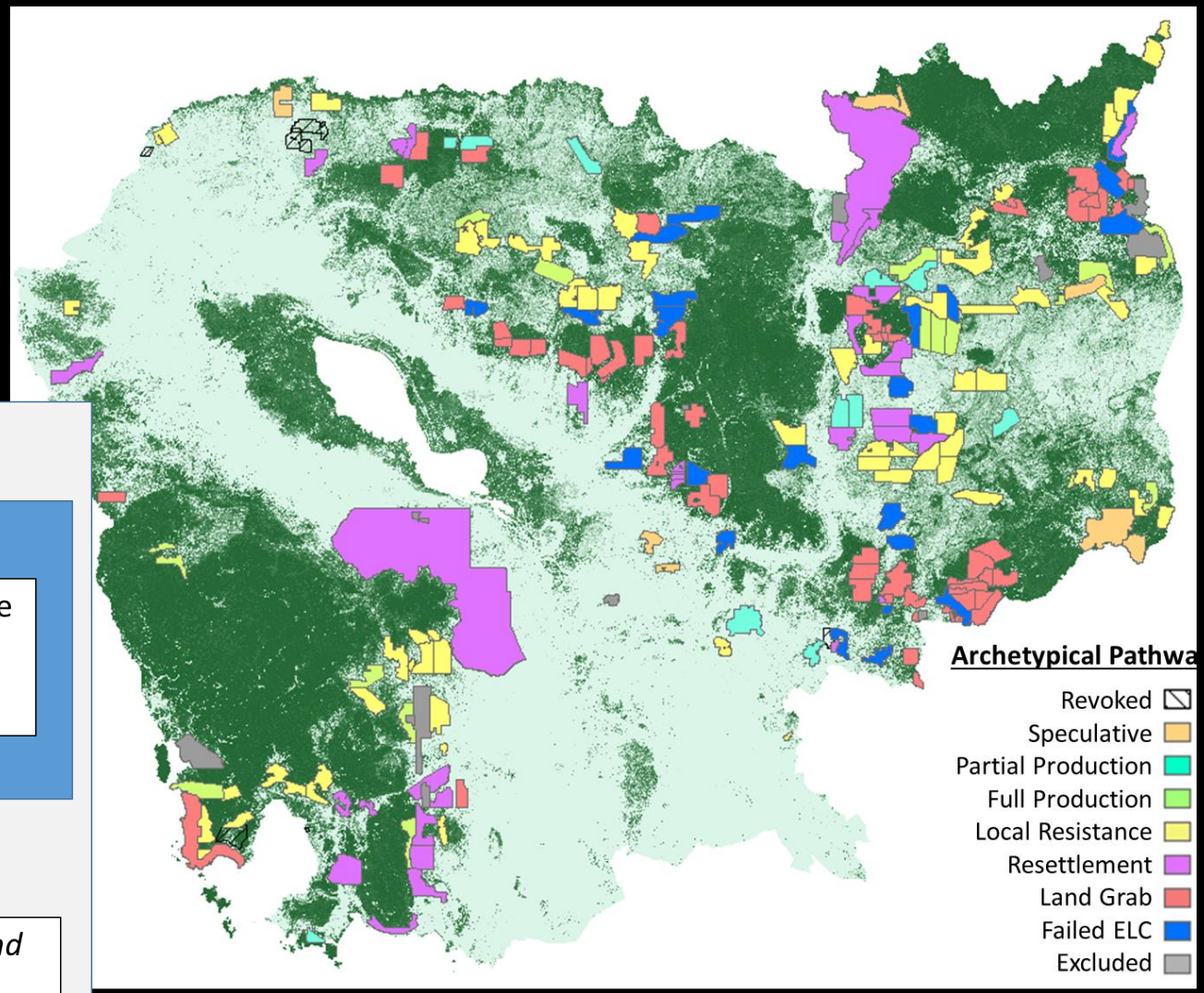
Results: Average treatment effect on the treated (ATT) – observable iLUC

1. Communes with ELCs producing rubber were **29.3% more likely**
2. Communes with ELCs undergoing direct LUC within 3 years of their transaction date were **25.9% more likely**
3. Communes in provinces with > 20% of land in ELCs were **64.3% more likely**

Results: Archetypical Pathways

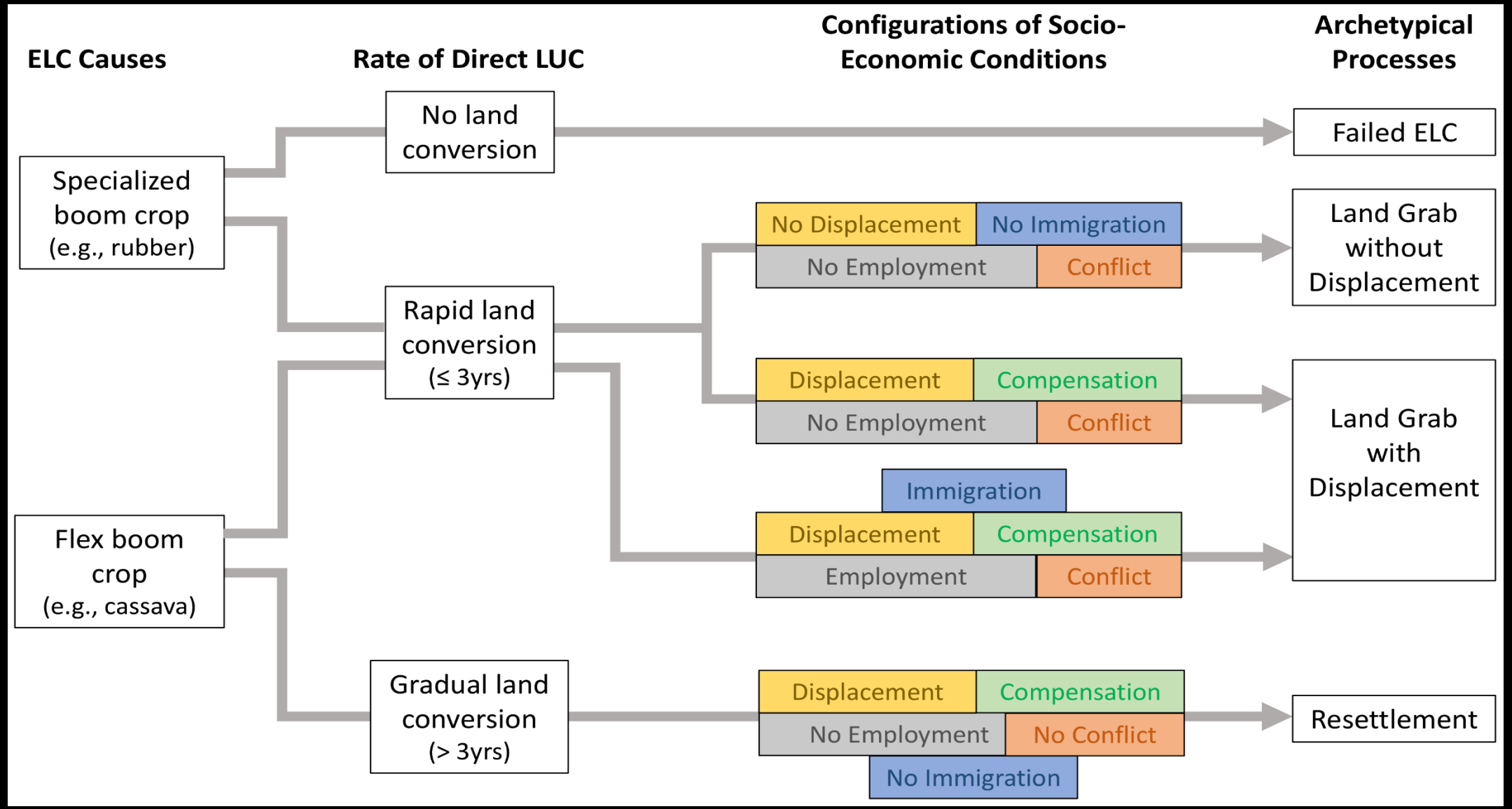
- QCA results for causal mechanisms and social outcomes
- Observed rates of direct and indirect LUC
- Link in space and time using causal inference





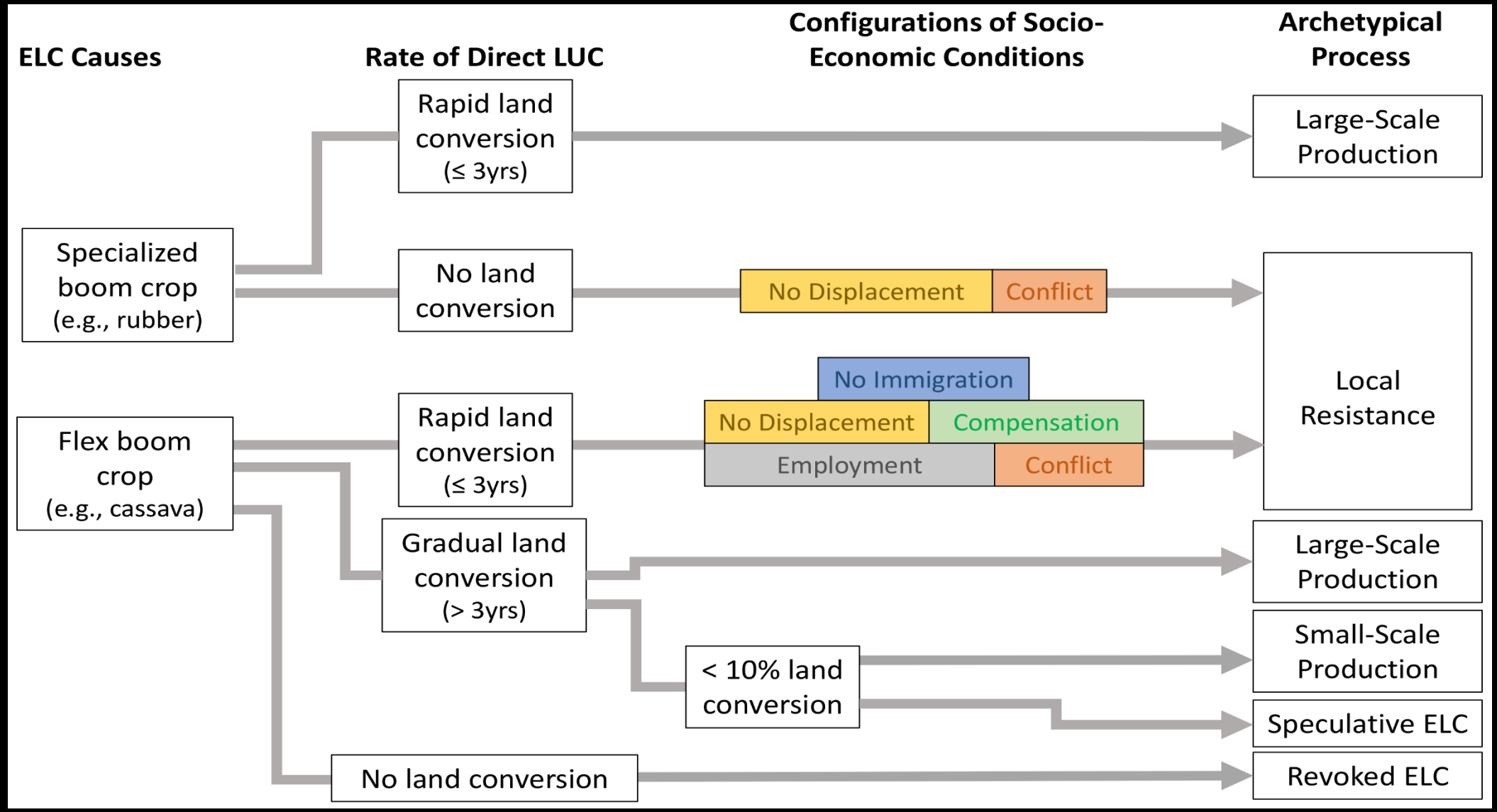
Results: Archetypical Pathways: iLUC

- Archetypical pathways associated **with iLUC**



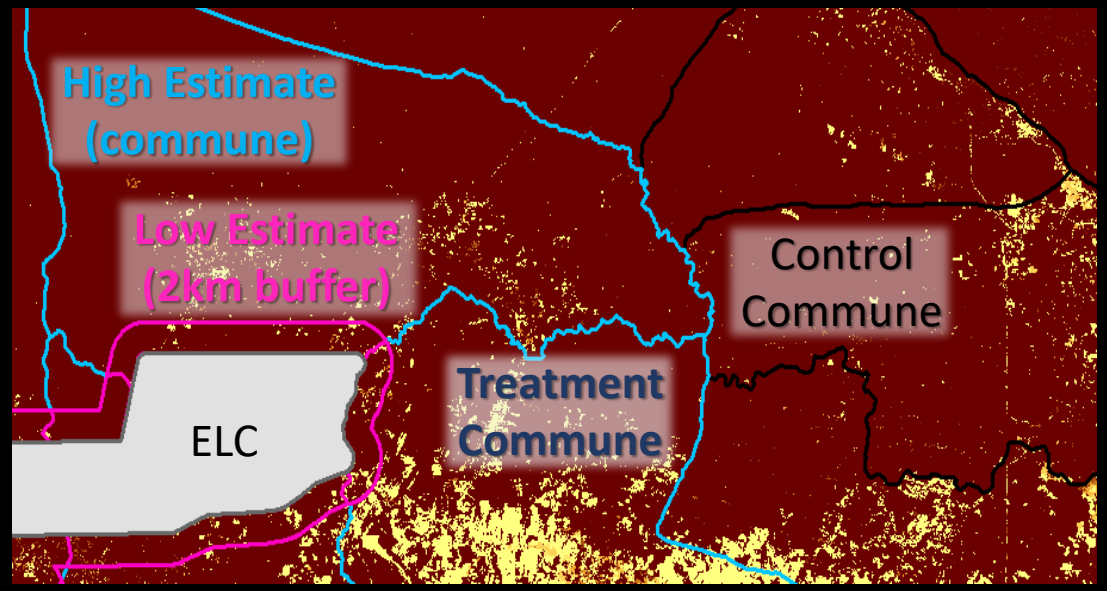
Results: Archetypical Pathways: no iLUC

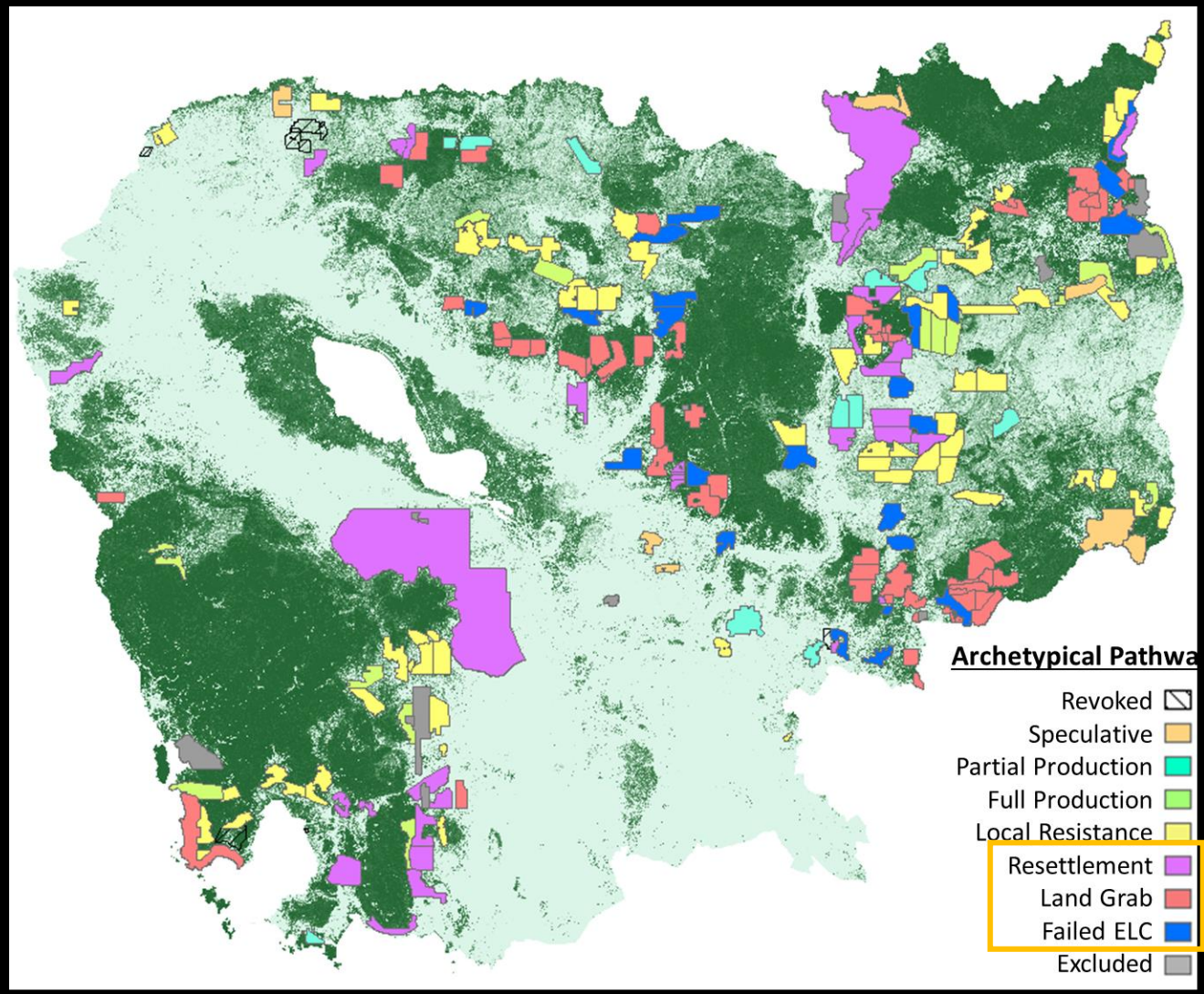
- Archetypical pathways associated **without iLUC**



Methods: iLUC Deforestation Estimates

- iLUC archetypes
- Two spatial scenarios
  - 2km buffer (low estimate)
  - Commune (high estimate)
- Two temporal scenarios (0 to 4 years)
  - Deal year (establishment)
  - Implementation year



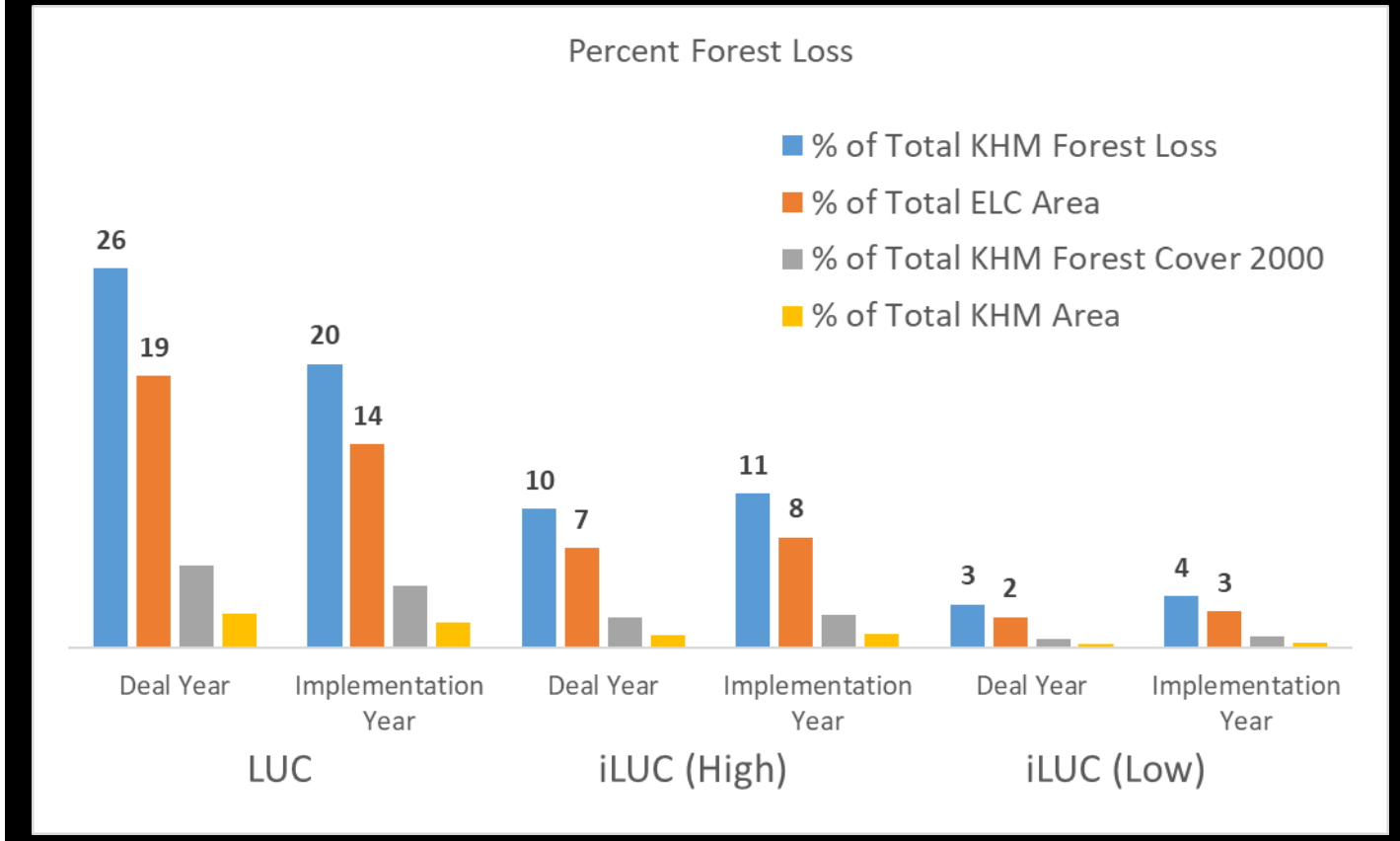


How much forest loss is due to iLUC?

Results: Deforestation Estimates

- iLUC from ELCs adds 3 – 11% of Cambodia's forest loss

	Time Lag	Forest Loss within 2 km Buffer (1000 ha) Avg. Annual	Max. Annual	Total	Forest Loss within Zone 1 (1000 ha) Avg. Annual	Max. Annual	Total
Since Deal Year	0	1.87	7.79	22.42	5.61	25.04	67.38
	1	2.98	10.63	35.76	9.06	29.50	108.70
	2	4.06	11.25	48.71	13.05	32.66	156.54
	3	5.16	11.56	61.96	17.28	35.81	207.31
	4	6.05	12.60	72.65	21.23	39.57	254.79
Since Implmnt. Year	0	2.26	10.95	29.38	6.61	27.04	85.95
	1	3.43	11.57	44.57	10.10	31.16	131.26
	2	4.49	12.86	58.39	13.39	37.30	174.01
	3	5.41	12.97	64.96	17.20	37.38	206.46
	4	6.28	13.85	69.09	21.03	41.18	231.30



Conclusions

- Indirect LUC is a non-trivial contribution to overall forest loss
- Synthesis is still a key priority for LCLUC, Global Land Programme
- Synthesis methods enabled linkage of process information to remote sensing and statistical signatures
  - Mixed-methods triangulation in space and time
  - Attribution of direct and indirect effects -> quantification of LCLUC with remote sensing tools
  - New questions can be raised, answered

Thank you for your attention!

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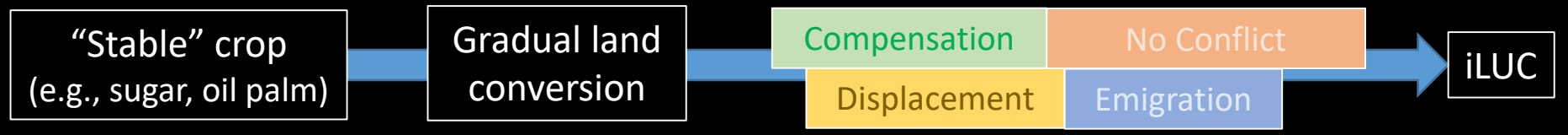
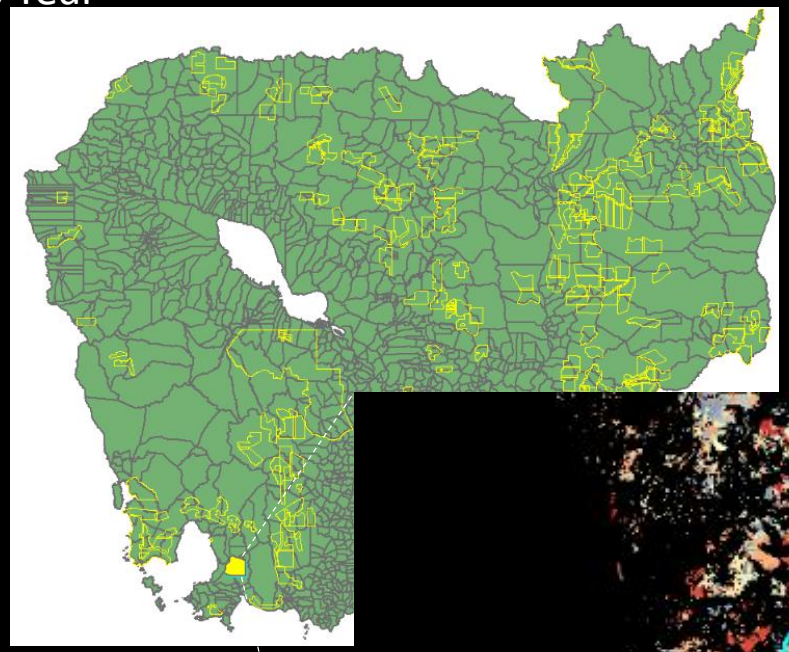
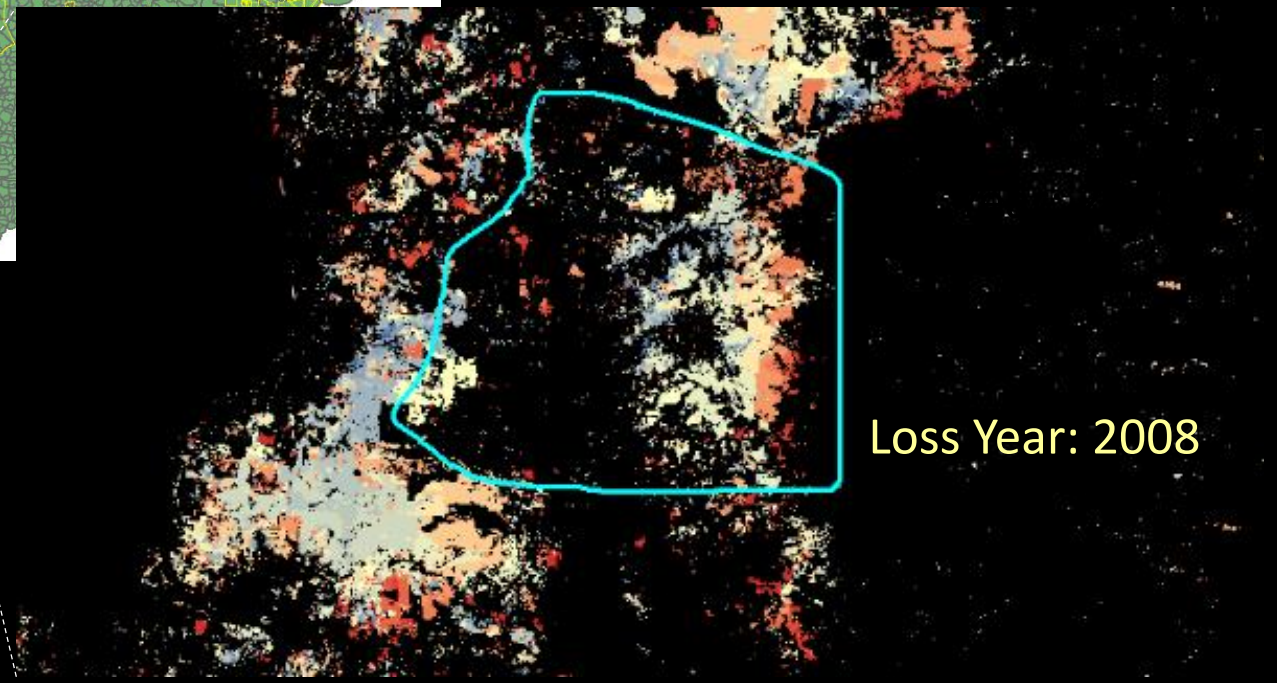
NASA Award #15-LCLUC15_2-0036

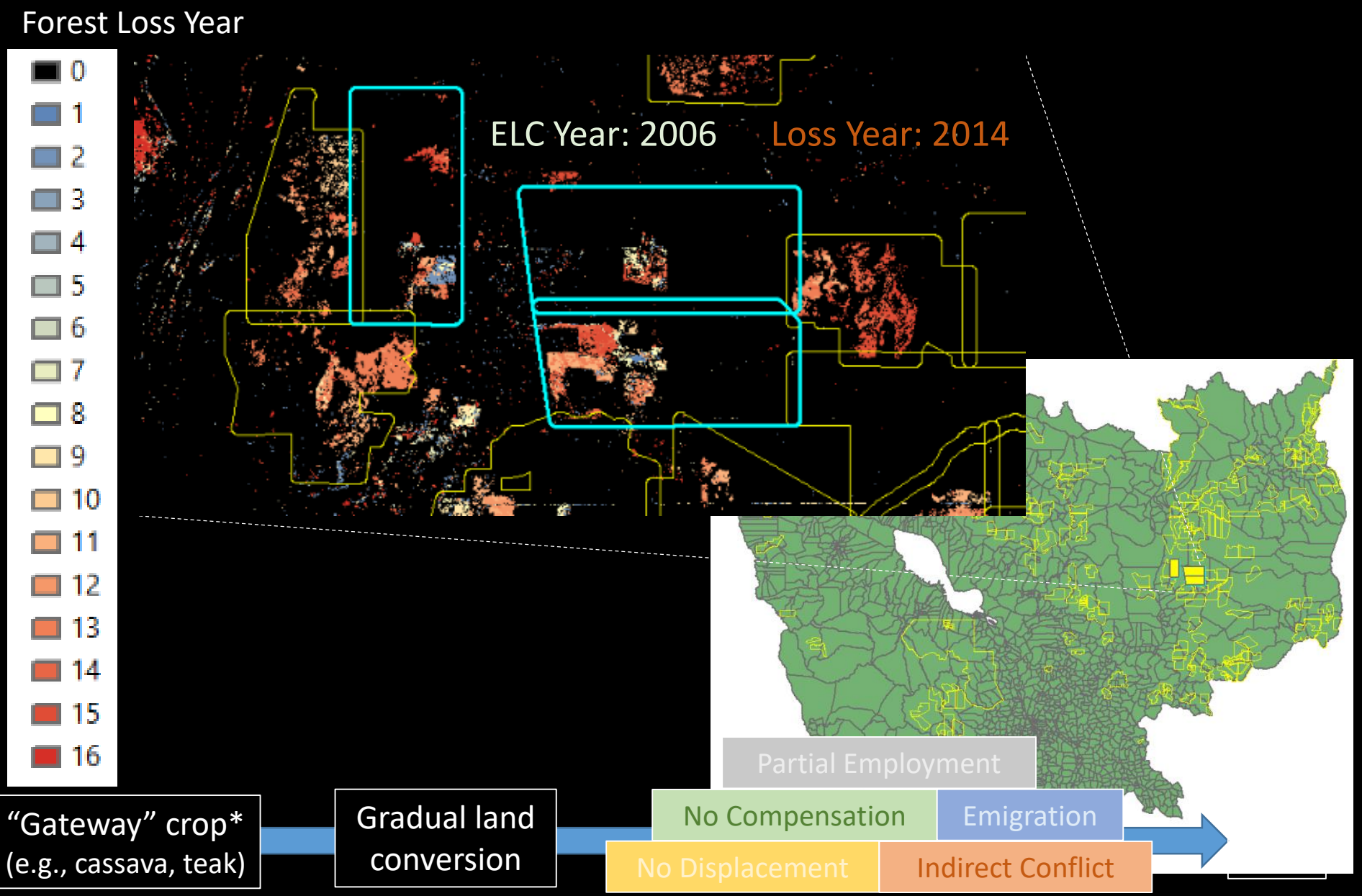
Case 1: Palm oil, Gradual LC, iLUC



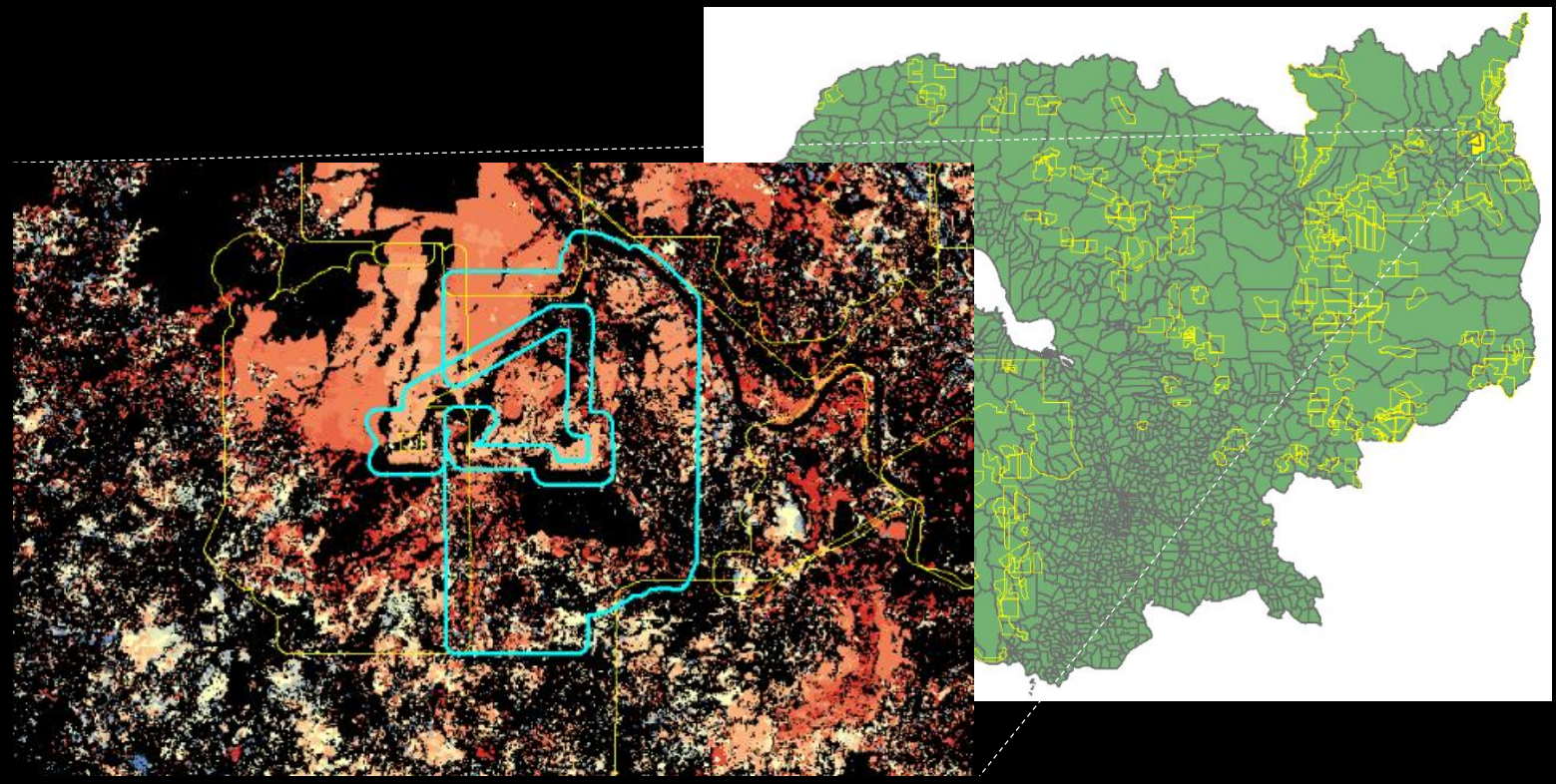




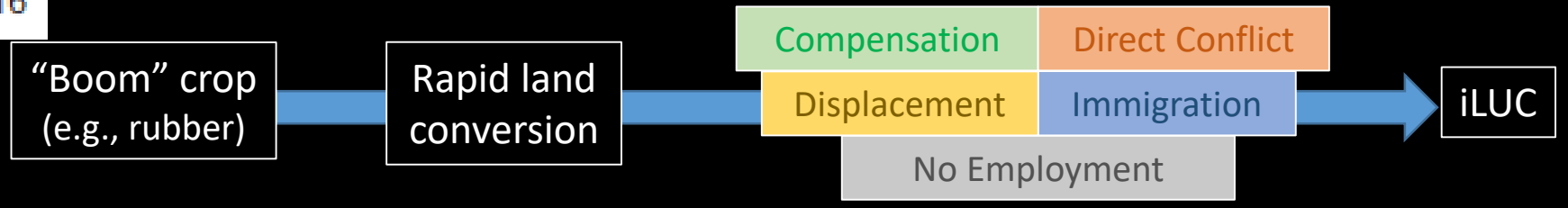
Case 2: Teak & Other Crops, Gradual LC, No iLUC



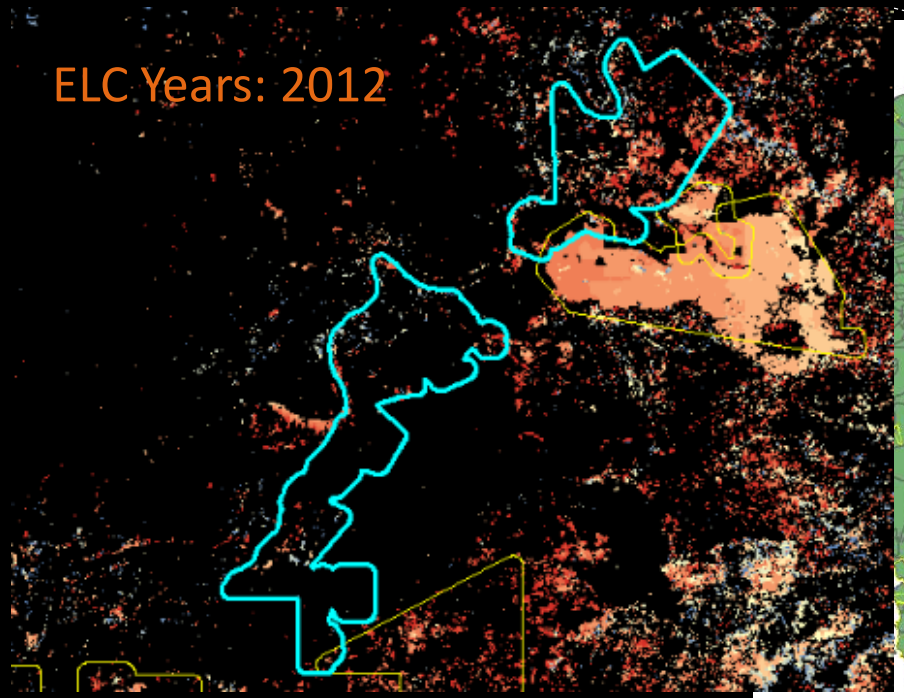
Case 3: Rubber, Rapid LC, iLUC



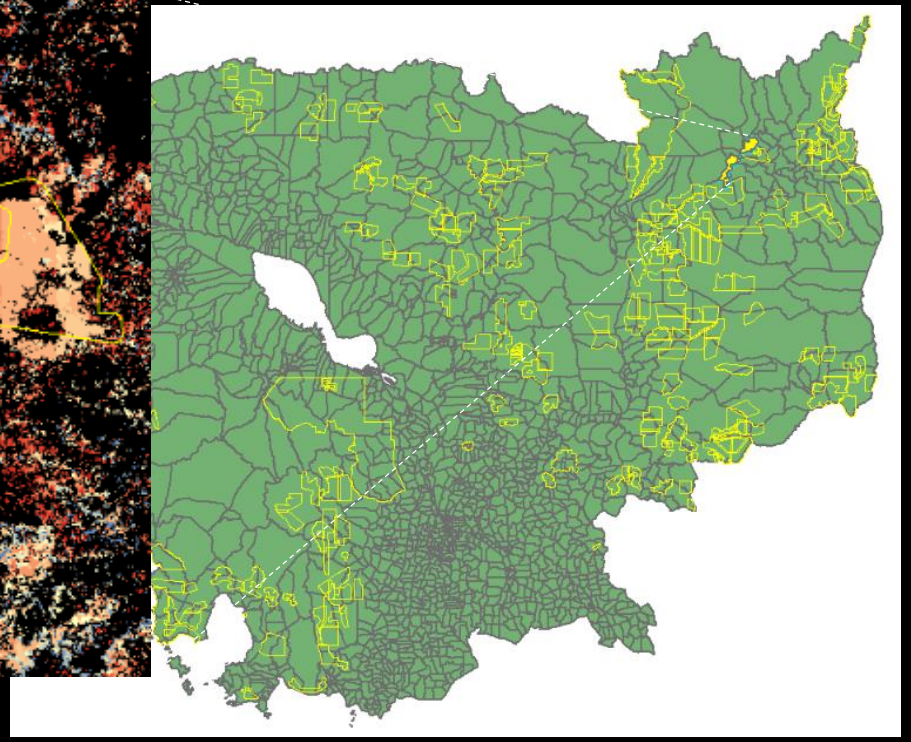
ELC Years: 2011 Loss Years: 2011-2013

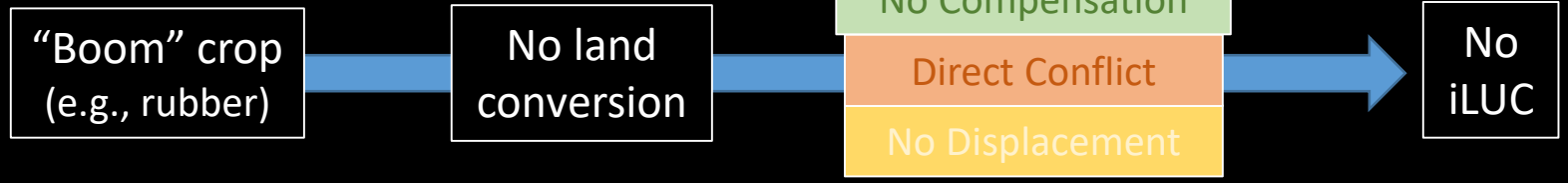


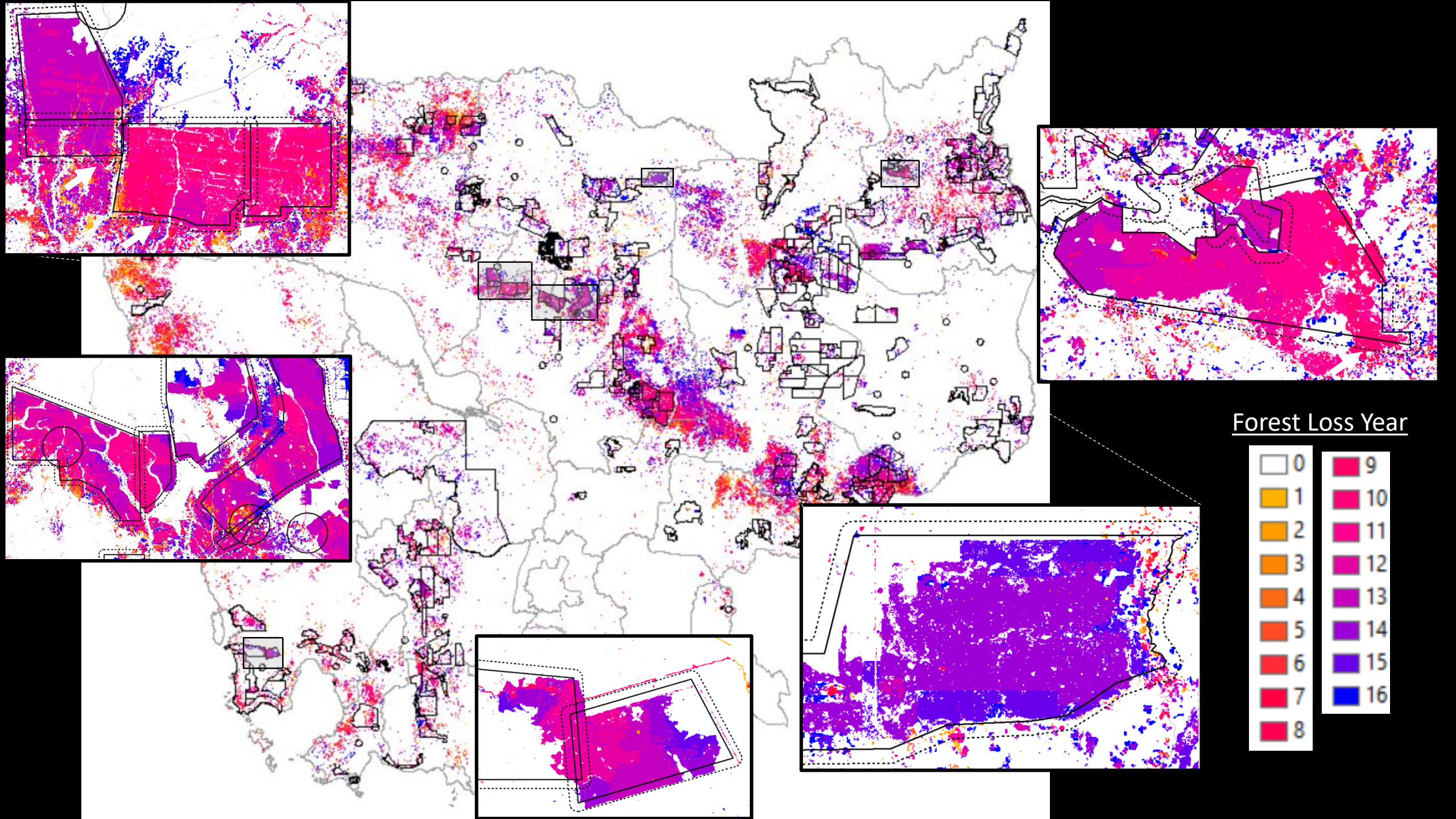
Case 4: Rubber, No LC, No iLUC



Loss Years: Not Observed






Forest Loss Year
0
1
2
3
4
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6
7
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9
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11
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13
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15
16

Conceptual Framework