Action Landscapes for Advancing The Nature Conservancy's Healthy Agricultural Systems Strategy in Latin America

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Executive Summary

We identified 14 "Action Landscapes" for targeting action to promote productive, resilient, and sustainable agriculture in Latin America through the Healthy Agricultural Systems (HAS) strategy. Across the region, The Nature Conservancy (TNC) will use the action landscapes to define where staff and resources have the greatest opportunity to achieve outcomes for nature and people, and where collaboration with partners and other stakeholders will transform the current agricultural system to achieve a mutually-reinforcing relationship with our natural ecosystem. The work was completed by a consortium from TNC, the Institute on the Environment at the University of Minnesota (IonE/UMN), the International Center for Tropical Agriculture (CIAT), and the Laboratório de Ecologia e Restauração Florestal (LERF) at the University of São Paulo. The report describes the process and key assessments that identify where investing in agriculture can help the economy thrive and reduce pressure on nature.

Growth in demand for agriculture (both crops and livestock), along with climate change, will intensify the challenges posed by the dominance of agriculture in Latin America. The Nature Conservancy (TNC) and many conservation organizations have traditionally focused on agriculture's threats to biodiversity. The Healthy Agricultural Systems (HAS) Strategy aims to complement these efforts by promoting and restoring productive, resilient agricultural lands in order to help the economy thrive, create new opportunities for partnerships, and reduce environmental impact on soil, water, and biodiversity.

We identified 14 action landscapes for focusing on-the-ground efforts of the HAS Strategy. Collectively, they represent the diversity of agricultural and natural systems within Latin America. Each landscape meets three criteria defined in the workshops. First, agriculture is a dominant land use. Second, the land is *either* suitable for high attainable yields for soy, maize, and/or sugarcane both now and in a warmer climate in 2030, *or* is a grazing-dominated landscape. Third, there is potential for increasing agricultural production by restoring degraded lands. In addition, many of the landscapes have several co-benefits, such as restoring and protecting nature and the benefits they provide (including biodiversity and other ecosystem services for agriculture).

Together with TNC members and partners, the Consortium completed three main goals to provide a data-driven foundation for each of the criteria needed to identify the action landscapes:

(1) *Identify areas that are most suitable for achieving high crop yields now and in 2030.* Our research analyzed soybean, maize, and sugarcane, which are indicative of agriculture in the region as they span a wide range of moisture requirements and therefore are representative of other crops in the region. We find that the area of these crops highly suitable for high yields will dramatically decrease in a warmer climate. Fortunately, each crop is currently widely grown in areas suitable for high attainable yields both now and 2030. (Work led by IonE/UMN);

(2) *Identify areas where agricultural land is degraded from cropland and grazing management.* We mapped 10 indicators that represent landscape conditions, cropland productivity, and pasture productivity. Collectively, they can be used to assess convergence of evidence of degradation. Degraded land hotspots were mapped within each biome, such as the Gran Chaco and the Chiapas-Mesoamerican Highlands. (Work led by IonE/UMN);

(3) *Identify landscapes where restoration can improve agricultural production or ecosystem function.* We identified areas for restoration considering a set of interventions that can be applied on the ground (such as natural regeneration, active restoration projects and rehabilitation initiatives). For the HAS strategy, higher priority areas are those where intervention will improve ecosystem services that benefit agricultural lands. Along with increase in yield in lands with high agricultural suitability, our goal was to identify the strategy that is most likely to succeed for each region in an ideal win-win land sharing scenario. (Work led by LERF/USP and CIAT).

The work was completed through a series of three workshops with other TNC teams and external partners between October 2017 and June 2018. These workshops defined the aim of the action landscapes, identified data gaps, and drafted a set of preliminary landscapes. Analysis and advisory calls before and following the workshops supported data-driven solutions. A map-based online survey completed by experts in conservation, science, government, and industry helped validate the findings. Final and interim products were developed by the Consortium.

The action landscapes define a set of landscapes where local action reinforces the larger effort to maintain, restore, and promote productive and resilient agricultural systems throughout Latin America, in a collective effort within TNC and with partners to create synergies and to further advance existing initiatives. This report complements the HAS Strategy 2018-2027 Strategic Plan, and will be supported by the Business Plan that directs implementation within the action landscapes.

Introduction

This report summarizes the "Action Landscapes" produced to advance The Nature Conservancy's (TNC) Healthy Agricultural Systems (HAS) strategy in Latin America.[1] Based on quantitative analyses of landscape variables, biophysical data, satellite observations, and climate models, these action landscapes serve to identify priority landscapes where the HAS strategy is most likely to succeed. Understanding these priority areas, both now and projected in the future, will help to promote key interventions and practices that will support various public-private-producer partnerships and alliances to transform the sector and shift to a climate-resilient, regenerative agriculture approach. TNC will determine a sub-set of action landscapes for taking direct action and strategy implementation, based on locations of current effective HAS projects, robustness of partner and stakeholder collaboration, and availability of capacity and financial resources.

Much of the analysis presented here was developed by a consortium consisting of the University of Minnesota's Institute on the Environment (IonE/UMN), the International Center for Tropical Agriculture (CIAT), and the Laboratório de Ecologia e Restauração Florestal (LERF/USP) at the University of São Paulo, and TNC. The analysis was driven by a series of workshops between October 2017 and June 2018.[2] In these workshops, participants collectively defined the aim of the action landscapes, identified data gaps, and drafted a set of to identify a set of action landscapes. Progress was discussed and reviewed with the Conservation Program leaders between the workshops.

This report describes three new analyses created by IonE/UMN, CIAT, LERF/USP, and TNC to support this planning effort. These analyses identify areas that are: *most suitable for achieving high crop yields now and in 2030, degraded lands and soils,* and *where agricultural production could be improved with restoration.* We also describe a map-based online survey completed by experts in conservation, science, government, and industry that helped validate the findings. The last section describes how these new analyses and related work were integrated to identify a set of action landscapes.

[1] For more details on HAS Strategy, see "The HEALTHY AGRICULTURAL SYSTEMS STRATEGY in LATIN AMERICA: A Conservation Approach to Increasing Agricultural Productivity. 2018-2027 STRATEGIC PLAN"

[2] Workshop participants and other TNC contributors are listed in Appendix 2.

High yield croplands in current and future climates

Purpose

To identify areas within Latin America for investing in highly productive agriculture, we estimated attainable[3] crop yields for soy, maize, and sugar cane. These three crops represent a range of climate conditions required for high attainable yields. Sugar cane has high water demand, whereas maize can grow in hotter and drier conditions. Soybean's ideal condition for high attainable yields is between sugarcane and maize. Further, the three crops have high commodity value, are major exports, and are grown across the region. We assume that areas with high attainable yields for any of the three crops will be important for many crops or grazing. This work was led by IonE/UMN.

Methods

Attainable yields were estimated using a refined version of a yield model based on current yields and climate analogs (Mueller et al. 2012). A similar approach was also used to assess risk of biofuel expansion as part of TNC's Development Risk Assessment (Oakleaf et al. 2015) and elsewhere (West et al. 2014; Mueller et al. 2012). Methods used here refined the earlier approach in two important ways: One, a regression model is used to estimate attainable yields over a continuous range of environmental conditions rather than discrete analog units. Two, by using a regression model, we are able to use a wider range of environmental variables, including soil variables and weather-variability measures. We acquired or calculated each of these variables from several sources for crop distribution and yields (Ray et al. 2015; Ray et al. n.d.), current climate (Hijmans et al. 2005), future climate[4] (CCAFS WorldClim Climate Data dataset), and soils (Nachtergaele et al. 2008; Fischer et al. 2008).

Suitability maps for cropping were based on climate analogs: areas were considered suitable if they shared total annual precipitation and temperature profiles with a cropped area. The consortium discarded an early iteration of the analysis because it was too restrictive.

We mapped the attainable yields onto the suitable areas, with an additional limitation requiring attainable yields within 50% of the global best yields. Consequently, many areas currently growing these crops are suitable, but are unlikely to have high yields either now and/or in the future relative to the global market. The analysis was completed for both 2010 and a much warmer climate (RCP

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[3] Consistent with Mueller et al. (2012), we define *attainable* as the 95th percentile of yields that are reported at a regional level for a given set of environmental conditions. This term is used to avoid confusion with potential yields, which are based on field experiments rather than what farmers currently attain. Attainable values are thus more realistic because they reflect current best practices in seed varieties, fertilizer use, and other management practices and don't rely on assumptions of economically unrealistic farmer practices.

4 See Hijmans et al. 2005. Data comes from WorldClim Climate Data using version WorldClim 1.4 as baseline 'current' climate; future climate source is the downscaled global climate model (GCM) data from CMIP5 (IPPC Fifth Assessment). Data available at http://www.worldclim.org/cmip5_5m.

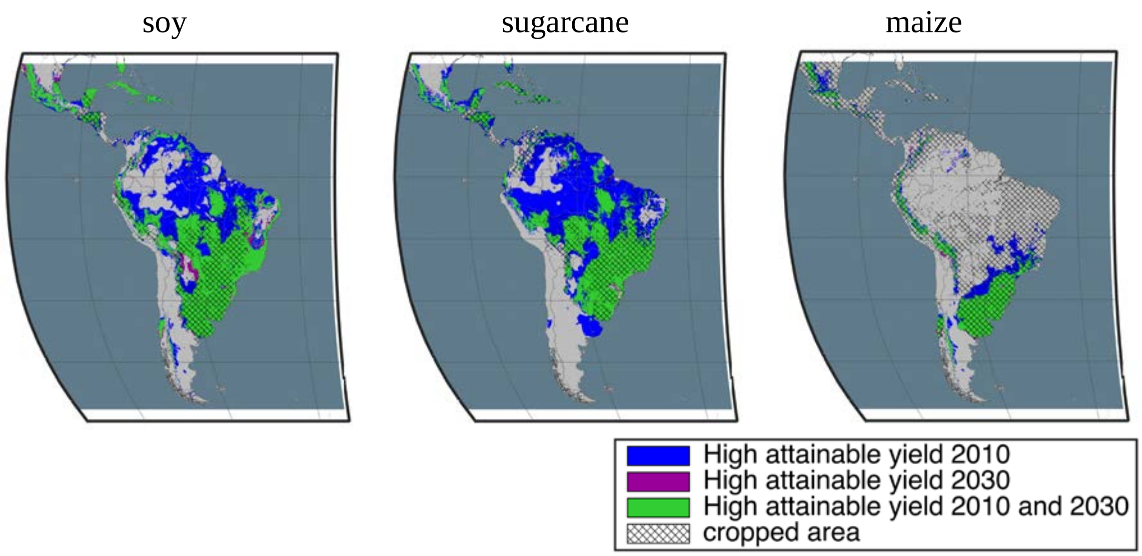
8.5) in 2030.[5] Finally, the high (>50%) attainable yield analyses for each crop were combined to create a composite map.

[5] The output for the year 2030 based on 'extreme warming' (RCP 8.5) in the IPCC AR5. There is little divergence in many scenarios by 2030 and the current trend is closer to this scenario than an 'moderate' one.

Products

Current and future land area suitable for high attainable yields

Current and future suitability was mapped for soy, maize, and sugarcane. The suitable area includes both land currently used for agriculture or non-agriculture. The current climate is based on a WorldClim Climatology (1970-2000); future climate is based on 2030 projections (see approach details). High attainable yields are defined as being above 50% of the global best yields. Approximately 95% of areas currently growing soy and sugar cane are suitable for high attainable yields. In contrast, only 50% of the current maize growing areas are highly suitable. Areas with low and decreasing attainable yields may be at greater risk for cropland expansion if commodity prices remain high.



	Suitable area with high attainable yields (Mha)			Current crop production (Mha)	
	Current (2010)	Future (2030)	Current and 2030	Current Harvested area	Current production but low attainable yields
Soybean	1286	815	763	43	0.6
Sugarcane	1355	665	652	12	0.5
Maize	425	290	273	28	14

Areas suitable for high attainable yields for major crops in current and future climates

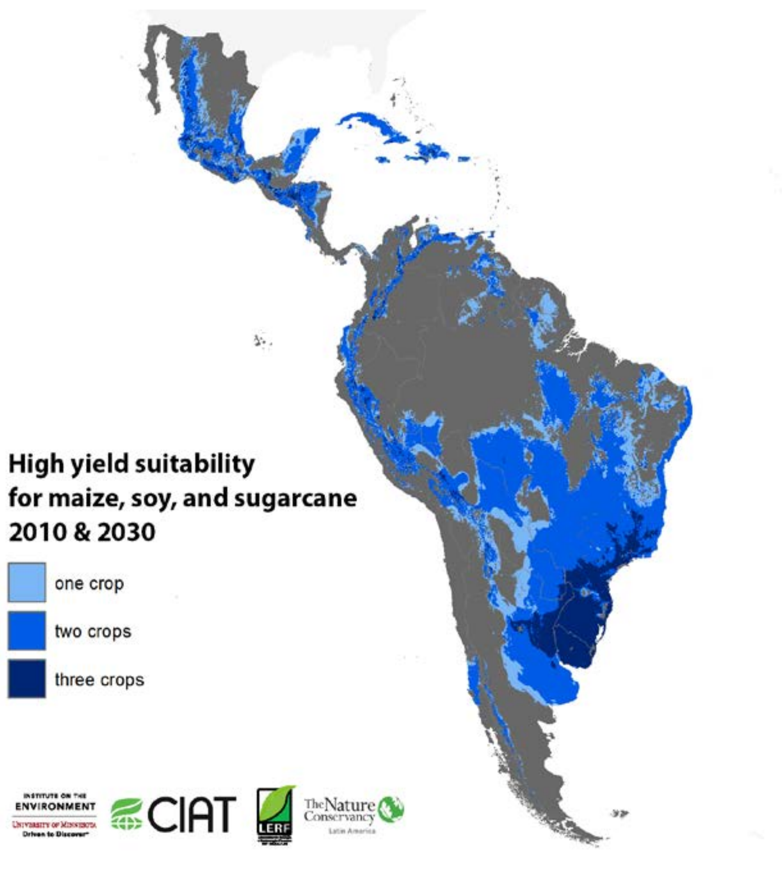
In general, the suitable land for high attainable yields is projected to decrease for each of the crops. Much of the land suitable for high attainable yields—both now and in the future—are concentrated in Brazil, Argentina, and portions of Central America. Perhaps more importantly, each crop is widely grown in areas suitable for high attainable yields both now and 2030 (overlap of green and hashmarks). However, several areas currently growing the crop (primarily maize) do not have high attainable yields. Further, climate change will likely improve conditions for high yields in a very small area (purple). The final methods were refined during and following the DC meeting based on feedback from TNC colleagues. Products in this report are consistent with country-level efforts in Brazil (Deconto & Girardi 2008) and Argentina (Zunino, personal communication).

Composite map of areas suitable for high attainable yield areas both now and future

Areas with attainable yields above the global 50th percentile for each crop were combined to create a composite map of high attainable yields. As mentioned above, maize has the smallest area suitable for high attainable yields. We assume that areas that are highly suitable for any of the crops are likely areas of potential intensification or risk of expansion.

Limitations & future work

The general approach used here has been peer reviewed. The refined methods developed for this project will be peer reviewed as part of a related publication currently being prepared. Further model refinements and climate scenarios will likely not qualitatively change the results in this analysis.



We suggest that future work should focus on including oil palm in the assessment. This commodity is a major driver of deforestation across the tropics (Vijay et al. 2016), and it grows in environmental conditions not well represented by soybean, maize, or sugarcane. Potential suitability for oil palm has been mapped globally (Pirker et al. 2016). However, even these products are limited by lack of detailed information about where oil palm is currently grown as well as its rapid expansion into a wider range of environmental conditions.

Degraded lands and soils

Purpose

We improved methods to map degraded lands and soils for targeting restoration efforts for improving agricultural productivity and eventually tracking the impact of TNC's strategies. Although a few degraded lands map products exist, the estimates of degraded lands within South America alone range from 56-851 million hectares (Gibbs & Salmon 2015). Further, existing products largely reflect land use change rather than degradation of croplands and pastures. Given the time constraint (March – May 2018), the aim was to produce a preliminary product for determining degraded agricultural lands that was more than adequate for planning decisions yet also suitable for publication and distribution after further fine-scale validation. This work was led by IonE/UMN.

Approach

Degradation is defined here as reduced productivity of the land or soil due to human activity. Because the term encompasses a wide variety of land conditions, we calculated and mapped 10 indicators that represent landscape conditions, cropland productivity, and pasture productivity. Although these indicators are not independent, they represent a wide range of proxies for soil and landscape health. Collectively, the indicators can be used to assess convergence of evidence for mapping degraded land hotspots. Agricultural land cover[6] and biome masks[7] were used for all indicators. The table below summarizes the methods used to calculate and map each indicator.

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[6] Agricultural land was defined as the cropland and mixed land cover types in the 300m resolution ESA-CCI data set. We modified the data set to exclude cells classified as "mixed" that had >20% tree cover (Hansen et al. 2013). For pastures, we also excluded areas >50% of the grid cell was cropland.

[7] Twenty-eight Latin American and Caribbean biomes were derived by aggregating ecoregions in the Terrestrial Ecoregions of the World data set (Olson et al. 2001). IonE/UMN defined biomes based on major habitat types, climate, and larger regions as defined by ecologists.

Indicators of degraded lands and soils – landscape conditions

Landscape Conditions	Current	Trend	Methods
bare soil	✓ [8]	✓	We use the normalized difference bareness index (NDBal) (Zhao & Chen 2005) to assess bare land and the differential greenness enhancement index (DGEI) (Rizzi et al. 2009) to assess seasonality in vegetation cover. NDBal is the normalized difference between shortwave and thermal infrared bands (Landsat) and its positive value indicates higher thermal response and lower moisture. DGEI is the normalized difference between maximum and minimum vegetation index response and indicates if the target area varies during the year.
vegetation productivity index	✓ ✓	✓ ✓	We used the annual maximum and minimum values of the Enhanced Vegetation Index (EVI) on cloud-free days from the MODIS Terra satellite at 250m resolution (MOD17v6) to derive several vegetation productivity indices: The max EVI value and (maxEVI-minEVI)/(maxEVI+minEVI). An average value more than 1 standard deviation below the biome mean for either of these quantities indicates **current** low vegetation productivity. A significant decrease over the period from 2000 to 2017 indicates a negative **trend**.
abandoned land		✓	All areas within an agricultural class that experienced a state change to a non-agricultural class between 2000 and 2015 extracted from ESA-CCI data layers.

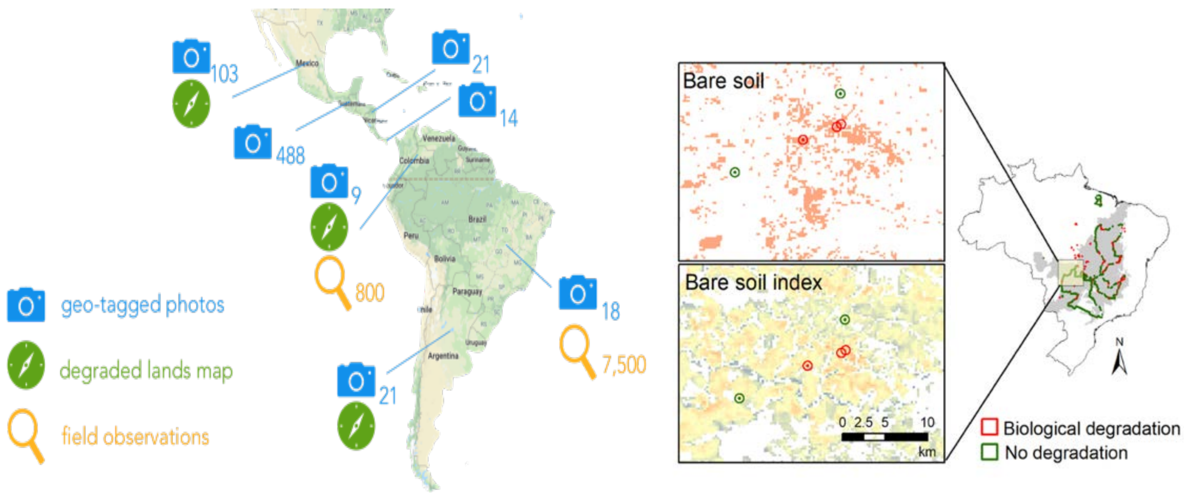
[8] There is a checkmark for each indicator. When two are present, that means two indicators.

Indicators of degraded lands and soils – pasture productivity

Pasture Productivity			
forage gap		✓	Potential pasture productivity was estimated for each year (2000-2014) for each biome using a quantile regression model (similar to the attainable yields analysis) as a function of the following variables for estimating EVImax: total annual precipitation, growing degree days, elevation, 10-year return cold, and topsoil carbon. The difference between the actual and potential is the gap. Trend calculated using linear regression. Variables derived from the following: MOD17v6, (Harris et al. 2014), (Stoorvogel, Bakkenes, Temme, et al. 2017), (Nachtergaele et al. 2008), ESA-CCI, (Olson et al. 2001), (Hansen et al. 2013)
seasonality		✓	From global maps of vegetation phenology (Didan & Barreto 2016) we calculated the trend in the rate of senescence for growing season one for the years 1981 – 2014 using linear regression.
Cropland Productivity			
yield		✓	The current crop yield condition trend was statistically determined from a 50-year analysis (1964 to 2013) for top 10 global crops at ~ 8500 administrative units in the region (Ray et al. n.d.). Degraded area hotspots defined as administrative units with yields not increasing now in any crop.
harvested area		✓	Same as above, but harvested area instead of yields.

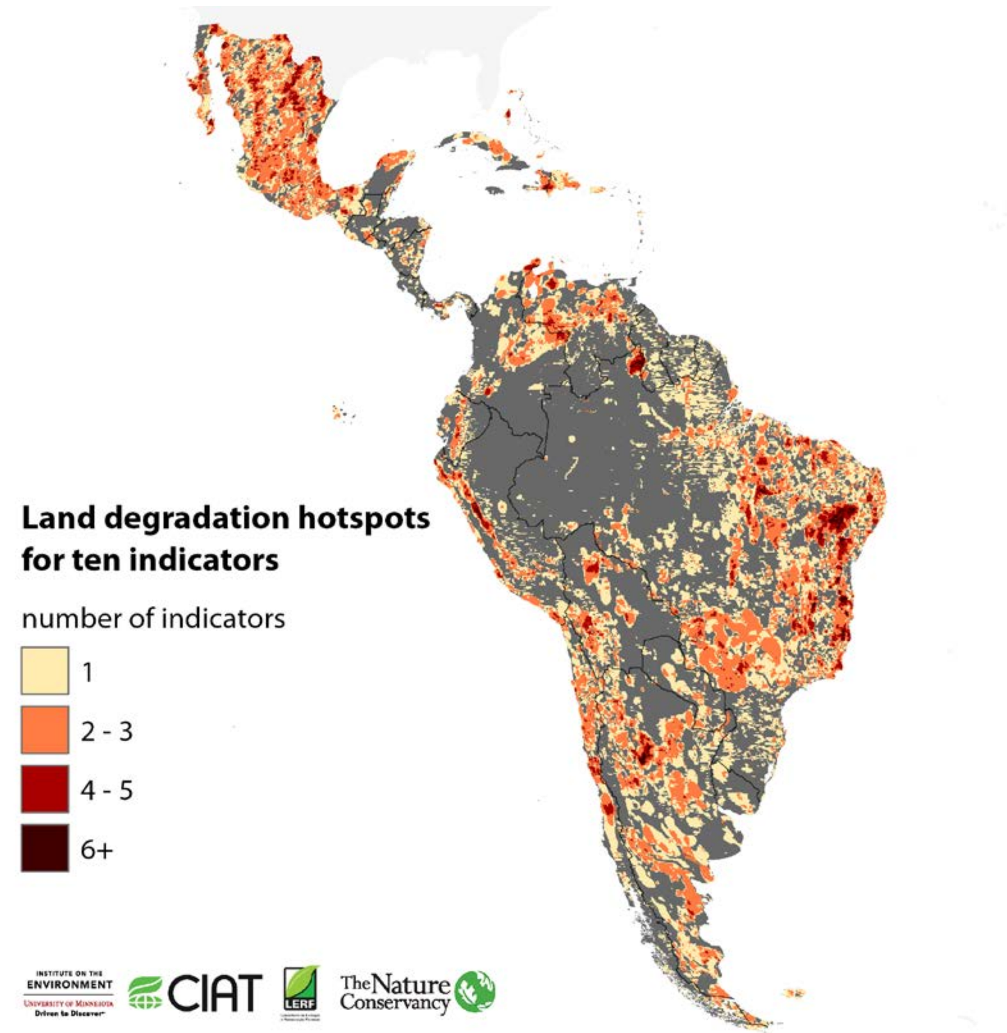
The majority of calculations were done using the Google Earth Engine. The hotspots and other post-processing routines were done locally in Matlab, R, and Python. Final products were mapped in ArcGIS and Illustrator.

Hotspots were defined for each indicator. To reduce bias across the range of habitats and agricultural practices, hotspots were identified for the agricultural land within each individual biome. For example, the amount of bare soil in very arid biomes is much higher than humid ones. Within each biome, we generated a heat map (a map in which intensity/color represents the distance-weighted sum of degraded pixels within ~40km) and then defined the hotspots as the set of the most intense regions which comprise 50% of the degraded pixels.



Preliminary validation and comparison using data from TNC staff and partners

We developed a preliminary validation data base from using geo-tagged photographs (683) and field observations (15,500). Degraded lands maps for three countries were used for a visual comparison with the maps developed here. TNC staff and partners from Mexico, Colombia, Brazil, and Argentina provided all validation and comparison data. The figure on the right illustrates the preliminary validation comparing the bare soil indicators calculated here with the CFA-funded pasture health study led by Laerte Ferreira at the Universidade Federal de Goiás (UFG). Maps of each indicator will be further refined as our work moves from planning to the implementation stage.



Products

Degraded land hotspots – composite of 10 indicators

We created a final degraded lands map by calculating the sum of the number of indicator hotspots for each grid cell. Darker red areas are places that are hotspots for several indicators (see above table). While this approach is not a direct measure of degradation, the approach represents a convergence of indicators that point to places for intervention. Hotspots were mapped relative to each biome. For example, degraded land hotspots in Patagonia and the Llanos may have different indicators and values, yet both be degraded. The use of several indicators to characterize landscape condition, pasture productivity, and cropland makes this map much more useful for targeting intervention than other products, which are commonly generated from a single metric or expert opinion.

Limitations and next steps

Although the final product met the needs for priority setting across the region, a few next steps are critical to finalize the work. First, maps presented here will be further refined as our work moves from the planning to the implementation stage. Additional field observations, geo-tagged photographs, and results from the online expert survey, will be used in this finer scale mapping. This finer scale validation will build on the preliminary assessment here using 16,000+ points. The products could then be peer reviewed and shared. Second, composite indicator maps can be refined by focusing on which indicators—and important thresholds—matter most within each biome. The feasibility of this refinement depends on expert input and literature review. Third, degradation due to changes in land-use or climate can be separated from other forms of degradation by comparing our results to maps of land-use change and degradation proxies that are corrected for their annual correlations with precipitation (as in Bai et al. 2008).

Priority areas for restoration

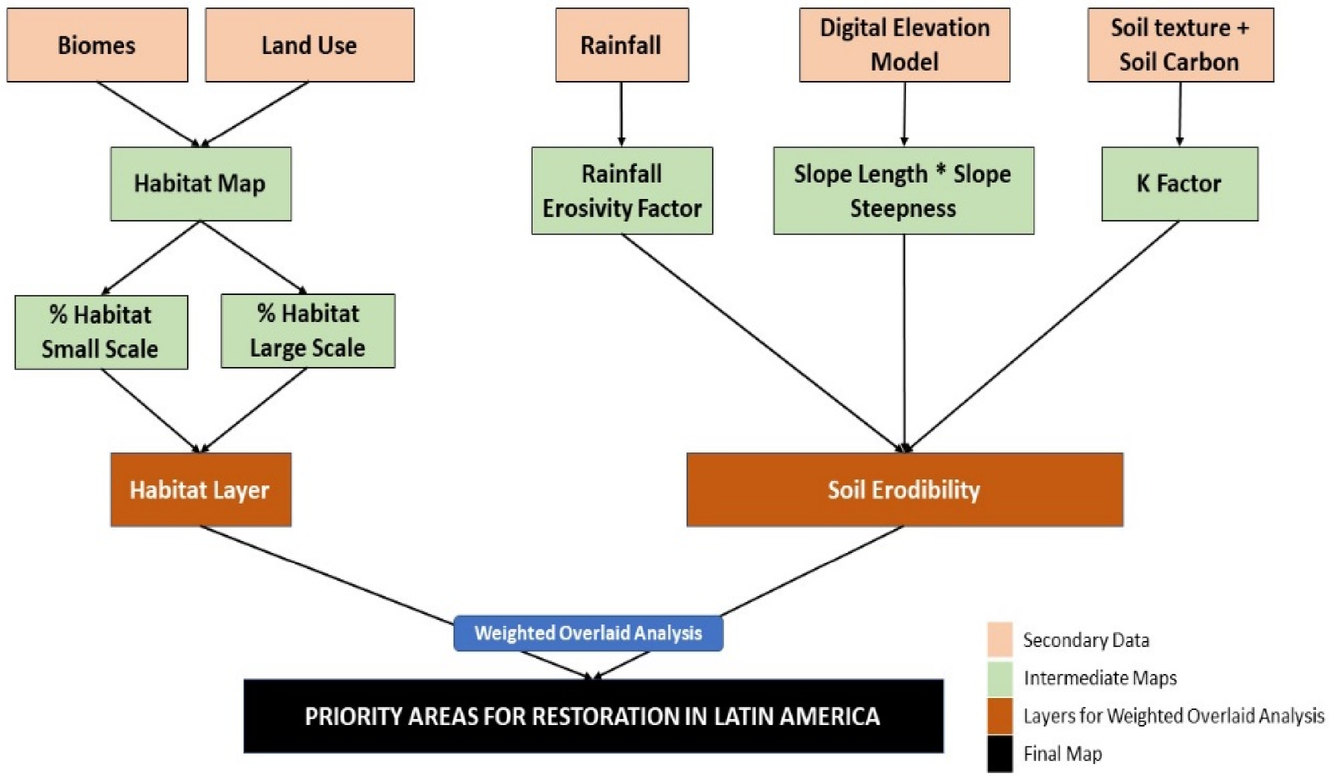
Purpose

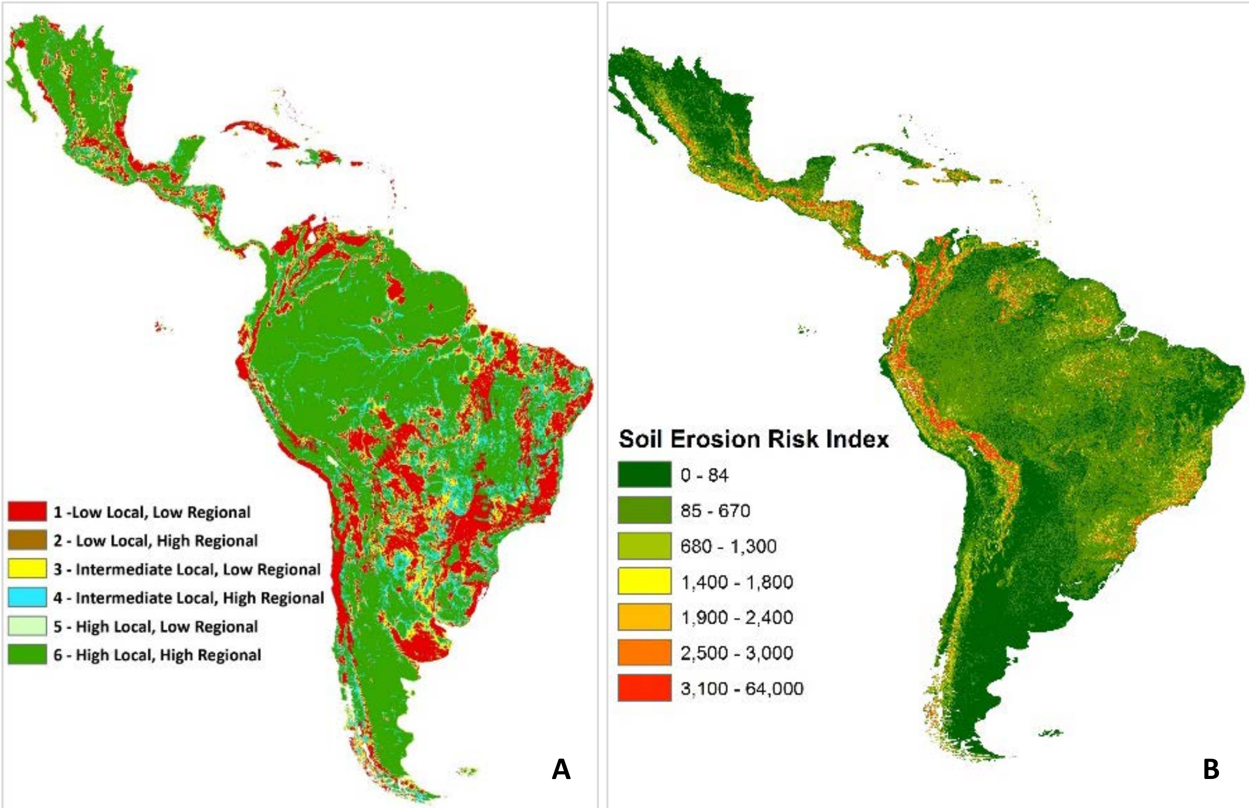
We mapped priority areas for restoration of both natural and agricultural lands. This product helps target efforts within the Healthy Agricultural Systems strategy, considering that restoration interventions could be planned to focus on ecosystem services for agriculture. Our efforts here build on previous analysis to identify priority areas for restoring forests within the Atlantic Forest, adapting the methods so that they could be applicable for non-forest biomes (Banks-Leite et al. 2014). This is a new product for Latin America, considering that previous publications' continent-wide focus on forest restoration or potential for natural regeneration, does not fully align with the purposes of HAS Strategy. This work was led by CIAT, LERF/USP.

Approach

This initiative for mapping priority areas for restoration in Latin America considers the particularities of each biome, different native vegetation domains, and the different strategies that can be applied in each situation. For the purpose of HAS Strategy, we proposed a framework based on previous studies, but modified to broaden its applicability for non-forest biomes and to include an agriculture perspective. We used the amount of habitat in two-scale analysis and a soil erosion risk layer. The combination of these two layers by a weighted-overlaid analysis produced a unique map of restoration priority areas.

Framework for the Latin America Restoration Priorities mapping





Local- and regional-scale habitat analysis (A)

This map was produced using land cover data from the Climate Change Initiative (CCI) from the European Space Agency (ESA, 2015). The analysis was performed for each biome separately, using the classification proposed by the IonE/UMN. A classification of habitat and non-habitat, considering forest and non-forest dominance in biomes, was proposed. For each biome, we analyzed the amount of habitat (in percentage) in two scales: local scale (focal landscapes of 10,000 ha) and regional scale (focal landscapes of 125,000 ha). For each biome, the amount of habitat in the two scales was combined (adapted from Giannini et al. 2015). For each biome, the threshold values were calculated using Natural Breaks (Jenks 1967) for the local scale, and using the median of percent of habitat for the regional scale. The reclassification of the habitat distribution map, considering the thresholds proposed, produced the Habitat Layer, used in the weighted overlaid analysis.

Soil erosion risk (B)

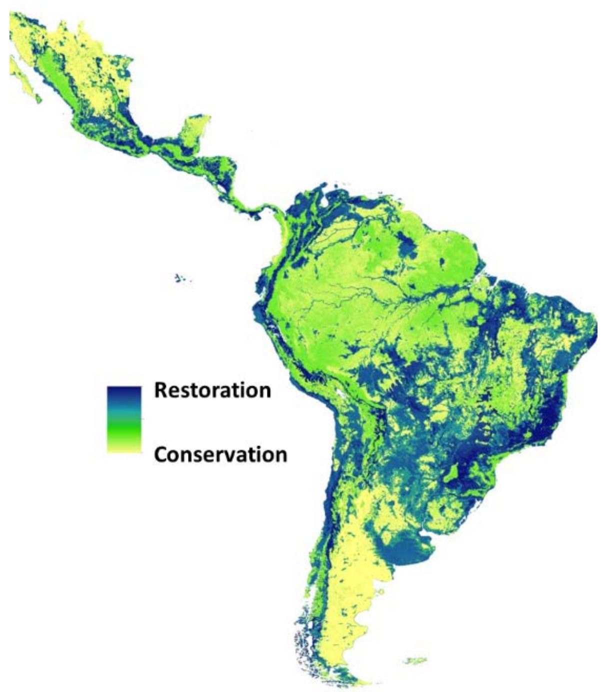
We adapted the RUSLE model, using remote sensing and GIS. The soil erosion risk was calculated as a product of (1) Rainfall erosivity factor (secondary data from Panagos et al. 2017); (2) K factor (calculated using data from Stoorvogel, Bakkenes, ten Brink, et al. (2017) and methods defined by Neitsch et al. (2005); and (3) A combination of slope length and slope steepness using Digital Elevation Model and methods defined by Ganasri and Ramesh (2016) and Oliveira et al. (2013).

Weighted-overlay analysis to identify priority areas for restoration in Latin America

The weight of each layer was proposed considering the purposes of HAS Strategy, so that the layers that corresponded with the strategy's goals were assigned higher weights.

Layers	Weight
Risk of Soil Erodibility	
Low Risk	0
Moderate Risk	25
High Risk	75
Very High Risk	100
% of Habitat Cover	
Low % of Habitat cover in both scales (1)	100
Intermediate % of Habitat Cover in both scales (3;4)	75
Low % Habitat Cover in Local Scale + High % in Regional Scale (2)	50
High % of Habitat Cover in local scale + Low % in Regional Scale (5)	25
High % of Habitat Cover in both scales (6)	0

Products



Priority Areas for Restoration in Latin America Region

This product aimed to identify, in LAR, where we should focus the efforts for conservation, for restoration of biodiversity and for rehabilitation focusing on ecosystem services supply for agriculture. The application of the intervention that is more likely to succeed in each situation is key for the success of such initiatives, in any scale of analysis. For the HAS strategy, the highest priority restoration areas should be targeted considering that the on-the-ground interventions most likely to succeed are the ones focusing on ecosystem services for agriculture, such as soil conservation, pollination, water protection and carbon storage, among others. In the context of lands with high agricultural suitability being targeted for increasing yields, lands with low potential for agricultural mechanization become the best candidates for natural regeneration, active restoration projects, and other rehabilitation initiatives (including economic purposes such as agroforestry), in an ideal win-win land sharing scenario.

Limitations and next steps

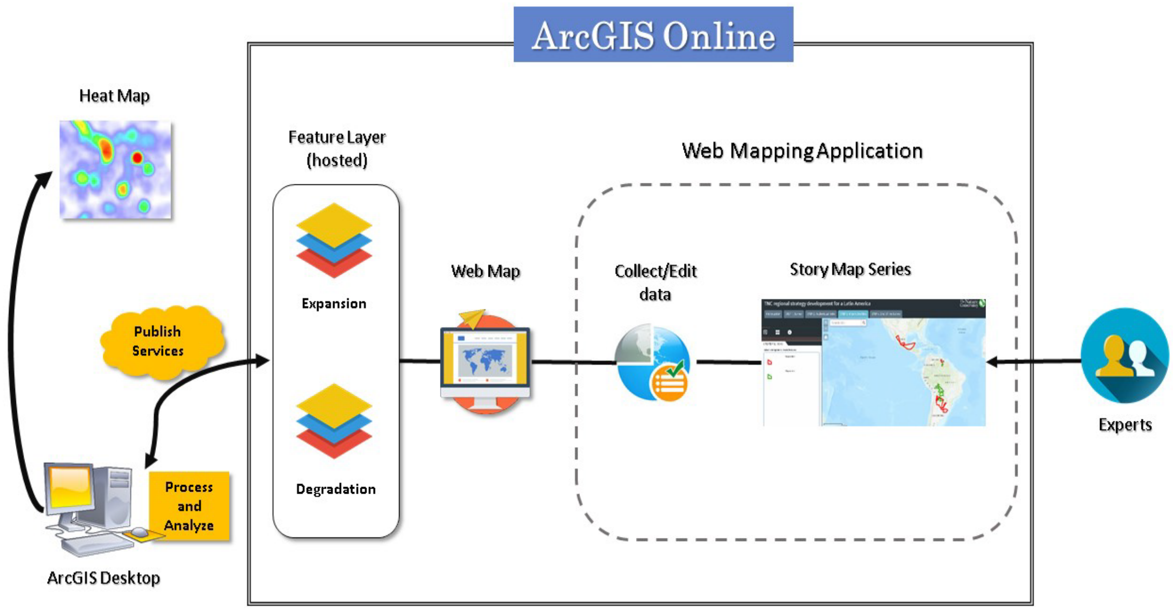
We still have limitations of data on distribution of native savannas along the continent. Although we adapted the framework to assess non-forest biomes, the lack of differentiation of native grasslands and pastures affected our results in biomes like Pampas, Patagonian Steppe and Chihuahuan Desert. As a result, the analysis categorized these areas as primarily areas for nature conservation though we know they are also critical grazing lands. We accounted for this limitation in the criteria for selecting action landscapes. The data produced will be organized for publication, since it provides a novel framework that addresses different outcomes of restoration and conservation interventions, combining conservation and agriculture goals in the same framework. These data can also inform for a TNC-wide strategy for restoration in Latin America.

Map-based, Online Expert Survey of Degraded Lands & Agricultural Expansion

Purpose

We created a map-based online survey completed by experts in conservation, science, government, and industry. We used the results to validate the analysis of degraded lands and agricultural expansion, as well as identify emerging issues and the driving forces leading to these changes. To reach a broad set of experts, we developed a list of expert colleagues of TNC from partners of the Climate Change in Agricultural Food Security (CCAFS), Latin American Soil Information System (SISLAC), TNC partner lists, and lists of restoration initiatives. This work was led by CIAT.

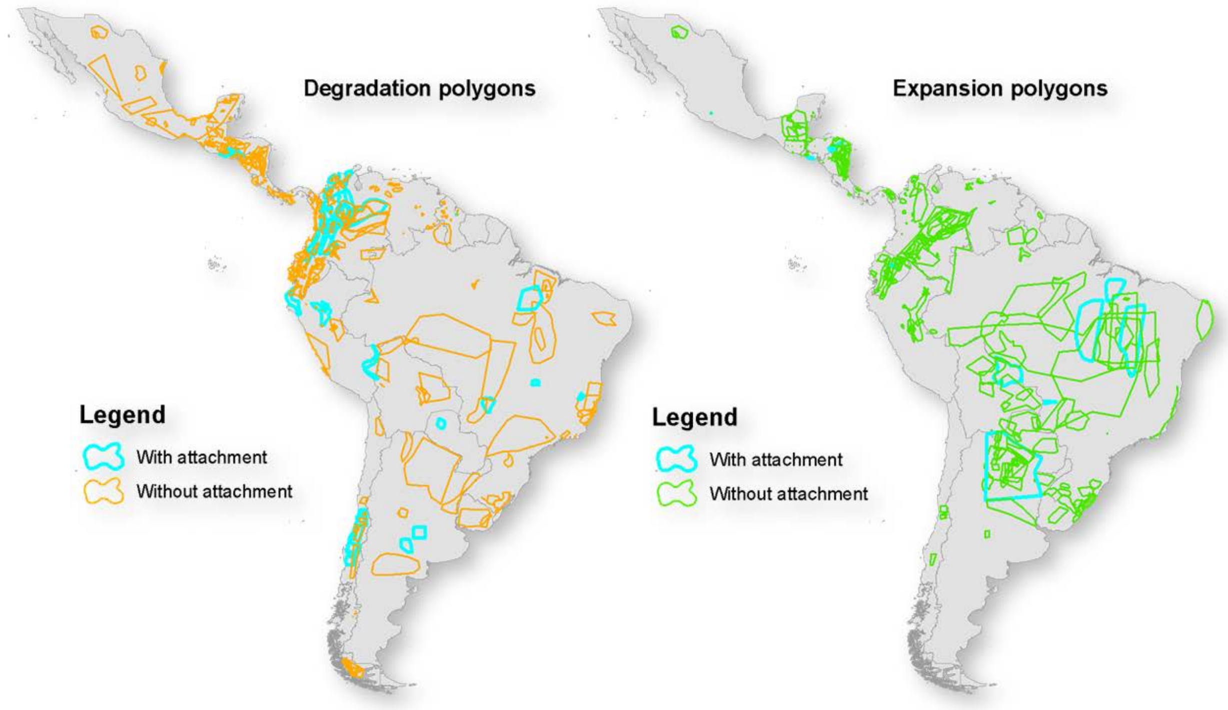
Approach



Creating the survey and compiling the input

We created a map-based online expert survey to delineate the drivers and locations of land degradation and agricultural expansion. Over 150 experts completed a survey, drew polygons on a map, and attached related files using a web-based interface. The interface we developed from tools from Esri (ArcGIS Online, Story Maps, ArcGIS Desktop), YouTube, and Survey Monkey. These tools facilitate cartographic representation on maps and processes carried out on cloud servers. We created geodatabases for both agricultural expansion and degradation, with specific fields for capturing user data. Once the layers were configured, we published these as services which were then used to create web maps. We used existing tools that allow respondents to create and edit polygons, include tabular information, upload files related to polygons and save them to cloud servers. These capabilities were embedded in a StoryMap template organized by steps (tabs) on the survey interface. The StoryMap application allowed us to embed a Survey Monkey instrument and YouTube videos showing how to use the application. The survey instruments were made available in English, Spanish, and Portuguese. The results of the survey were then analyzed using ArcGIS and standard office software. Hotspot maps were created by distributing points systematically within each polygon and then using kernel density tools to create the maps.

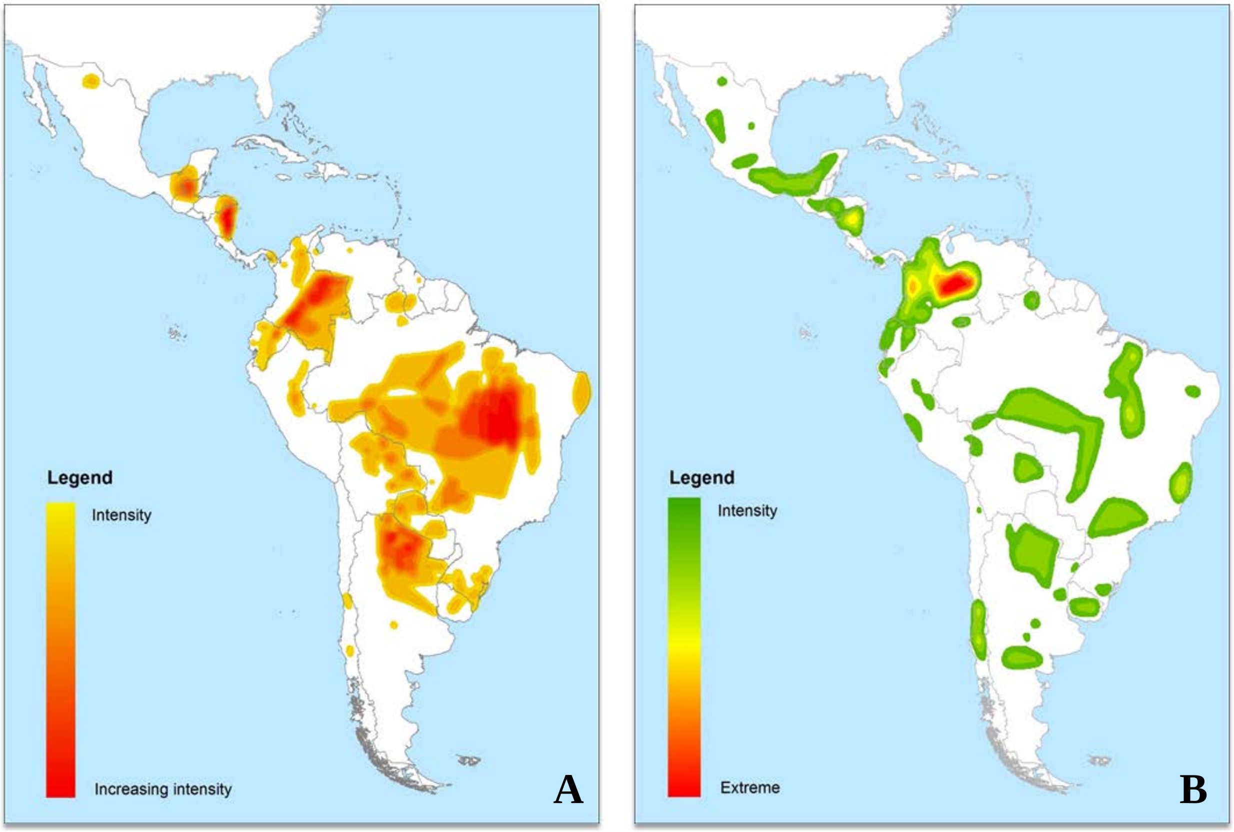
Products



Survey responses

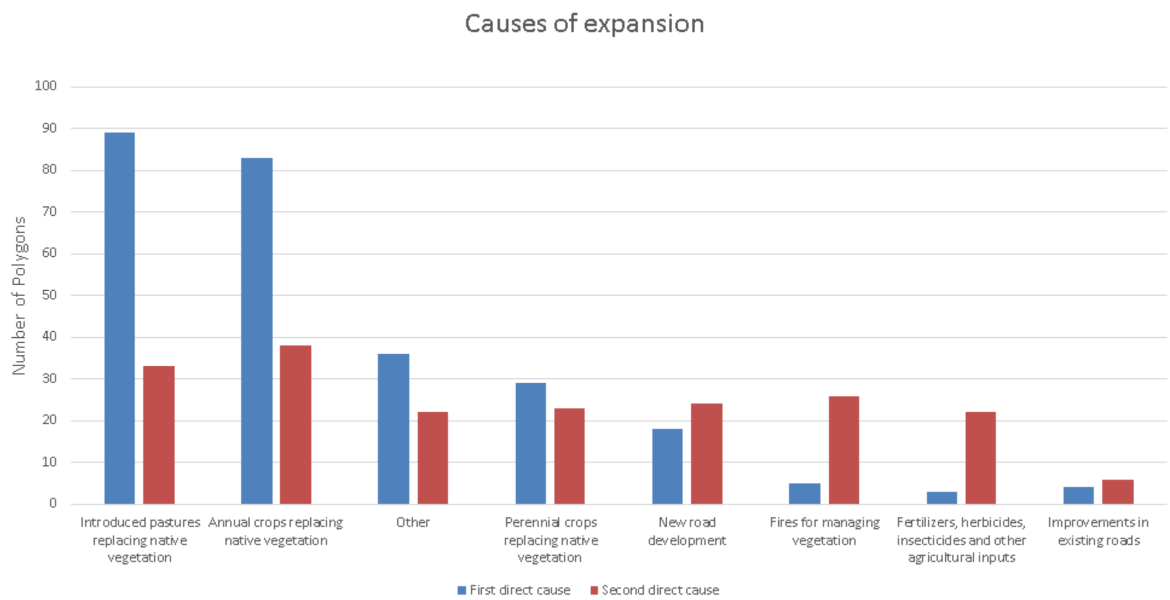
The initiative solicited participation broadly from Latin American experts[9], 346 of which activated ArcGIS Online accounts for adding polygons and 157 of which completed the Survey Monkey instrument. Our partners created 442 polygons of areas indicating land degradation and 289 polygons of areas where they expect agricultural expansion. 90 files were attached to polygons, though some of these included compressed files. All countries of the region contained expansion and degradation polygons, except for Suriname and French Guiana.

[9] We sent out 4,200 individual emails to potential respondents, but we do not know how many received the invitation because of email filters and invalid addresses. Therefore, a response rate could not be calculated.



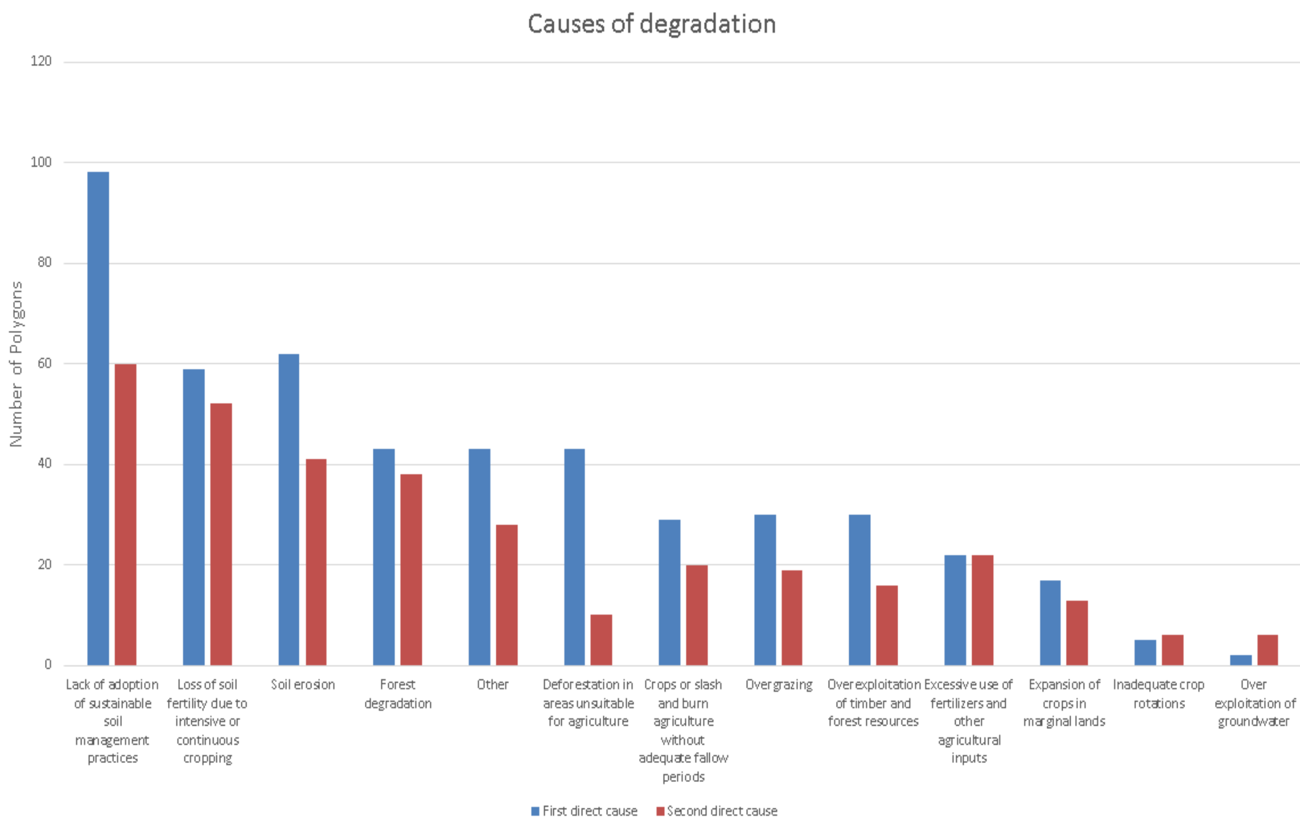
Hotspots of agricultural expansion (A) and land degradation (B)

The hotspot maps show areas where survey participants indicated expected agricultural expansion and known land degradation. Multiple respondents indicated five key areas where agricultural expansion is expected in the future: (1) the Petén and Yucatan areas of northern Guatemala and southern Mexico, (2) the Caribbean coast of Honduras and Nicaragua, often referred to as the Mosquito Coast, (3) the Piedmont and low lands of the Orinoquía and Amazon regions in Colombia, (4) parts of the Amazon and Cerrado region in west central Brazil and (5) northern Argentina including the Chaco. Areas of future agricultural expansion were found in most of the other countries, but to a lesser extent. Land degradation hotspots included the Piedmont and lowlands of the Orinoquía region, the Central American hillsides in Guatemala, Honduras and Nicaragua, the West Central and Atlantic Forest regions in Brazil, and Central Chile, among others.



Causes of agricultural expansion

The most important first cause of agricultural expansion was the development of introduced pastures replacing native vegetation, with nearly 90 polygons indicated as such (Figure 4). The second most important first cause of agricultural expansion was annual crops replacing native vegetation, with more than 80 polygons indicated. These two causes of agricultural expansion were also the highest second cause given for between 30 and 40 polygons in both cases. Another important cause of agricultural expansion was perennial crops replacing native vegetation. Between 18 and 20 polygons each as a first direct cause and second direct cause of agricultural expansion were attributed to new road development. Two important secondary direct causes of agricultural expansion were fires for managing vegetation and the use of agricultural inputs, with 28 and 26 polygons respectively indicated.



Causes of land degradation

The first causes of land degradation cited were lack of adoption of sustainable soil management practices (90 polygons), loss of soil fertility due to intensive continuous cropping (58 polygons), soil erosion (62 polygons), forest degradation (43 polygons) and deforestation in areas unsuitable for agriculture (43 polygons), among others (Figure 5). Slightly fewer number of polygons were cited as a second cause of land degradation, generally following the trend of the first cause.

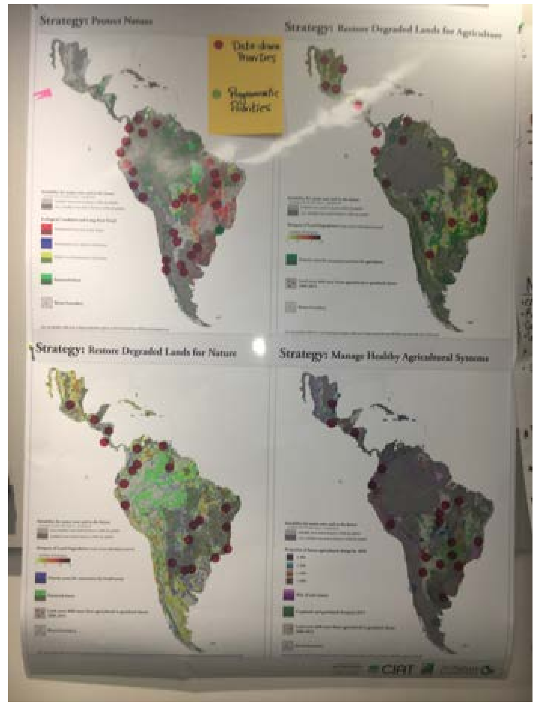
The survey also asked respondents to attach files related to any of the polygons they indicated as areas of expansion or degradation. 90 files were attached, some of which were compressed files in ZIP format. We expect to use these files in implementation of the TNC Healthy Agriculture Strategy. For example, in the Dry Chaco area, land-use change negatively effects ecosystem functioning (Baldi et al. 2015). One report includes a map of degraded areas and priorities for restoration in Colombia (Bello et al. 2014). For the Central Chile region, Hernández et al. (2016) evaluated land-use change impacts on soil quality. The files attached to polygons also included photographs, graphics files, and gray literature related to the polygons. All of these files are being evaluated for use in our ongoing work.

Limitations and future work

This was the first time that our working group had used this kind of survey that allows respondents to interactively map areas in an online application. While the lack of responses in many countries means that the survey is not representative, the data did provide us with an overview of key areas of agricultural expansion and land degradation, as well as a data set to compare with the degraded lands mapping based on remote sensing data. 157 experts completed the full survey, while another 189 completed some parts of the survey. Our interaction with survey respondents will continue to acquire more validation information, support further analyses and advance this collective effort.

Identifying Action Landscapes

Collectively, the action landscapes are intended to identify areas for TNC's HAS interventions. As



such, they represent the diversity of agricultural and natural systems within Latin America. Each landscape meets three criteria.[10] First, agriculture (either crop or livestock) is a dominant land use. Second, the land is *either* suitable for high attainable yields for soy, maize, and/or sugarcane both now and in a 2030 warming scenario, *or* is a grazing-dominated landscape. Third, there is potential for increasing agricultural production by restoring degraded lands. There are additional ecosystem co-benefits, including restoring and protecting biodiversity, carbon sequestration, and other benefits.

This approach emphasizes landscapes where on-the-ground action will reinforce the intent of the Healthy Agricultural Systems strategy—maintaining, restoring, and promoting productive agricultural systems that are resilient and sustainable. By sustainable intensification in areas with high agriculture suitability, the Strategy aims to help reduce habitat conversion elsewhere. Other landscapes are important for many reasons, but may not be essential to develop *this* strategy. Hence, the approach is distinct from, yet could be paired with, TNC's related efforts to reduce deforestation and other forms of habitat degradation by agriculture.

[10] Defined on June 5, 2018 as part of a two-day workshop in Washington DC

Defining a draft set of landscapes through workshops

Preliminary set of action landscapes

We used data proxies for the above-mentioned criteria to identify a draft set of action landscapes. An iterative group process facilitated visual assessment of four large maps[11] that were identified at the January 2018 meeting as important for identifying action landscapes: Protect Nature, Restore Degraded Lands for Agriculture, Restore Degraded Lands for Nature, and Maintain Productive Agricultural Lands. Participants placed dots on the maps where they saw areas that appeared to meet many of the criteria. These annotated maps, notes from our discussion, and email comments from remote participants were compiled at the end of the first day of the meeting. The working group proposed and reviewed a preliminary set of 12 landscapes. It was then presented to senior managers of TNC's regional and global Lands conservation programs the following day. We agreed that further data-driven review was needed to: assess agreement with the visually identified draft landscapes, determine if additional landscapes were "missed," and map the landscapes using consistent, data-driven methods.

Data-driven review and boundary delineations

The week following the DC workshop, we improved our crop suitability maps[12] and created a series of binary maps for each of the three criteria outlined above. Next, these three criteria were mapped together and weighted by the rank importance:

1. Places that are highly suitable for maize, soy, sugarcane, or ruminant grazing (pasture)
2. Suitable, plus categories one, three, or four in the Restoration Priorities analysis
3. Suitable, plus degradation hotspot (> 3)
4. All criteria combined

The union of these hotspot maps created an objective, binary map from which to compare the action areas defined at our meeting. This re-analysis refined boundaries, added three landscapes, and removed one landscape. The Central and Southern Peruvian Amazon is listed as provisional because it does not meet all the selection criteria, but may be an important place for oil palm expansion. Brief summaries of each of the action landscapes are in Appendix 1.

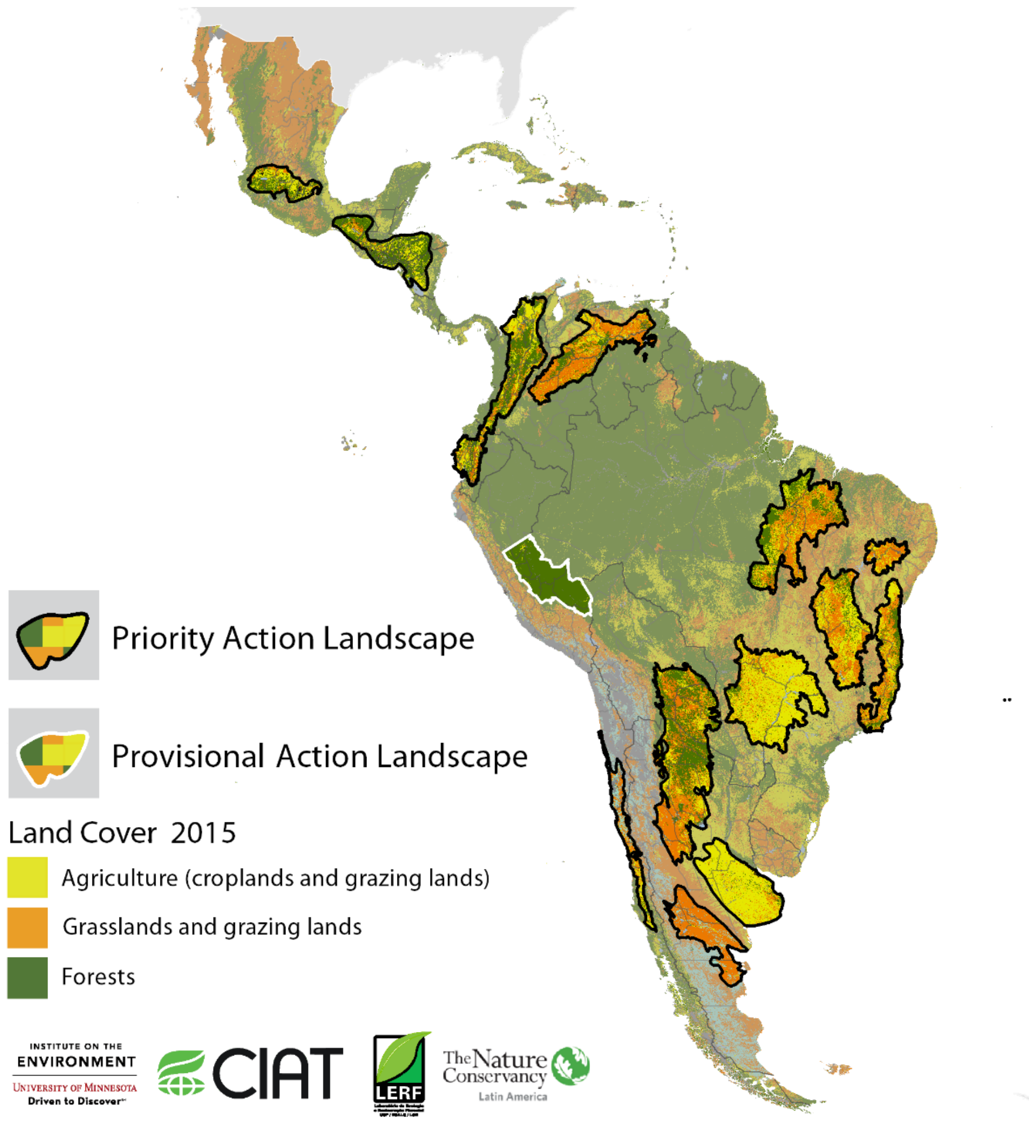
Boundaries for the action landscapes were delineated using the following rules:

- *Use ecoregion boundaries* and/or data from the analysis
- *Refine action landscape boundaries using suitability masks.* Action landscapes should be limited to include areas highly suitable both now and the future for soy, maize, and/or sugarcane.
- *Ensure that some degraded lands are included* in each of the suitable areas within the action landscape.

[11] Protect Nature, Restore Degraded Lands for Agriculture, Restore Degraded Lands for Nature, and Maintain Productive Agricultural Lands

[12] See "Suitability for high attainable yields" section for details.

- *In some cases, ecoregion boundaries were not used* as the starting point. Four action landscapes are areas much smaller than the ecoregion boundary. For example, the Cerrado ecoregion is not subdivided in The Ecoregions of the World data set. The boundary lines follow microregions and correspond to the indicators for data used in the analysis managing and restoring land for agriculture.



Action Landscapes for the Healthy Agricultural Systems Strategy

Collectively, the action landscapes represent the diversity of agricultural and natural systems within Latin America. Each landscape is dominated by agriculture, is suitable for high attainable yields (or grazing) now and the future, and is identified as a priority area for restoring degraded lands for agriculture. This product is the result of workshops, analysis, and review that occurred between October 2017 and June 2018. One landscape was designated as *provisional* as it did not meet all the criteria, but it may be important given the high risk for oil palm expansion. TNC's Latin America Regional Lands Conservation program will determine a sub-set of action landscapes (between six and eight) for taking direct action with the HAS strategy. These landscapes will be chosen according to places where projects are being implemented now, potential for scalability (see Appendices 2 and 3), and the level of support and collaboration with partners and stakeholders. Other action landscapes will be the target of work through and by partners under the HAS platform, thereby implementing healthy agricultural systems with a systems approach perspective across Latin America.

Areas selected by TNC for direct implementation may focus on key areas or a nucleus within an action landscape, depending on refined local assessments and the tactical application of synergistic interventions. In the landscapes TNC selects for direct intervention, habitat restoration priorities and important biodiversity areas protection will be considered in conjunction with the implementation of healthy agricultural systems.

Review

The criteria and final action landscapes Map were presented to directors of conservation programs throughout the Latin America region during the week of June 18, 2018. The main concerns expressed by the directors related to the suitability map and the emphasis on agriculture instead of biodiversity. In this final report, we addressed these concerns by explicitly stating that the analysis assessed the current and future suitability for high attainable yields for soy, sugarcane, and maize. The maps show the locations of where each crop is currently grown but not suitable to attain yields greater than 50% of the global values. We also describe how these landscapes and the HAS strategy are intended to complement efforts to reduce habitat loss to agriculture. The action landscapes defined here do not imply that other areas are not important. Rather, they define a set of landscapes where local action reinforces the larger effort to maintain, restore, and promote productive and resilient agricultural systems throughout Latin America.

Acknowledgements

This project was the result of many contributions from TNC staff and partners through workshops and conference calls (see Appendix 4). We would like to particularly thank a few people. Leandro Baumgarten's (TNC) feedback refined our methods for both the restoration priority setting and crop suitability mapping. Hernán Zunino (TNC) reviewed and helped refine the crop suitability analysis. TNC colleagues Giovana Baggio and Rubens Benini helped refine the restoration analysis and review the results. Laerte Ferreira (UFG) helped develop methods for mapping degraded lands and provided field validation data. Samuel Stiffman provided computer programming support for the degraded lands analysis. Several colleagues from CIAT—Mirjam Pulleman, Marcela Quintero, Carlos Gonzalez, and Carlos Nagles—provided guidance, methods, and/or analysis. Andrés Felipe Zuluaga Salazar, Marco Antonio Galindo Olguín, Hernán Zunino, and Alejandro Martínez helped refine landscape boundaries. Santiago Verón of the Instituto Nacional de Tecnología Agropecuaria provided and interpreted data for degraded lands in Argentina. Several TNC staff provided georeferenced photos and national data sets for validating/comparing the degraded lands mapping: Andres Felipe Zuluaga Salazar, Gustavo Iglesias, Hernán Zunino, Javier Beltrán, José (Manolo) Canto Vergara, Liliana Dávila, and Mauricio Castro Schmitz. About 350 experts contributed to the online mapping of degraded lands and agricultural expansion; over 150 completed the related Survey Monkey.

Appendix 1. Summary notes on Action Landscapes

The notes below summarize key points of the discussion, data analysis, and boundary delineation of the action landscapes. They are not intended to be thorough descriptions on the landscapes. The landscapes are sorted north to south. The names given to each landscape are descriptive of the key jurisdictional, topographical and/or biome areas, and are subject to re-naming should it be needed.

Action Landscapes

- **Central Highlands - Bajío**
    - *Characteristics*:
        - Highly suitable for soy and maize throughout, sugarcane in some areas
        - Degraded lands throughout
        - High priority for both maintaining ecosystem services in agricultural landscapes as well as restoration for agriculture
    - *Boundary*:
        - Used the boundary of two corresponding two ecoregions: Trans-Mexican Volcanic Belt and Bajío Dry Forests.
        - Final boundary was smoothed
    - *Notes*: Despite placeholder name, not all area is "highland"

- **Chiapas - Mesoamerican Highlands**
    - *Characteristics*:
        - Highly suitable for soy and maize throughout the landscape. Portion of landscape is also highly suitable for sugarcane both now and in the future
        - Opportunities to increase agricultural production through restoration of degraded soils
        - Co-benefits include opportunities for restoration and protection of native ecosystems
    - *Boundary*:
        - Started with ecoregion boundaries that corresponded to the polygon drawn at the meeting.
        - Narrowed the focus to the areas identified as most suitable for maize both now and in 2030, priority areas for restoring degraded areas for agriculture
        - As a result, we excluded the coastal areas on the Pacific side, as well as the lowland rainforest on the Caribbean side of Nicaragua, Honduras, and Guatemala. Note that this exclusion included the Petén Moist Forests and Yucatán Moist Forest, and Pantanos de Centla ecoregions as suggested by Alejandro Martínez and drafted at the meeting.

- **Llanos**
    - *Characteristics*:
        - Extensive grazing is a dominant land use
        - Soil degradation is widespread

        - The landscape is not highly suitable for soy, maize, or sugarcane in the future
        - Rapid expansion is projected, resulting from infrastructure investments and land tenure changes resulting from the Peace Agreement
        - Expansion is primarily for soy, oil palm, and other commodities
        - Co-benefits include opportunities for restoring and protecting native grassland and savanna ecosystems
    - *Boundary*: Used the Llanos ecoregion boundary
    - *Notes:* TNC does not currently work in Venezuela

- **Northern Andes and Pacific/Caribbean Lowlands**
    - *Characteristics*:
        - It contains some of the most highly productive lands in the region (e.g. sugarcane in the Cauca valley with the highest yields for that crop globally, productive coffee growing region on the Andean slopes, etc.)
        - According to a national analysis for forage and pasture, the northern part of the valley is productive and will be productive in the future under proper ranching systems
        - It has a high restoration for habitat potential, as co-benefit, connected with key areas for biodiversity conservation
    - *Boundary:*
        - Includes the Magdalena River basin, which is highly suitable for ranching in the north and highly suitable for high crop yields in the valleys both now and the future
        - Boundary extended beyond the basin to the north and west to include highly suitable ranching areas; urban and suburban administrative units were excluded
        - Boundary extends into Ecuador and includes high elevation areas for grazing and highly productive croplands in the valleys and along the coast
    - *Notes:*
        - This landscape was discussed at the June 2018 meeting in Washington, DC but the boundary was not drafted. The boundary presented here is based on input from Andrés Felipe Zuluaga Salazar and Marco Antonio Galindo Olguín and additional analysis using the selection criteria.

- **Agricultural Frontier (Maranhão, Pará, Mato Grosso, Tocantins)**
    - *Characteristics*:
        - This landscape is the frontier of expansion between the Amazon and Cerrado ecoregions
        - The landscape is a mix of pasture, row crops, and natural vegetation
    - *Boundary*:
        - Used the area that corresponds the priority areas for "manage sustainable, intensive ag" and "restore for ag" categories
        - Modified to focus on areas most suitable for soy, maize, or sugarcane

        - Generally used Brazil's microregion boundaries except where there was limited correlation with the data-driven boundary
    - *Notes*:
        - Likely a strong overlap with TNC's HAS and Zero Deforestation strategies
        - Strategies and partners may be very similar here as in the Western Bahia / MATOPIBA Action Landscape

- Caatinga
    - *Characteristics*:
        - Extensive grazing for hundreds of years
        - Predominantly smallholder ranching
        - Soy and maize are grown here, but very low suitability for either crop now or future
        - Agribusiness is expanding in the area, developing new soy varieties and investing in irrigation
        - Degraded lands are extensive
        - Severe drought for last 5-7 years
    - *Boundary*:
        - Overlap of concentration of degraded land hotspots and pastures (UFG)
        - Boundaries correspond to municipalities
    - *Notes*: This landscape was part of the Western Bahia / MATOPIBA landscape delineated at the meeting. It was separated here because the agricultural and socio-economic systems are very different

- Western Bahia / MATOPIBA
    - *Characteristics*:
        - Dominated by agriculture
        - Highly suitable for soy and maize now and in the future
        - Rapid expansion
        - Degraded lands throughout
    - *Boundary*:
        - Used the north-south area defined as highly priority for agricultural ecosystem services and restoration in the LERF-CIAT analysis.
        - Boundary extended west to include all of the MATOPIBA region
    - *Notes*: The strategies and partners here will likely be quite similar to the "Agricultural Frontier" landscape

- Atlantic Forest
    - *Characteristics*:
        - Landscape dominated by pasture and row crops
        - Highly suitable for soy and maize both now and in the future
        - Degraded lands widespread
        - Co-benefits include restoration of the Atlantic Forest biome

- *Boundary*:
  - High overlap of agricultural dominant landscape; high priority for managing ecosystem services and restoration for agriculture; extensive degraded lands; abundant pasture; and highly suitable for soy and maize
- *Notes*:
  - The data- and criteria-driven process identified this landscape after the June 2018 meeting in DC. The boundary represents the extent or concentration of where all criteria are met. It was not defined visually at the meeting.

- **Cerrado of Central West Brazil**
  - *Characteristics*:
    - Dominated by agriculture, both row crops and pasture
    - Highly suitable for soy and maize, both now and in the future
    - Degraded soils are very extensive
  - *Boundary*:
    - Identified area with high overlap of: highly suitable for agriculture now and in the future), degraded lands, high priority for managing ecosystem services in agricultural landscape, and abundant pasture. Pasture data was from UFG.
    - Used Brazil's microregions that correspond to with the overlap area defined above
    - Boundary is primarily in the Cerrado, but includes part of an Atlantic Forest ecoregion, which is dominated by agriculture and is more of a transition zone than a forested one
    - Excluded the Pantanal, where agriculture is more of a ranching system integrated into the wetland ecosystem
  - *Notes*:
    - May want to consider having the Pantanal as an Action Landscape in the future. Before 2016, only 30% of land parcels could be cleared. Now, 60% of the land can be cleared.

- **Chilean Matorral**
  - *Characteristics*:
    - Southern portion of the ecoregion is highly suitable for row crop commodities
    - Northern portion is primarily used for ranching
    - Degraded lands are throughout the ecoregion
  - *Boundary*: Chilean Matorral ecoregion boundary
  - *Notes*: This landscape was delineated as provisional during the June 2018 meeting in DC. After the meeting, we confirmed that it met the data-driven selection criteria.

- **Gran Chaco**
  - *Characteristics*:
    - Agricultural systems vary widely and include: extensive ranching, feedlot operations, smallholder farming, and intensive row crops

        - Portion of the landscape is highly suitable for soy and maize both now and in the future
        - Opportunities to increase production by restoring degraded soils
        - Rapid expansion of agriculture
        - Co-benefits include protecting and restoring native Chaco ecosystem
    - *Boundary*:
        - The Dry Chaco ecoregion encompasses the landscape drawn at the meeting
        - We narrowed the focus to areas that are most suitable for maize and/or soy both now and the future.
        - As a result, the Action Landscape is in the southern portion of the Dry Chaco
    - *Notes*:
        - Boundary and crop suitability reviewed with Hernán Zunino of TNC Argentina Lands Conservation

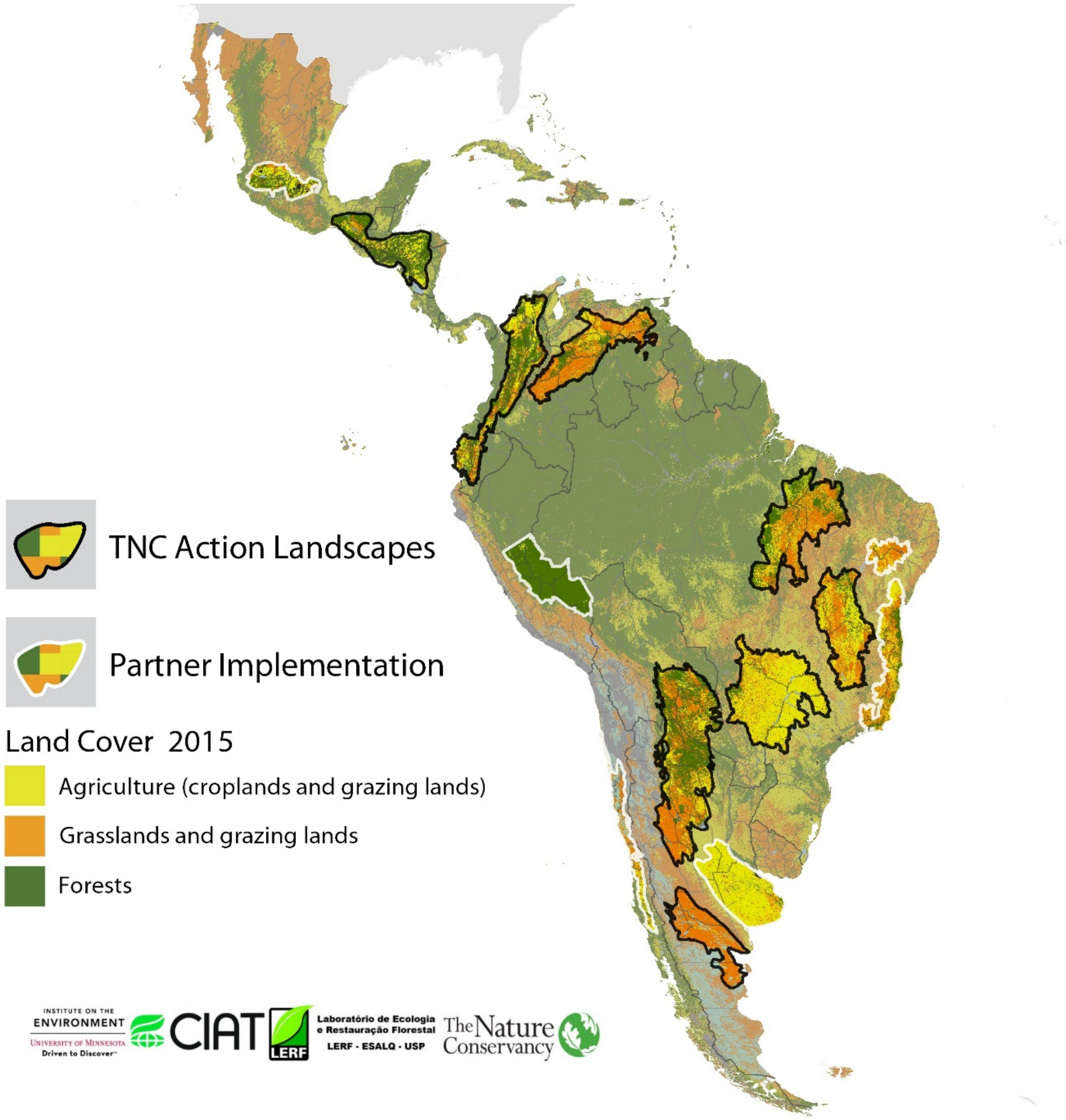
- **Humid Pampas of Southern Buenos Aires**
    - *Characteristics*:
        - Highly suitable both now and in the future for soy, maize, and sugarcane
        - Potential for increasing production by restoring degraded soils throughout
        - Much of the land is managed very intensively for row crops
    - *Boundary*:
        - Used the Humid Pampas ecoregion boundary
    - *Notes*:
        - Boundary and crop suitability reviewed with Hernán Zunino of TNC Argentina Lands Conservation

- **Patagonia**
    - *Characteristics*:
        - Grazing is extensive
        - Limited suitability for soy, maize, or sugarcane
        - Opportunities to improve grazing production through restoring degraded soils
        - Co-benefits include: restoration and protection of the native grassland ecosystem
    - *Boundary*:
        - The Low Monte ecoregion encompasses the area drawn at the June 2018 meeting in DC
        - We excluded the northern portion, which has less grazing and less degradation (may be more intact for biodiversity, but not a priority for the HAS strategy)
        - Boundary reviewed with Hernán Zunino of TNC Argentina Lands Conservation

Provisional Action Landscape

- **Central and Southern Peruvian Amazon**
  - *Characteristics*:
    - Most of the landscape is currently forested
    - High expansion for oil palm anticipated
    - Co-benefits include restoration and protection of biodiversity hotspots in the Yungas and Madre de Dios regions
  - *Boundary*:
    - CIAT colleagues' analysis showed that boundaries were strongly aligned across portions of the piedmont region in Madre de Dios and Ucayali. Polygon is a portion of the ecoregion boundary.
  - *Notes*:
    - This action landscape is *provisional* because it does not meet all of our selection criteria. It is largely forested (not dominated by agriculture) and is not considered highly suitable for the crops in our analysis or as a grazing area. However, it may be an important area given the high risk of oil palm expansion.

Appendix 2. Action Landscapes where TNC will directly implement HAS strategy



Appendix 3. Action Landscapes Metrics

Action Landscape	TNC Conservation Program	Total Area of Action Landscape	Human Population	Degraded Soil (ha)		High Soil Erosion Risk		High Land Restoration Potential		Maize Productivity	Water Services	Habitat conversion 2004-2018	Decrease in soil carbon	Vertebrate Species Richness
*Ordered from south to north. * Denotes Action Landscapes where TNC will directly implement HAS strategy*		*ha*		***Low-Medium***	***High-Very High***	*ha*	*% of total landscape area*	*ha*	*% of total landscape area*	*Index*	*Index*	*ha*	*% Decrease in soil carbon stocks*	*Mean*
Patagonia - Low Monte*	South Andes	26,172,232	1,243,307	20,521,409	403,158	66	0.00	860,428	0.03	0.00	0.00	22,444	0.02	15,692
Chilean Matorral	South Andes	14,825,777	9,644,756	11,203,321	2,059,541	697,112	0.05	14,317,569	0.97	2.59	0.15	324,813	0.07	18,331
Humid Pampas of Southern Buenos Aires	South Andes	36,834,920	21,412,472	16,023,956	62,621	41,743	0.00	27,208,953	0.74	3.07	0.03	104,675	0.30	12,639
Gran Chaco*	South Andes	78,615,791	4,735,781	25,835,009	3,705,141	1,899,450	0.02	51,589,200	0.66	2.57	0.19	4,808,056	0.08	15,307
Cerrado of Central West Brazil*	Brazil	59,971,906	12,851,932	48,244,567	2,099,338	1,922,403	0.03	42,633,376	0.71	1.78	0.66	369,144	0.17	12,678
Atlantic Forest	Brazil	27,440,152	27,520,376	16,532,366	6,640,582	10,491,578	0.38	22,507,068	0.82	1.99	0.12	190,113	0.15	18,917
Western Bahia - MatoPiBa*	Brazil	38,524,723	3,557,105	25,856,683	3,759,920	3,367,074	0.09	17,247,503	0.45	1.33	0.20	1,006,319	0.14	16,244
Central & Southern Peruvian Amazon	NASCA	27,543,377	1,515,710	6,133,785	25,138	10,020,999	0.36	951,285	0.03	1.51	0.16	489,494	0.01	18,331
Agricultural Frontier (Maranhão, Pará, Mato Grosso, Tocantins)*	Brazil	50,604,389	5,647,792	33,530,482	4,042,262	5,387,979	0.11	35,967,038	0.71	2.46	0.09	3,169,388	0.10	13,268
Caatinga	Brazil	8,609,944	1,378,863	2,615,249	5,935,257	99,199	0.01	3,407,672	0.40	-2.67	0.01	10,794	0.09	16,608
Northern Andes - Pacific/Caribbean Lowlands*	NASCA	40,533,906	33,119,577	16,888,419	348,478	19,932,870	0.49	30,195,005	0.74	2.84	0.34	684,756	0.02	19,813
Llanos*	NASCA	37,544,080	4,256,482	27,673,016	2,595,409	474,889	0.01	13,029,529	0.35	1.89	0.26	304,019	0.08	14,561
Chiapas - Mesoamerican Highlands*	MNCA	27,436,332	33,366,569	11,032,731	232,793	16,162,844	0.59	14,471,357	0.53	0.98	0.04	636,788	0.21	19,843
Central Highlands - Bajío	MNCA	13,677,805	51,529,942	11,387,418	1,967,797	2,625,269	0.19	10,229,524	0.75	1.81	0.26	22,700	0.04	19,556
Explanation of Data Factor		Action landscape polygons were created in the meeting in Arlington, June 2018. They were created among consensus from all teams who gathered the data.	Human population within each action landscape.	Reduced productivity of the land or soil due to human activity. Data was drawn from 10 different indicators to represent landscape conditions and productivity.		Soil erosion risk was calculated as a product of (1) Rainfall erosivity factor; (2) K factor ; and (3) a combination of slope length and slope steepness.		Two maps were combined to create this weighted analysis: habitat layer and soil erodibility. Habitat layer divides the landscape into forested and non-forested, respectively habitat and non-habitat. Soil Erodibility is the same map for soil erosion (rainfall, slope, soil texture, digital elevation model)		Measures productivity of maize as the key indicator crop. Annual max and min values of the Enhanced Vegetation Index (EVI) on cloud-free days.	Relative realized water provisioning services (RRWPS) Index, shows the intensity of downstream use measured as the normalized area of irrigation, number of people and number of dams. RRWPS is high where the prevailing climate and land use generate high volumes of clean water which can be used (and reused) by large numbers of downstream users.	Every 16 days Terra-I provides data for vegetation gain or loss. It uses historical seasonal NDVI changes to predict future land cover change.	% Decrease in soil carbon stocks from natural condition	Taken from a forthcoming analysis: Touval, J., Baumgarten, L., Sotomayor, L. (in preparation), The LAR Situation Analysis: Viewing TNC's Shared Conservation Agenda through a Latin America Filter. The Nature Conservancy (TNC), Arlington, Virginia.
Source of Data:		Criteria for making the priority areas are: crop or livestock is the dominant land use, land is either suitable for highly attainable yields for soy, maize and/or sugarcane both now and in the 2030 warming scenario (or is a grazing landscape), third, there is potential for	SEDAC, CIESIN from Columbia University. Population count dataset.	ESA-CCI land cover data, Landsat, MODIS		RUSLE model (adapted by UMN)		ESA-CCI land cover data.		MODIS Terra satellite	King's College London, Mark Mulligan, Costing Nature.	Terra-I (Land cover algorithm product from CIAT, using MODIS data)	CIAT data	Priority areas for vertebrates, alliance for zero extintion sites, protected areas, Ramsar sites, CONABIO priority areas, TNC ecoregional profiles, IDB's critical natural areas.
Relevant link:			http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev10								http://www.policysupport.org/costingnature	http://www.terra-i.org/terra-i/about.html	https://www.4p1000.org/	

Appendix 4. Participants in workshops, conference calls, reviews

The final product is a result TNC colleagues contributing to the project through workshops, conference calls, reviews, and other means.

Giovana Baggio
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Mario Barroso
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Rubens Benini
Deborah Bossio
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Juliana Delgado
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María Martínez Murillo
Ginya Truitt Nakata
Marco Antonio Galindo Olguín
Andrés Felipe Zuluaga Salazar
Mauricio Castro Schmitz
Marcio Sztutman
Ian Thompson
Jerry Touval
Aurelio Ramos
Horacio Rodríguez Vázquez
Fernando Veiga
José Canto Vergara
Tomas Walschburger
Angela Watland
Hernán Zunino
Christina Welch
Ana Teresa Colón
Juan Carlos Godoy
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