86% was associated to pastures and natural herbaceous vegetation. Forest loss occurred primarily (39%) on areas non classified by the territorial planning Law, followed by medium (33%), high (19%) and low (9%) conservation priority classes. These results illustrate the potential contribution of remote sensing to characterize complex human environmental interactions occurring over extended areas and timeframes.

### Change in land coverage and use in the Amazon basin, 2000–2017 / *Cambio de cobertura y uso del suelo en la Cuenca Amazónica para el periodo 2000 - 2017*

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La Red Amazónica de Información Socioambiental Georeferenciada (RAISG) -un consorcio de organizaciones de la sociedad civil de los países amazónicos orientado a la sostenibilidad socioambiental de la Amazonía- en un esfuerzo por contribuir en el análisis de los cambios de la cobertura y el uso del suelo en la cuenca Amazónica, viene liderando conjuntamente con la Iniciativa Mapbiomas, la elaboración de estos mapas anuales para el periodo 2000 - 2017. Esta iniciativa ha sido posible gracias a la contribución de cada uno de los miembros de la RAISG, 7 ONGs miembros de la red que representan a 6 de los 9 países de la Cuenca Amazonica, y a la coalición con el equipo de Mapbiomas Brasil. Esta coalición ha permitido robustecer la metodología Mapbiomas Brasil para que la herramienta responda a las características propias del resto de la cuenca, pues la cuenca incluye otros biomas que no están presentes en Brasil como son las áreas andinas de los países de Bolivia, Perú y Ecuador. El interés de la red es producir información y conocimientos capaces de incidir sobre la generación de políticas públicas sostenibles. Dar a conocer los resultados obtenidos en cifras y mapas para todo el ámbito amazónico -partiendo de la premisa que la Cuenca Amazónica debe ser entendida y planificada de manera integral, transfronteriza y holística- contribuirá a mejorar nuestro conocimiento sobre los bosques amazónicas, las dinámicas de uso y demás coberturas vegetales de la cuenca. Asimismo, contribuirá a la planificación y ordenamiento territorial.

### Tree species classification with multivariate neural networks and time series of satellite data

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Accurate information about tree species is of great interest for the forestry sector, as well as for ecological modelling. Medium to fine spatial resolution satellite images can be used to identify tree species, particularly when multi-seasonal data are available. With the current availability of satellite data time-series with high temporal resolution, phenology information expressed as seasonal variations in the signal, can be used to improve tree species mapping. In this study we use a dense time-series of freely available optical satellite data (Sentinel-2) and sample plots from the Swedish National Forest Inventory, to classify tree species all over Sweden. Computing power from the cloud-based Google Earth Engine gives us the possibility to process and analyze time-series data for thousands of images, an analysis that was not possible before. Characteristic patterns in the time-series are used by a Deep-Learning neural network (Convolutional neural network and Long short-term memory are tested) to classify tree species. Preliminary results indicate that dense time-series of freely available satellite data and Deep-Learning neural networks can improve tree species classification.

### Mapbiomas Arida: monitoring degradation in the semi-arid and the regeneration in the units of recovery of degraded areas in the Northeast of Brazil

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The MapBiomas - Arida platform is one of the spin - offs of the Mapbiomas Project (www.mapbiomas.org) and aims to create a system to support managers and the local community so that they can follow the evolution in time of the biophysical processes that trigger the desertification and the actions developed in the Units of Recovery of Degraded Areas - URAD, aiming at the Land Degradation Neutrality - LDN, which is one of the Sustainable Development Objectives - SDO, established by the United Nations - UN. In this platform On this platform are available annual biophysical data from 2000 to 2018 derived from remote sensing products processed from the GEE (Google Earth Engine). These are: Annual Coverage and Land Use Maps; Annual transitional matrix maps; Annual Net Primary Productivity Maps; Annual $CO_2$-Soil maps and Annual water mirror maps. In addition, it has a Workspace environment, that is, an interactive online environment where managers and specialists can monitor the evolution of the areas imaged by various sensors (Landsat 7 and 8, Modis and Sentinel) in each pixel of the images. Arida also has makes available an App for mobile devices for field data collection and registration of new URADs.

### Identifying areas for native vegetation restoration in degraded lands with the help of MapBiomas and GLOBIOM-Brazil

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Created by Greenhouse Gas Emissions Estimation System (SEEG) in 2015, MapBiomas (Brazilian Annual Land Use and Land Cover Mapping Project) is one of the most recent Brazilian initiatives to generate annual land cover/use maps. Its mapping methodology is fully automated and integrated with Google Earth Engine and allows the possibility of comparing historical data since 1985. This mapping methodology facilitates the application of the Brazilian Forest Code, in addition to monitoring protected areas and pointing out opportunities for forest restoration. This study aims at using MapBiomas as the initial land cover/use map of the GLOBIOM-Brazil model. GLOBIOM-Brazil is a global economic partial equilibrium model that simulates, in a spatially explicit way, the competition for land among the main sectors of the land-use economy subjected to technology, resource and policy restrictions. Brazil's new Forest Code, including its debt offset mechanism (CRA), is explicitly included in our scenarios. Potential forest restoration areas are taken from the Rural Environmental

Registry (CAR). Final identification of forest restoration areas also takes into account the opportunity costs, estimated by GLOBIOM-Brazil. Restoration costs take into account the previous use of the land, i.e., if it was cropland, pasture, abandoned land or degraded land. Our results emphasize the use of MapBiomas and GLOBIOM-Brazil as a support in the development of forest restoration policies.

### Agricultural losses from biogeophysical climate change in Brazil: A business case for ecosystem protection?

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In the Amazon and Cerrado biomes of Brazil, slowing ecosystem conversion could help to protect valuable ecosystem services, but comes at the cost of foregone revenue from the expansion of agricultural activities. As part of a wider effort to estimate the likelihood that reducing ecosystem conversion will be net beneficial to key agricultural and government actors, we produced spatially explicit, near-term, probabilistic estimates of economic damage to the agricultural economy stemming from ecosystem services lost under ecosystem conversion. Underlying these estimates was an ecological forecasting framework. We assembled the framework using two sets of statistical models, selected for their predictive skill and drawing on remotely sensed and in situ evidence. Agricultural land use and native ecosystem area were extracted from Mapbiomas 3.0. The first model set predicted the response of agriculturally relevant rainfall and temperature parameters to regional land use and land cover change. The second set predicted the response of agricultural productivity to changes in the regional climate. Together with idealized land use and land cover scenarios, we linked these models and used them to forecast economic damage to the agricultural sector stemming from ecosystem conversion. The results of the forecast exhibited a high degree of uncertainty, but nevertheless revealed the costs of damage from a considerable area of ecosystem conversion to robustly exceed the opportunity cost of conservation. Partitioning the uncertainty demonstrated several priority areas for improved modeling and data in the agricultural, ecological, and climatological domains.

### Understanding the importance of the Cerrado for deforested-driven greenhouse gas (GHG) emissions in Brazil from 1990 to 2017

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The Cerrado, second largest biome in Brazil, is characterized by a savanna-dominated matrix enfolding forest and grassland patches. Native vegetation was already suppressed in 45% of its 2M km² territory in 2017. Cerrado remnants reserves 9 GtC, but this stock is prone to rapid conversion due to lack of protection and agricultural suitability. Governmental monitoring of GHG emissions associated with Cerrado deforestation covers the period of 1990-2010, leaving an information gap about the role Cerrado plays in the national emission profile in recent years. Here we present trends in land-use change emissions estimates for Cerrado from 1990 to 2017, produced by the SEEG (System for Estimating Greenhouse Gas Emissions) initiative. To estimate deforestation-driven emissions we used country specific emission factors and annual deforestation rates derived from the MapBiomas time-series. Deforestation was defined as pixels that remained in a vegetation class for at least three years and then transitioned to a land-use class, remaining in the later for two years or longer. Emissions from 1990 to 2017 were summed 18% of Brazil land-use change sector (7 $GtCO_2e$). Cerrado average contribution to the land-use change sector was 22% from 1990-1999, 15% from 2000-2009 and 20% from 2010-2017. The increase in Cerrado contribution in recent years indicates accelerated conversion in Cerrado in relation to other biomes. The Brazilian Forest Code allows for legal suppression of 325.000 km² and an associated emission of 3.2 $GtCO_2e$. Reducing national land-use change emissions requires urgent efforts by both public and private sectors to halt deforestation in Cerrado.

## D4b: TECHNOLOGICAL INNOVATIONS FOR NATIVE FOREST MANAGEMENT IN DIFFERENT BRAZILIAN BIOMES

### Forest management 4.0: planning with drones / *Manejo Florestal 4.0 - planejamento com aeronaves remotamente pilotadas (RPAs)*

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A cada dia se fazem mais presente no campo, os processos que envolvem as geotecnologias de precisão, com inclusão de máquinas robotizadas e guiadas por computadores, sensores de presença e GNSS. Importantes aliadas nessa nova era do planejamento florestal de grande teor digital, são as aeronaves remotamente pilotadas (RPAs) ou mais conhecidas como *drones*. O manejo de precisão de florestais tropicais na Amazônia também acompanha a nova geração tecnológica, contemplando para isso: os inventários florestais semiautônomos a partir de RPAs, GNSS pós-processado e uso de algoritmos para segmentação e geolocalização automática de árvores. O objetivo do trabalho foi propor um calendário preliminar de inventário florestal com uso de RPAs (classe III), contemplando as árvores codominantes e dominantes, acima de 50 cm de DAP1,3m. O mapeamento da cobertura florestal a partir de ortofotos de alta resolução (< 7 cm) será uma etapa que deverá preceder a entrada da equipe de inventário em campo. Dessa maneira, a equipe de inventário florestal iniciará seus trabalhos com a geolocalização precisa de todas as árvores dominantes, facilitando significativamente a busca por espécies de interesse. O trabalho foi na reserva florestal da Embrapa Acre, na Amazônia Brasileira, com a RPA DJI P4Pro, por meio de voos semiautônomos. Para segmentação foram testados diversos parâmetros utilizando o algoritmo GEOBIA. O acompanhamento mensal da floresta a partir de ortofotos de alta resolução, possibilita traçar um perfil modal preliminar das fenofases de cada uma das 14 espécies estudadas, demonstrando assim a viabilidade do inventário automatizado com as RPAs.

### Alternative systems for primary transport of wood planks in low-intensity sustainable forest management / *Sistemas alternativos para o transporte primário de pranchas de madeira no manejo florestal sustentável de baixa intensidade*

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Na Amazônia existem diversas experiências de transporte primário de madeira na modalidade de Plano de Manejo Florestal Sustentável (PMFS) Pleno, com inúmeros arranjos de equipamentos e planejamentos já definidos em função do terreno, equipamentos disponíveis e graus de investimentos. Mas na modalidade