Projecting Future Changes in Southeast Asia's Aboveground Forest Carbon Stock

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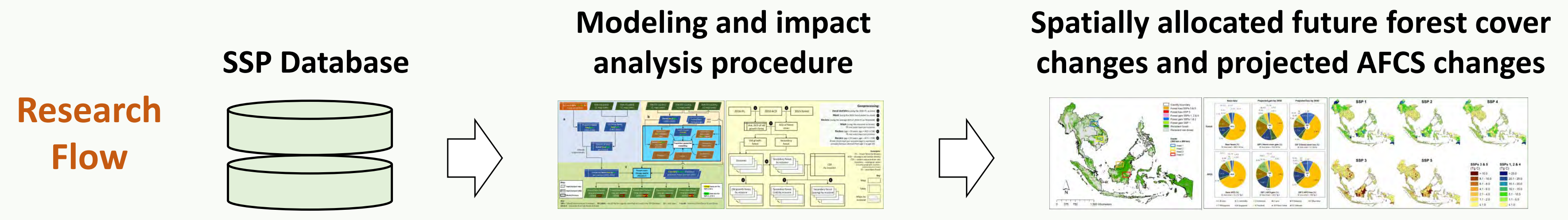
Introduction

While Southeast Asia's forests play important roles in biodiversity conservation and global carbon balance, the region is also a deforestation hotspot. Here, we considered the five shared socioeconomic pathways (SSPs) to portray a range of plausible futures for the region's forests, employing a state-of-the-art land change modeling procedure and remotely sensed data. More particularly, we focused on the spatial allocation of the projected quantities of future forest cover changes in the region from 2015 to 2050 under the five baseline SSPs. The potential implications of these spatially allocated projected forest cover changes were examined by quantifying their consequent aboveground forest carbon stock (AFCS) changes at the country and province levels.



Forest cover loss and degradation in Sarawak, Malaysia due to logging

(Fieldwork photos by Ronald C. Estoque, September 2019)

Methods

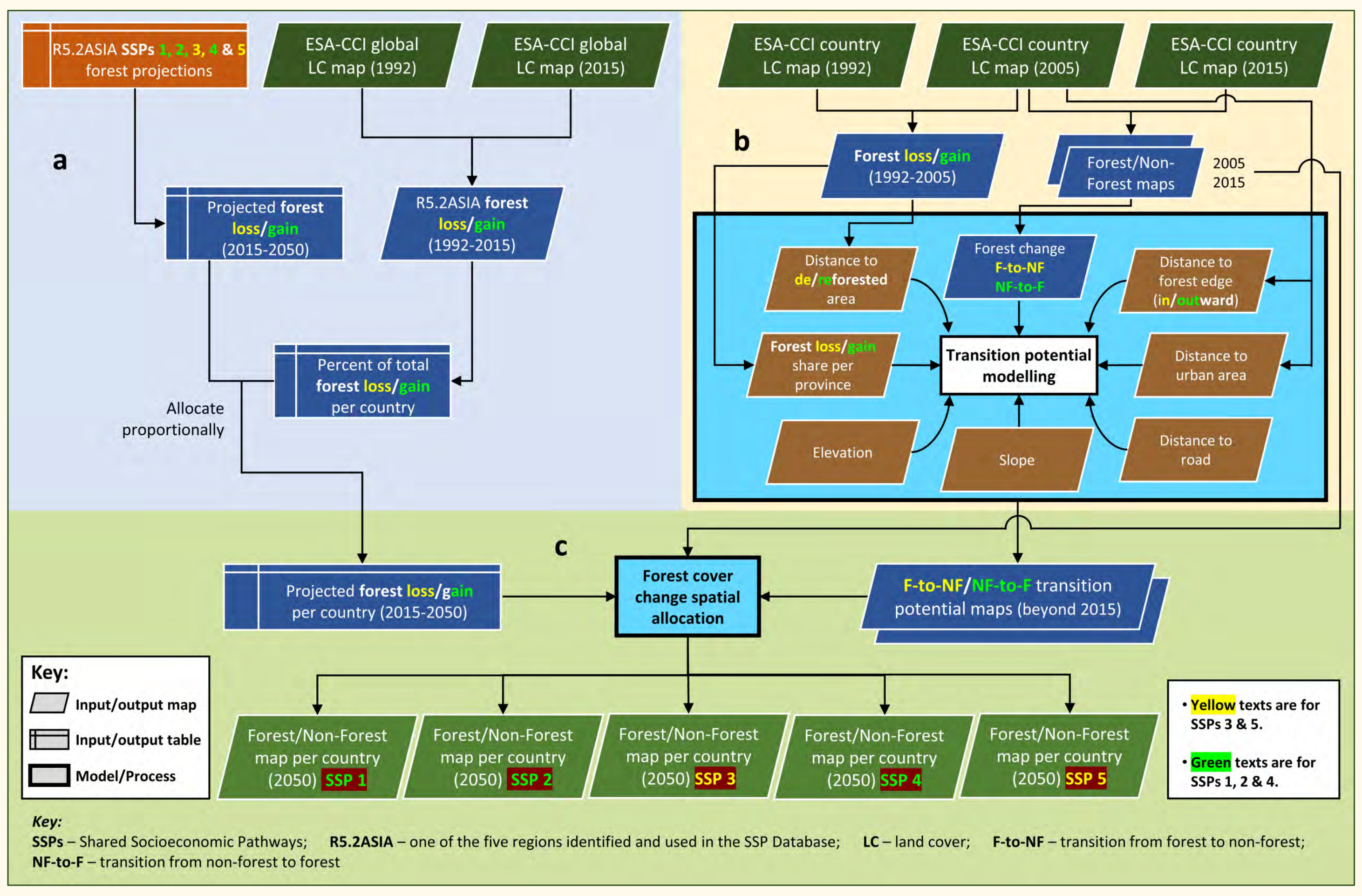


Fig. 1. Flowchart of the spatially explicit land change modeling procedure developed and used in this study.

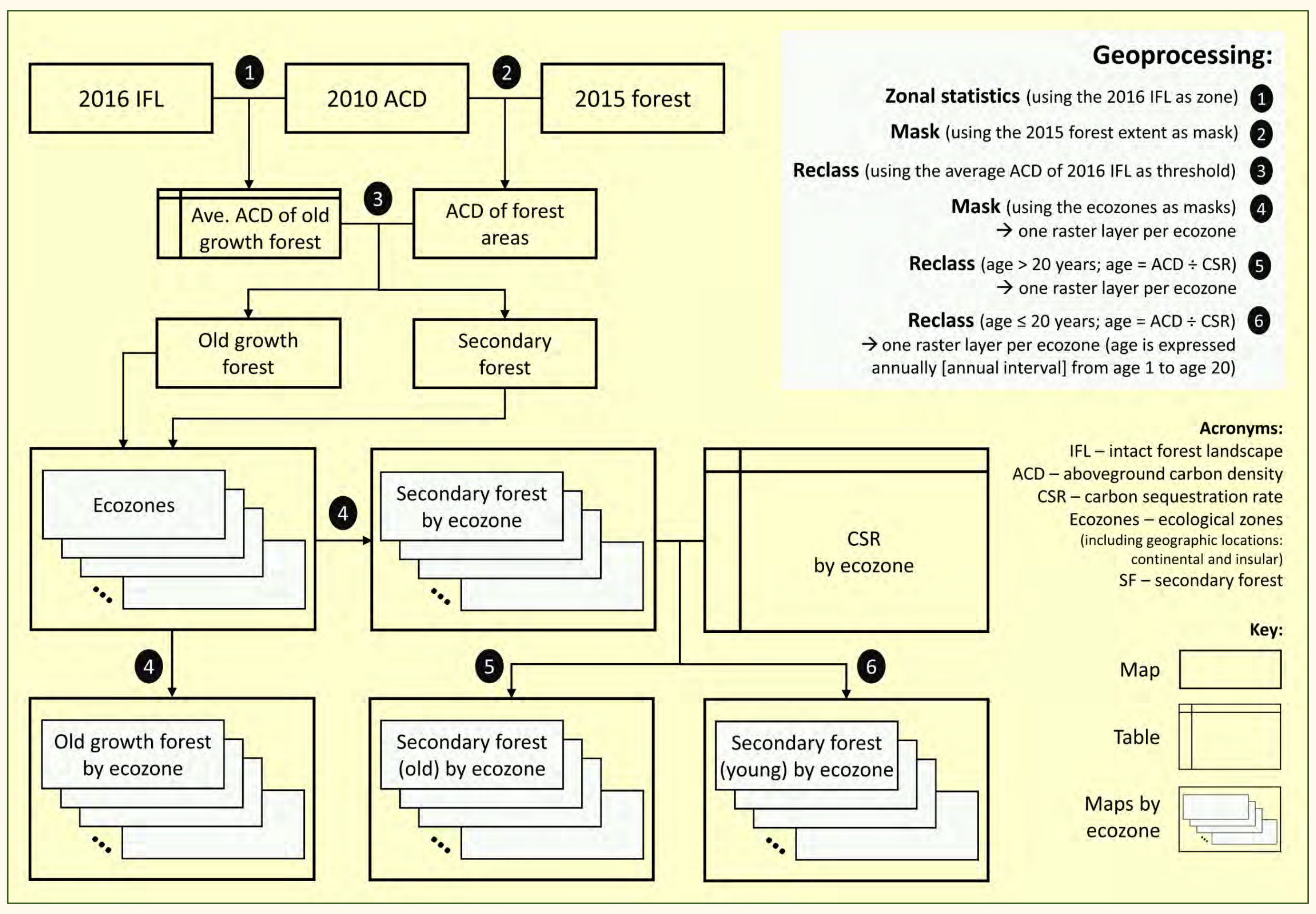


Fig. 2. Flowchart of geospatial approach developed and used in this study to reclassify the forest class by ecozones.

Loss

$$\text{AFCS Loss}_{\text{Y,V}(2015-2050)} = \sum_{i=1}^{n} \text{ACD}_{i,2050} \times \text{A}_{i}$$

where ACD_i and A_i refer to the 2050 projected above ground carbon density (Mg C ha^{-1}) and the land area (ha), respectively, of pixel i; and n is the number of pixels of the projected forest cover loss (2015–2050) with an ACD value within each country, Y, or province, V. Here, it is assumed that deforestation will happen in 2050.

$$\text{ACD}_{js,2050} = \text{ACD}_{js} + (\text{CSR}_{js} \times \text{GP})$$

where ACD_{js} and CSR_{js} refer to the 2010 aboveground carbon density (Mg C ha−1) and carbon sequestration rate (Mg C ha^{-1} yr^{-1}), respectively, of pixel j which is a member of sub-class s of old growth forest and old secondary forest; and GP refers to the growth period (40 years) for old growth forest and old secondary forest from 2010 (the year of the ACD) to 2050 (the end year of the projection).

Gain

$$\text{AFCS Gain}_{\text{Y,V}(2015-2050)} = \sum_{q=1}^{m} \text{ACD}_{q,2050} \times \text{A}_{q}$$

where ACD_q and A_q refer to the 2050 projected aboveground carbon density (Mg C ha^{-1}) and the land area (ha), respectively, of pixel q; and m is the number of pixels of the projected forest cover gain (2015–2050) within each country, Y, or province, V.

$$\text{ACD}_{qs,2050} = \text{CSR}_{qs} \times \text{GP}$$

where CSR_{qs} refers to the carbon sequestration rate (Mg C ha^{-1} yr^{-1}) of pixel q of the projected forest cover gain which is a member of sub-class s of the new young secondary forest; and GP refers to the growth period (17.5 years) for the projected young secondary forest with the assumption that trees would be planted not at one time, but rather across the 35-year period (2015–2050).

Results and Discussion

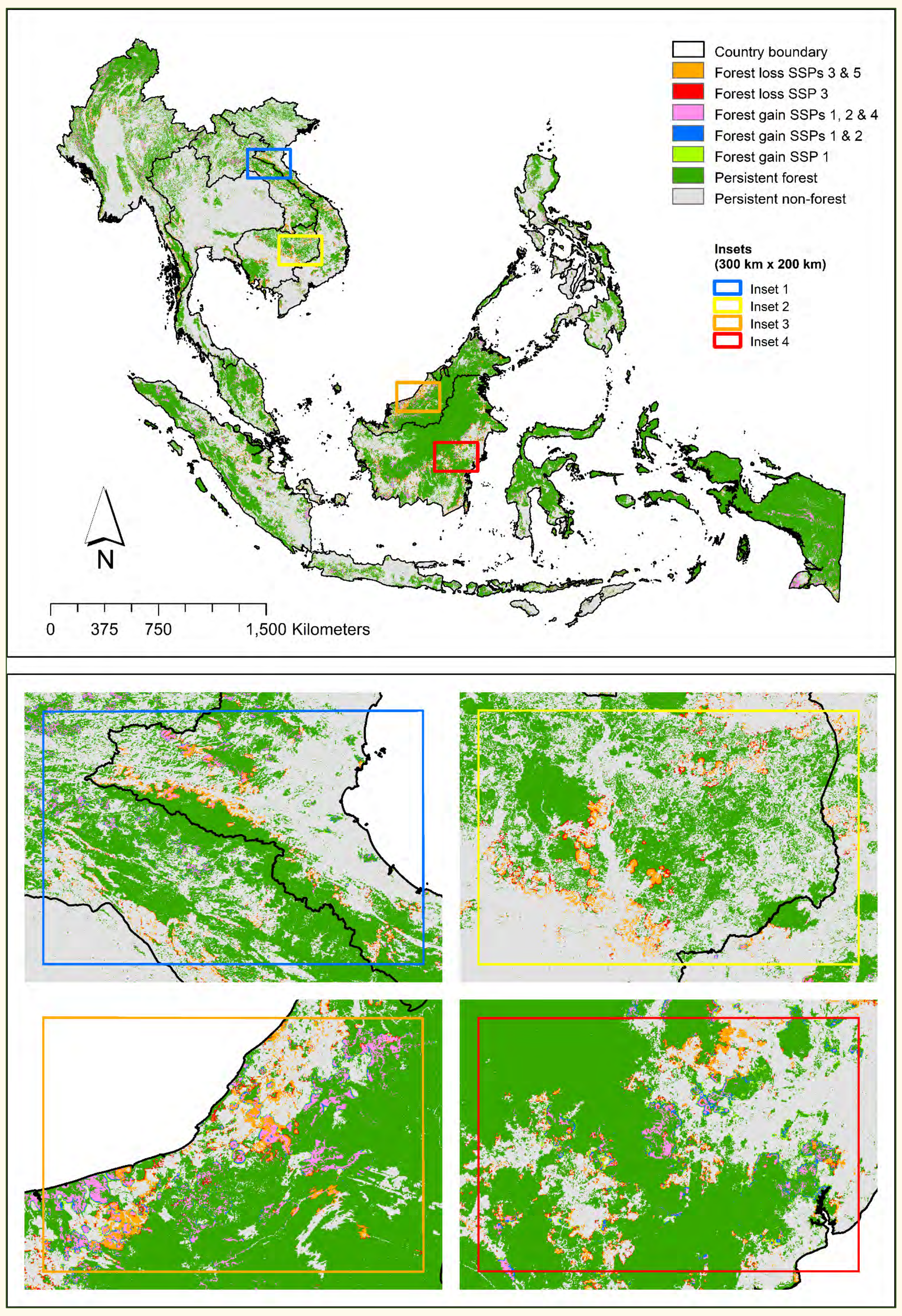


Fig. 3. Maps of the spatially allocated projected forest cover changes under the five SSPs (2015-2050).

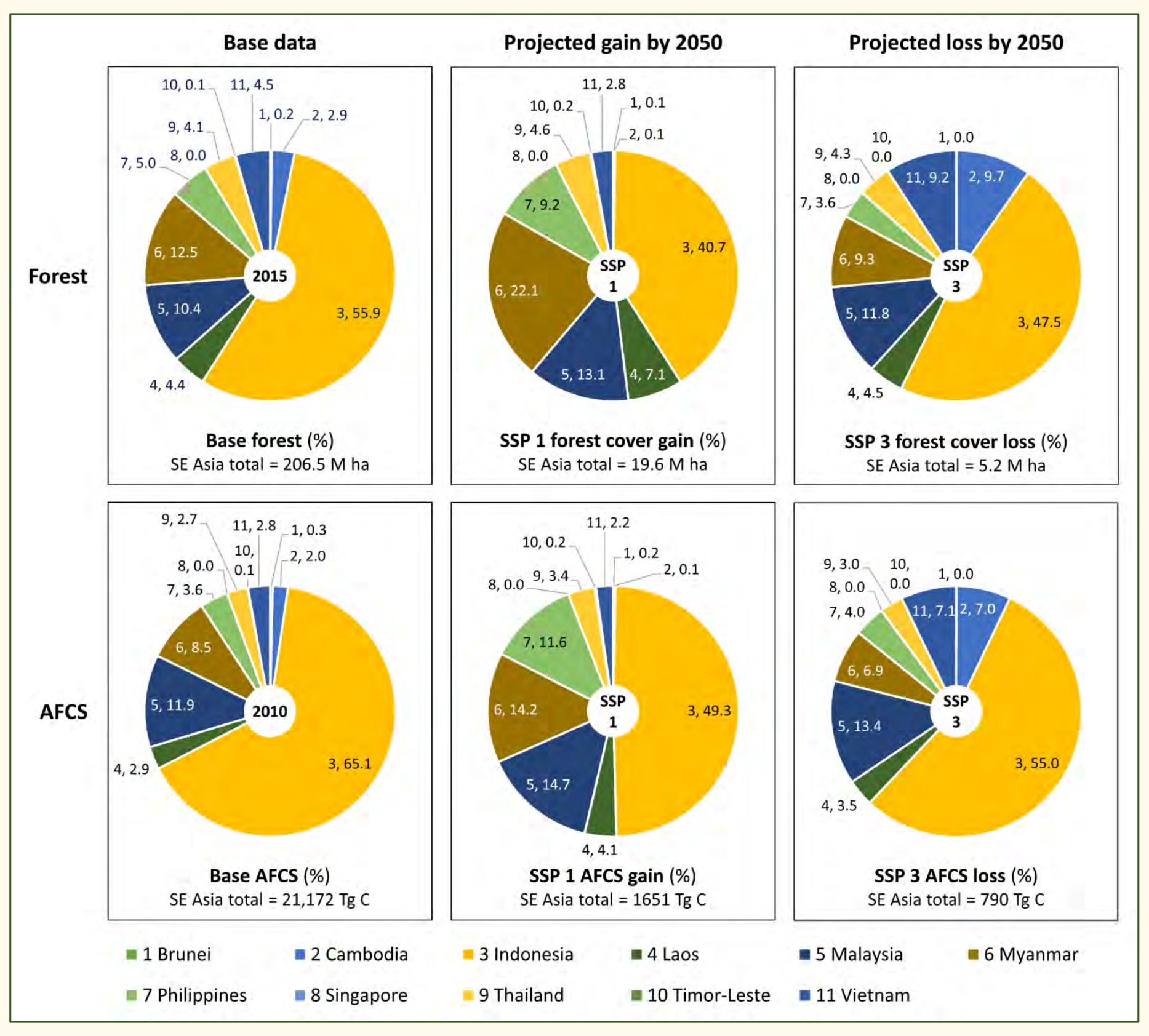


Fig. 4. Country-level distribution of future forest and AFCS changes (2015-2050).

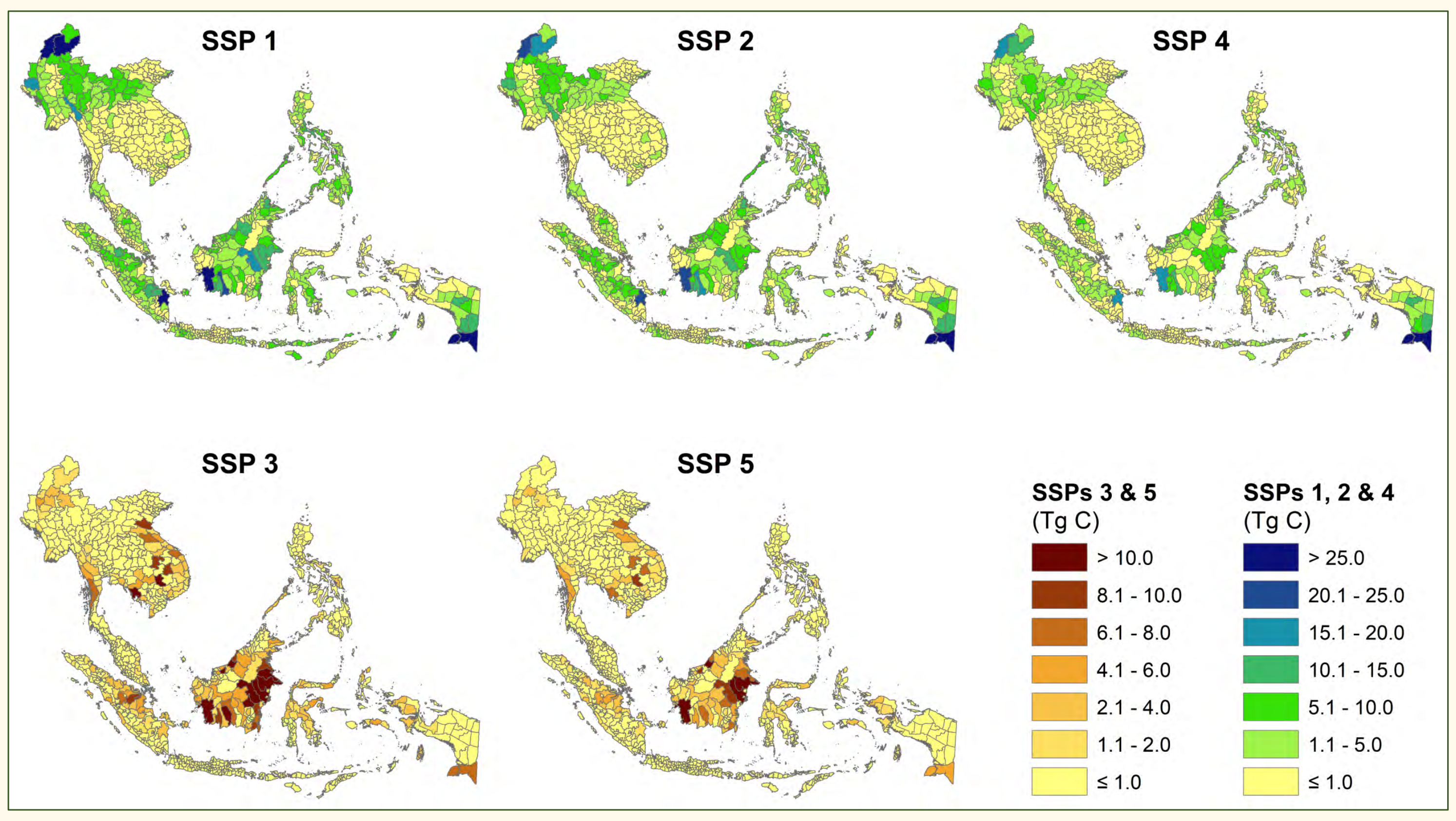


Fig. 5. Province-level distribution of future AFCS changes across the SSPs (2015-2050).

- We find that by 2050 under the worst-case scenario, SSP 3 (regional rivalry/a rocky road), the region's forests would shrink by 5.2 million ha. The region's aboveground forest carbon stock (AFCS) would decrease by 790 Tg C, 21% of which would be due to old-growth forest loss. Conversely, under the best-case scenario, SSP 1 (sustainability/taking the green road), the region is projected to gain 19.6 million ha of forests and 1651 Tg C of AFCS.
- Translating these projected changes in AFCS into rates, the forest gaining scenarios suggest that Southeast Asia would be able to sequester C at a rate ranging from 25 Tg C yr^{-1} (SSP 4) to 47 Tg C yr^{-1} (SSP 1). By contrast, the forest-losing scenarios suggested that the region would be emitting C at a rate ranging from 14 Tg C yr^{-1} (SSP 5) to 23 Tg C yr^{-1} (SSP 3).
- The choice of the pathway is thus critical for the future of the region's forests and their ecosystem functions and services. For the future directions of this study, its expansion to global scale and its relation with the forest transition theory and SDG 15 (Life on Land) are currently being considered.

More details can be found in:

• Estoque RC, Ooba M, Avitabile V, Hijioka Y, DasGupta R, Togawa T, Murayama Y. 2019. The future of Southeast Asia's forests. ***Nature Communinications*** 10:1829.