Mapping the Brazilian Amazon Ecosystem Integrity: A Bayesian Spatial Modelling Approach

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Introduction

Land use changes (LUC) are intrinsically related with biodiversity loss and integrity decrease of natural systems as well as the decrease of their ecosystem services (ES). Landscape patterns can be correlated with different levels of ecosystem integrity (EI) and consequently, with the potential environmental services provision. Therefore, relating land-use patterns with ecosystem integrity, makes it possible to predict environmental services provision in the future, based on the assessment of different LUC scenarios. In Brazil and other Latin American countries, where there is low field data availability - geographically distributed and periodically updated - a viable approach is the use of Remote Sensing (RS) data. The RS approach allows, not only monitoring the temporal variations of EI/BD and SE, but also spatial variations, using smaller or larger spatial resolutions satellite data, allowing to model those variables in different spatial-time levels.

Objective

Develop an integrative methodological approach able to establish the relationship between the Ecosystem Integrity, Ecosystem Services and Land Use Changes in time based mainly on Remote Sensing data that allows monitoring the environmental dynamics in differents spatial and temporal scales.

Methodology

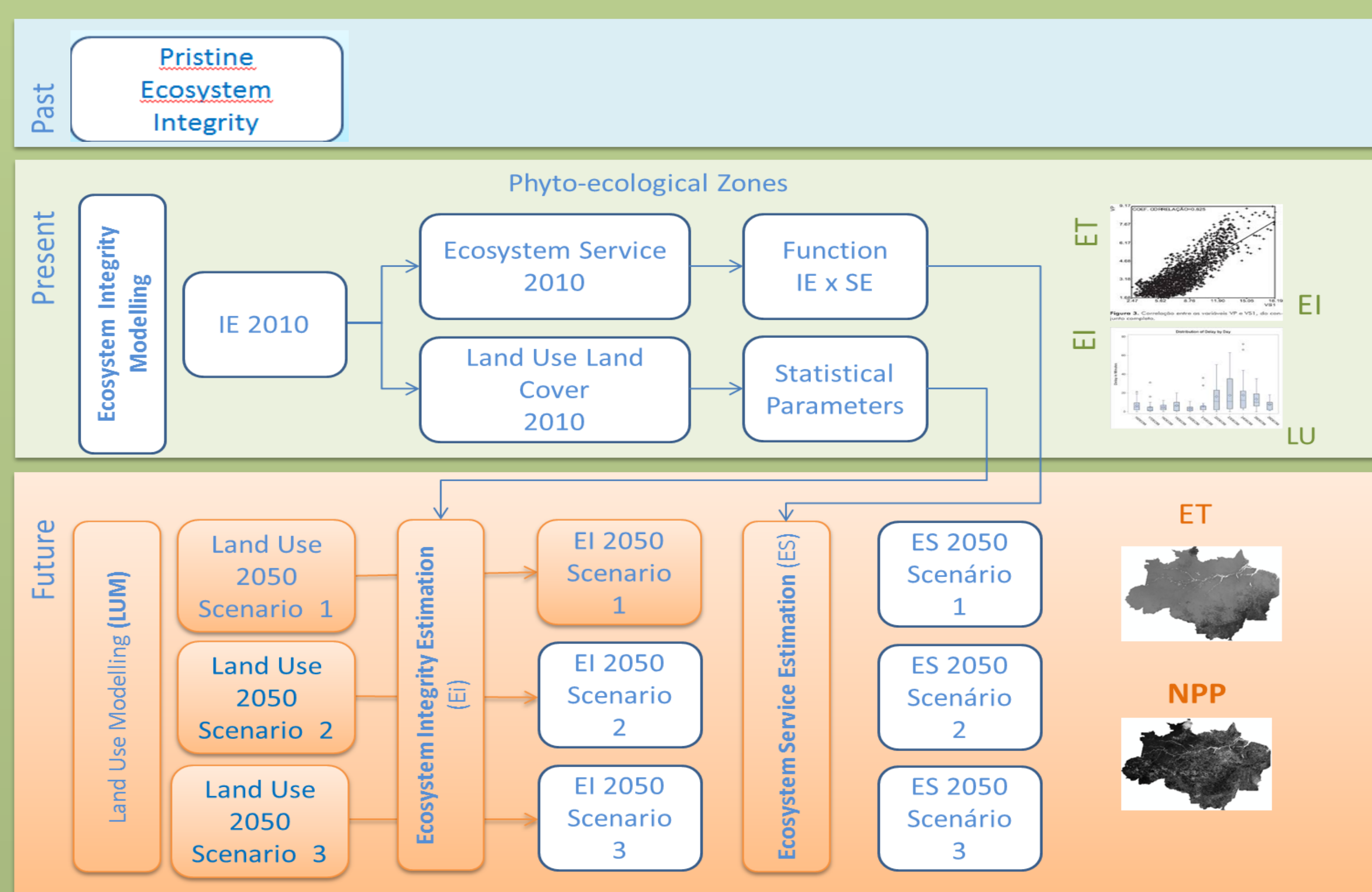The methodological integrated approach (figure 1) consists in the follow steps:

Figure 1. General methodological approach, from past to future, Modeling and linking Land Use Changes, Biodiversity Loss (EI) and Climate Ecosystem Services at the Legal Brazilian Amazon.

(II) Correlation of Ecosystem Integrity Spatial Model and Ecosystem Processes/Services Models (figure 3): (*a*) Evapotranspiration fluxes ecosystem service: estimated from MODIS Surface Resistance and Evapotranspiration (MOD 16), data developed by Numerical Terradynamic Simulation Group (NTSG), College of Forestry & Conservation - University of Montana. (Mu et al., 2007); (*b*) Carbon stocks spatial model: estimated from aboveground carbon stocks spatial model developed by Baccini *et. al*. (2004) within the Pantropical National Level Carbon Stocks Project (Woods Hole Research Center – WHRC, Boston University and the University of Maryland (MA, USA). The methodology was based on ground data, MODIS 500m imagery and GLAS LiDAR data;

(III) LUC-SSPs scenarios: generation of a Land Use Changes Model (Clue Model) for the Brazilian legal Amazon region based on SSPs scenarios but adapted to the sectorial policies reality currently in Brazil;
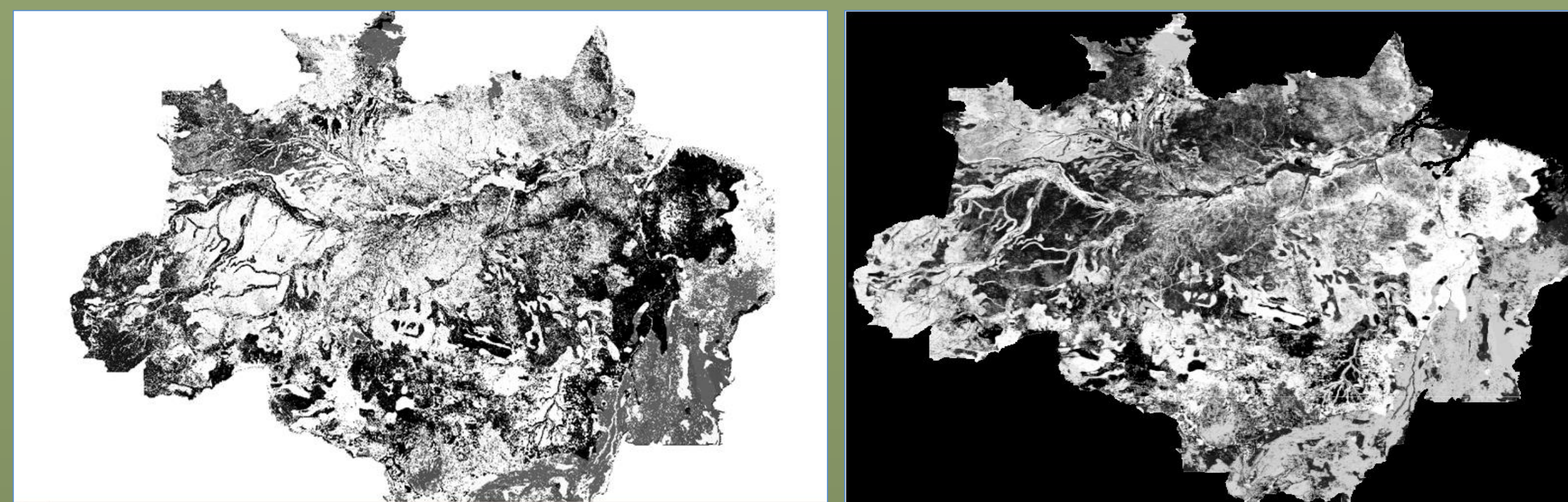
Results

Figure 4. Ecosystem Integrity estimation for the Brazilian legal Amazon: (i) Left: EI present (Range between white and dark = high to low EI; (ii) Right: Loss on EI = ▲IE = IE present − IE pristine (Range between white and dark = high to low Loss on EI). *Note: Models are still in validation.*

Conclusion

The preliminary results show that the methodological approach proposed was able to establish the relationship between the Ecosystem Integrity, Ecosystem Services and Land Use Changes, considering the scale adopted and models accuracy.

(i) Ecosystem Integrity Spatial Model: (*a*) Brazilian legal Amazon (regional scale - pixel 1kmx1km); (*b*) evidences probabilistic distribution based on learning process (*data-driven models*) (Expectation Maximization algorithm - Buntime, 1994); (*c*) Bayesian network (figure 2): expert conceptual model that related different spatial data (Remote Sensing data): (i) Biomass (MODIS/ USGS – NASA); (ii) EVI; (iii) LAI - Leaf Area Index (MODIS/ USGS – NASA); (iv) Tree Cover (MODIS/ USGS – NASA); (v) GPP- Gross Primary Productivity (MODIS/ USGS – NASA); (*d*) validation of the model is being held through the specific knowledge and some control-areas which there are available forestry and biodiversity data inventories;
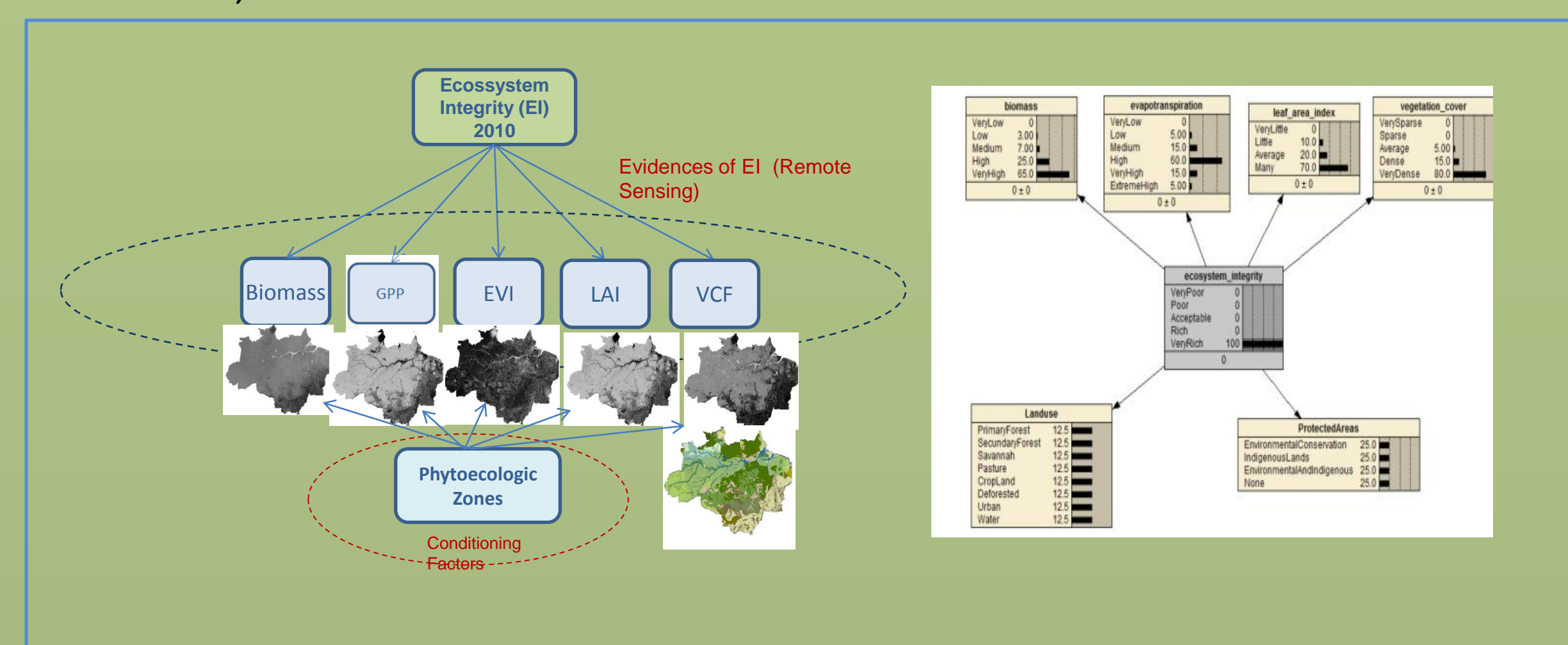

Figure 2. Methodological approach: Conceptual (left) and operational/Netica (right) Bayesian network applied to Ecosystem Integrity estimation for the Brazilian legal Amazon.
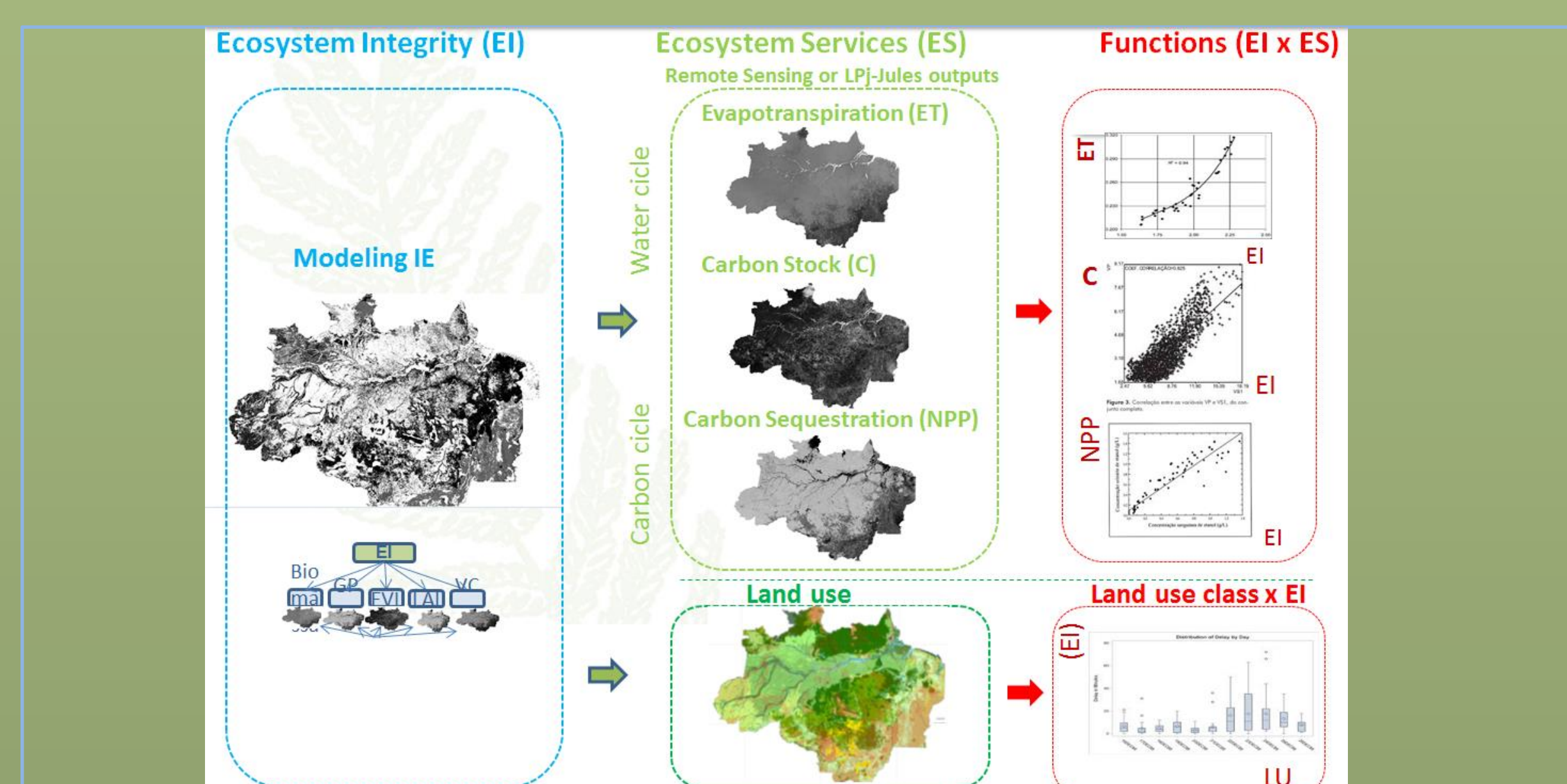

Figure 3 . Correlation approach linking Land Use Changes, Biodiversity Loss (EI) and Ecosystem Services at Brazilian Legal Amazon.

Acknowledgement

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