Tracking the loss of native grasslands in South America

Report prepared for BirdLife International Americas

By Jürgen Hoth jurgenhoth1521@gmail.com

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Content

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The background map *"Amerique Meridionale"* used in this and on the front page was published in 1748 by Jean Baptiste Bourguignon.

Acronyms

FAN	Fundación Amigos de la Naturaleza, Bolivia
FVSA	Fundación Vida Silvestre Argentina
GHGs	Greenhouse gases
IBAs	Important Bird Areas
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina
KBAs	Key Biodiversity Areas
LUC/LCC	Land-use change and land-cover change
NABCI	North American Bird Conservation Initiative
NDVI	Normalized Difference Vegetation Index
NICFI	Norway´s International Climate and Forest Initiative
TNC	The Nature Conservancy
UDELAR	Universidad de la República, Uruguay
UFRGS	Universidade Federal do Rio Grande do Sul, Brazil
UNAM	National Autonomous University of Mexico
USDA	United States Department of Agriculture
WRI	World Resources Institute
WWF	World Wildlife Fund

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Summary

The growing loss of native grasslands is a worldwide challenge, not only in terms of addressing the agents of change but also in terms of accurately tracking their loss across landscapes. Having started less than 10 years ago, **Plowprint** and **MapBiomas** are two leading initiatives that have been successfully applied to track land-use changes in North America´s Great Plains and South American Pampas, respectively. **Plowprint** is an initiative developed by WWF-US which is limited to North America as it relies upon the databases provided by the US and the Canadian governments. Established in 2015 in South America, **MapBiomas** is a collaborative multi-institutional and multinational initiative that relies on Landsat imagery made accessible by Google Earth Engine. This approach has been applied to various biomes throughout the region, including the grasslands associated with the Pampas. Part of its success is due to 1) its reliance upon a regional network of researchers from multiple organizations; 2) its support by Google´s engine computing platform; 3) its free and open access to its information; and, 4) keeping its development independent from governments. Given the level of progress achieved by **MapBiomas** in assessing land-use changes in various South American biomes–including grasslands– a key recommendation is for BirdLife to consider building synergies with this initiative.

Resumen

La creciente pérdida de pastizales nativos es un desafío mundial, no solo en términos de abordar los agentes de cambio, sino también en términos de rastrear con precisión su pérdida en los paisajes. Habiendo comenzado hace menos de 10 años, **Plowprint** y **MapBiomas** representan dos iniciativas líderes que se han aplicado con éxito para rastrear los cambios en el uso de la tierra en las Grandes Planicies de América del Norte y las Pampas de América del Sur, respectivamente. **Plowprint**, desarrollada por WWF-US, se limita a América del Norte ya que depende de las bases de datos proporcionadas por los gobiernos de Estados Unidos y Canadá. Establecida en 2015 en América del Sur, **MapBiomas** es una iniciativa colaborativa multiinstitucional y multinacional que se basa en imágenes Landsat accesibles a través de Google Earth Engine. Este enfoque se ha aplicado a varios biomas de la región, incluidos los pastizales asociados con las Pampas. Parte de su éxito se debe a 1) su dependencia de una red regional de investigadores de múltiples organizaciones; 2) su soporte por la plataforma computacional de Google; 3) su acceso libre y abierto a su información; y, 4) mantenerse independiente de los gobiernos. Dado el nivel de progreso alcanzado por **MapBiomas** en la evaluación de los cambios en el uso de la tierra en varios biomas de América del Sur, incluidos los pastizales, una recomendación clave es que BirdLife considere la creación de sinergias con esta iniciativa.

I. Introduction

The fate of biodiversity together with its functions and services is closely linked to the changes in land use. This can be already seen at a global scale with the grassland biome being considered one of the most threatened worldwide, mostly due to land-use change (Hoekstra et al., 2005; Carbutt et al., 2017; Dudley et al., 2020). The grasslands of North America are no exception; its severity is illustrated by the consistently high loss of grasslands birds as a group, which over the last 60 years have shown the steepest losses compared to the birds of any other ecosystem (NABCI, 2019). Growing warnings have also emerged over time for South America´s grasslands (Bilenca et al., 2009; Azpiroz et al., 2012; Modernel et al., 2016; Nanni et al., 2020) which is one reason why Birdlife International started since 2005 the "Alianza del Pastizal" and is now seeking to better assess land-use change and changes in bird populations to help muster the necessary response to stem the loss of South America´s biodiversity.

In the case of South America, the Espinal and Pampa´s grasslands are perhaps among the most impacted biomes, by having been exposed since the 16th century to the livestock industry, and more recently to the impacts of extensive cash crop production-related primarily to soybeans (Bilenca, et al., 2009; Priotto, 2017; Neves et al., 2020).

A timely and effective response to biodiversity loss depends largely upon the availability of reliable environmental monitoring and evaluation approaches based, including high-quality maps of land use and land cover (Gage et al., 2016: 113). Developing metrics for tracking the location and magnitude of the conversion of grasslands and other ecosystems to cropland over time can provide strategic information for agencies and organizations to work toward the conservation of these habitats effectively and accountably.

The goal of this report is to help BirdLife International determine the suitability of adapting and implementing in the Pampas´ grasslands of South America the WWF-led **Plowprint** initiative, used to monitor the status of North America´s grasslands. This includes summarizing costs and technical needs required to manage the spatial tool.

Assessing land-use changes through Plowprint and MapBiomas

This report is based on a literature review and on interviews with the following developers and practitioners of **Plowprint** and **MapBiomas**. Interviewees will be referred to in the rest of this document by their respective acronym, see below (their complete contact information is provided in the directory).

(FA) Fabiana Arévalos, Guyra-PY

(AE) Ana Eljall, FVSA

(PL) Patrick Lendrum, WWF-US

(MM) Mayra Milkovic, FVSA

(EP) Maria Eugenia Periago, FVSA

(EV) Eduardo Vélez, Geokarten, Brazil

II. Plowprint and MapBiomas

Worldwide, distinguishing native grasslands from non-native grasslands and crops is a challenge that frequently emerges when assessing land-use change. In the American continent, the two leading initiatives to assess land-use changes in land cover change (LUC/LCC) of grasslands is represented by **Plowprint**, developed by WWF-US for North America´s Great Prairies, and **MapBiomas** developed by a consortium for South America´s biomes, including the Pampas.

Starting in 2014, **Plowprint** was developed by WWF-US to identify remaining *intact*[1] grasslands in the Great Plains and, inversely, to assess cumulative loss of native grassland to cropland expansion in the Great Prairies extending from southern Canada into Central and southern USA (Gage et al., 2016: 107; WWF-US, 2020; Olimb and Lendrum 2021:111). This approach uses as a foundation the land-use maps developed by the federal governments of the US and Canada, generated by USDA's annual Cropland Data and the Canadian Annual Crop Inventory, respectively.

The hallmark characteristic of **Plowprint**, designed specifically to be able to assess the loss of native grasslands with the highest reliability possible, is the mapping of one pixel as native grassland but only if five consecutive years the same pixel remains unchanged. This stacking of pixels, as a way to reliably assess natural grasslands from those modified by agricultural practices, is what is known as the "**Plowprint**" (Olimb and Lendrum, 2021: 111). The interactive, online version of the US and Canadian **Plowprint** map can be visited here: https://www.worldwildlife.org/pages/plowprint-report-map#plowprint (see also figure 1).

[1] "**Intact**" is defined by Gage et al., (2016: 112) as "any pixel that had not been converted, developed, or classified as open water."

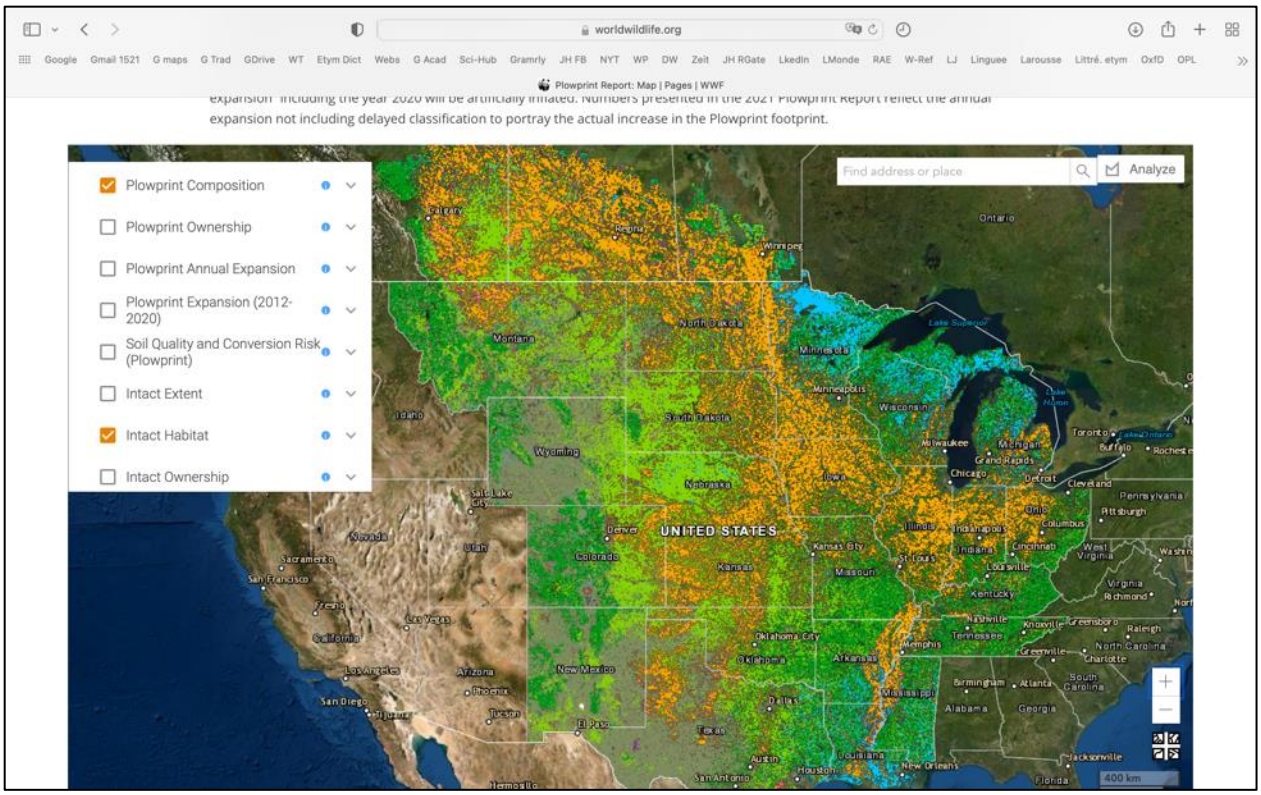

Figure 1. US and Canadian Great Plains´ grasslands in 2020, according to **Plowprint.** This screen image, showing the various land classifications, was taken from its platform available at https://www.worldwildlife.org/pages/plowprint-report-map. Where orange represents agricultural/crop areas; light green, the "intact" grasslands; olive green the shrublands: dark green, the forests; and light blue represent the wetlands. Downloaded December 12th, 2021.

The main limitations for **Plowprint** include:

- It is not scalable to the local level (Olimb et al, 2017:8) See, however, the similarities in Figure 3, below, comparing the outputs of **Plowprint** with **MapBiomas**.
- It depends on the accuracy of satellite-derived data intended for the identification of planted crop species versus native species (Olimb et al, 2017:8).
- It can only be applied in North America as it depends entirely upon quality data database provided by the US and the Canadian governments (potentially also from the Mexican government (PL).
- It cannot distinguish natural grasslands from "improved" grasslands seeded with exotic grasses, although **Plowprint** has repeatedly proven very helpful to show overall grassland loss to various types of agricultural purposes (PL).

On the other hand, **MapBiomas** is an analytical approach similar to **Plowprint** and initiated in about the same time (2015) by a collaborative network involving more than 70 researchers and scientists, from NGOs, universities, and technology companies, which organize their work by biomes and cross-cutting themes, based upon opensource technology (Souza and Azevedo, 2017).

This informal, dynamic and functional network produces large-scale land-use change and land-cover change (LUC/LCC) maps at a 30-metre resolution based upon Landsat information available from 1985 onwards (Sparovek et al., 2019). The main website of **MapBiomas** is https://mapbiomas.org/en

The data offered by **MapBiomas** is updated on a yearly basis and is validated by local professionals knowledgeable of each biome. Governments cannot decide upon the technical content but can provide recommendations (FA).

Most of **MapBiomas** work has been carried out in Brazil, and more recently has been expanded to other countries. The main biomes addressed by this initiative are the following:

- Amazonia
- Caatinga
- Cerrado
- Chaco
- Mata Atlantica
- Pampa
- Pantanal

The work in each biome is coordinated by different organizations. Nonetheless, all project areas follow the mapping overall protocol developed by MapBiomas Brazil allowing for adjustments to address unique features according to the needs of each ecosystem (Souza and Azevedo, 2017).

Overall, **MapBiomas** is considered a fast, reliable/high-quality, and low-cost approach to produce an annual temporal series of land cover and land use maps of the country and/or biome. This approach does not depend on the availability or accessibility of government maps but on publicly available satellite imagery made available by Google Earth Engine Platform (Souza and Azevedo, 2017: 20). In some biomes, like Chaco, the database is stored in the cloud thanks to the support of The Nature Conservancy (TNC). The resulting information is publicly and freely available (FA).

MapBiomas Specialty themes

Although the main driver of this initiative is to document land-use change, the **MapBiomas**´ researchers also have developed specific themes including:

- Identification of desertification process
- Deforestation processes & alert
- Estimations of emissions of greenhouse gasses (GHGs)
- Impact of Fire
- Forest regeneration
- Fragmentation analyses
- Mining
- Scenario modelling agriculture´s impact on biodiversity
- Urbanization.
- Water and wetlands

(Souza and Azevedo, 2017: 7).

Moreover**, MapBiomas** also awards $10,500 USD in yearly prizes to academic efforts that apply their information addressing special themes (FA).

One of the methodological areas of potential improvement for **MapBiomas**, identified in a recent evaluation by Sporovek et al. (2019: 38). includes addressing limitations and inconsistencies in land-use classifications, for instance, in being able to separate human-modified landscapes from natural landscapes, such as natural grassland from pastureland (a challenge also faced by **Plowprint**, according to WWF-US´ Patrick Landrum) or planted forest from native forest.

III. MapBiomas Pampas

The **MapBiomas**-Pampas group is the latest research team formed, mostly involving participants from Argentina, Brazil, and Uruguay. Each country has its national coordinator. Diego De Abelleyra, Argentina's Instituto Nacional de Tecnología Agropecuaria (INTA); Santiago Baeza, Uruguay´s Universidad de la República (UDELAR); and Eduardo Vélez (Geokarten) in Brazil. Tasso Azevedo is the general coordinator of this **MapBiomas** network and as with other biomes this one also has its own website: https://pampa.mapbiomas.org/

Through their website, this group recently released through the MapBiomas South American Pampa Collection covering the 20-year period from 2000 to 2019 of land cover and land use annual maps for Argentina, Brazil, and Uruguay, with 9 mapped classes and 30 m resolution, as can be seen in Figure 2.

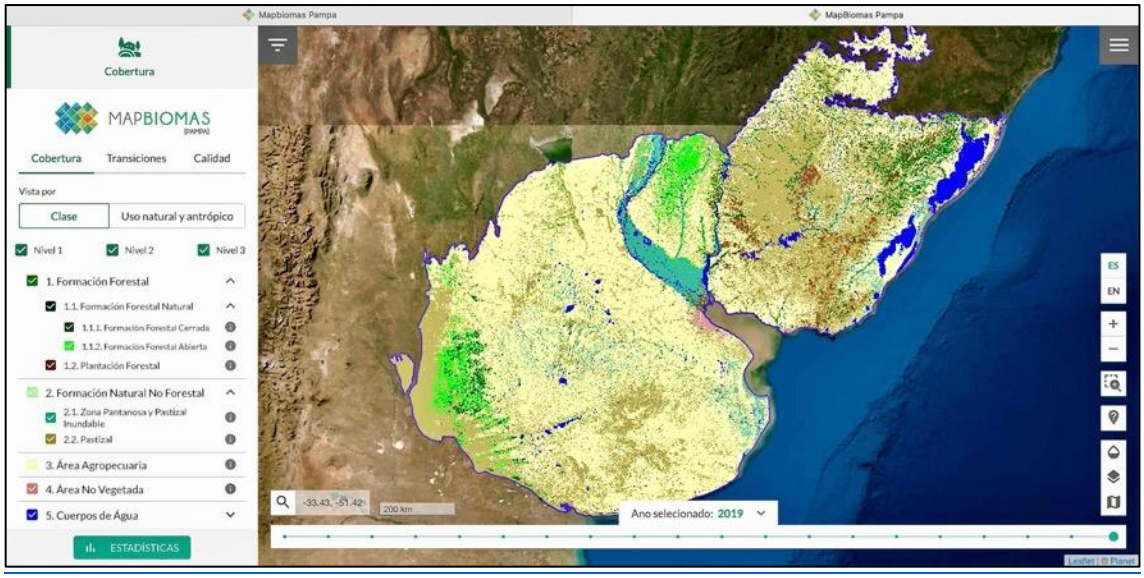

Figure 2. Pampas grasslands according to **MapBiomas**. Screen image taken from its platform available at https://plataforma.pampa.mapbiomas.org showing the various land classifications. Downloaded December 12th, 2021.

MapBiomas uses its own grasslands polygon (Figure 2) and may add confusion to the diverse set of existing Pampas´ grassland maps (Figure 3). Not only do different maps consider different

regional/physiographic subdivisions (Table 1) but also the extension of them may vary as happened with **MapBiomas**´ coverage of the Argentinian Pampas´ grasslands, which includes the Espinal phytogeographic province. The maximum discrepancy among the maps is of about 20% (ca. 2 million ha), which may cause confusion when generalizing results that would be representative of "the" Southern South American grasslands.

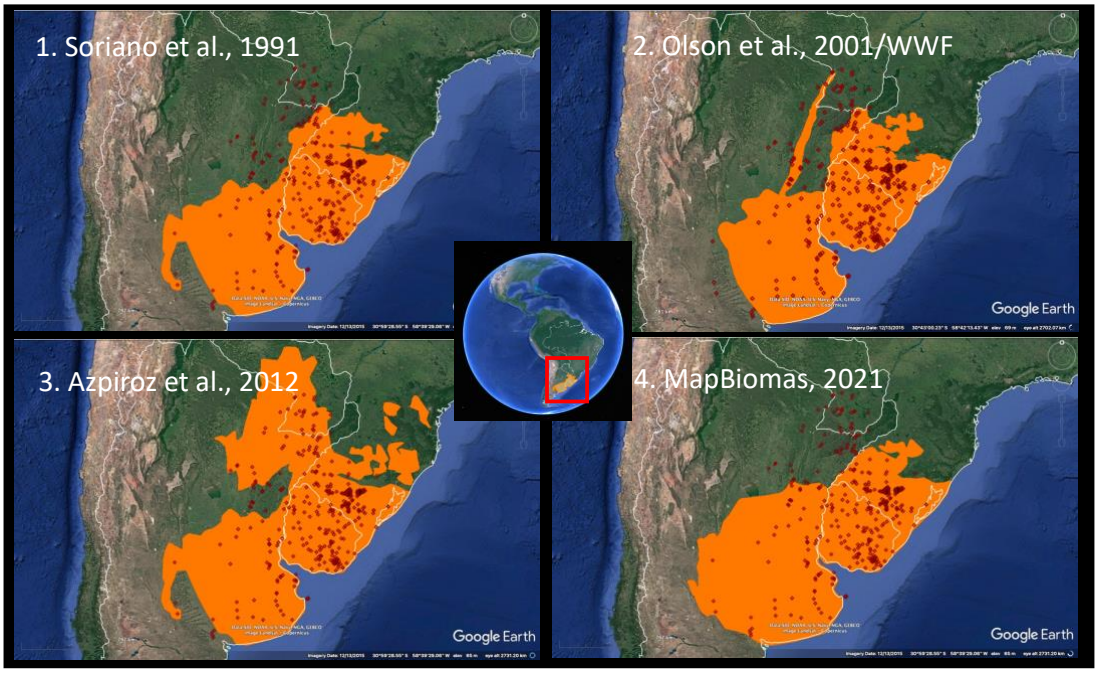

Figure 2. Different coverages of the Southern South American grasslands according to key mainstream maps. The red dots represent the 445 properties of ranchers that are currently members of the Alianza del Pastizal (Design. JHoth).

N.B. It is worth mentioning from the various Pampas representations depicted in Figure 2, that the map that seems to encompass the best the current membership of the 445 properties owned by the members of Alianza is the one offered by Aspiroz et al., 2012.

Table 1. Differences among mainstream published maps representing the Southern South American grasslands, featured in Figure 2. The slots highlighted in yellow show the regional subdivisions that were not considered by each map representation. (N.B: The area of each mapped representation was obtained by overlaying their published figure into GoogleEarth, and the actual measurement of the surface area by using https://www.earthpoint.us/Shapes.aspx).

Grassland regional subdivisions According to Soriano *et al* ., 1991; Olson *et a* l., 2001; and Azpiroz *et al* ., 2012.	Soriano *et al* ., 1991	Olson *et al.* , 2001/WWF	Azpiroz *et al.*, 2012	MapBioma 2021
Southern Pampa (RP1)	X	X	X	X
Flooding Pampa (RP2)	X	X	X	X
West Inland Pampa (RP3a)	X	X	X	X
Flat Inland Pampa (RP3b)	X	X	X	X
Rolling Pampa (RP4)	X	X	X	X
Mesopotamic Pampa (RP5)	X	X	X	X
Northern Campos in Argentina (RP6)	X	X	X	0
Southern Paraguayan grasslands (RP7)	0	0	X	0
Northern Campos in Brazil (RP8)	X	X	X	X
Northern Campos in Uruguay (RP9)	X	X	X	X
Southern Campos (RP10)	X	X	X	X
Brazilian Upland grasslands (BR)	0	0	X	0
Espinal	X	0	X	X
Humid Chaco grasslands (CH)	0	0	X	0
Paraná flooded savanna	0	X	0	X
Area (sq km)	852,181	823,343	1,199,432	1,014,123

As mentioned before, as much for **Plowprint** as for many other land-use change initiatives worldwide, one of the big challenges faced by MapBiomas has been to be able to distinguish 1) native grassland from crops; and 2) native grassland from cultivated pastureland (Sparovek et al.,2019: 41),

To address the former challenge, Eduardo Velez mentioned: “To distinguish natural grasslands from crops we use good quality samples to train the classifier. The variables used for this classification include spectral bands and various vegetation indices. The maps are annual and within each year information from the period with the greatest spectral contrast between grassland and agriculture is used, as well as variability information throughout the year. With this we are able to distinguish these two classes very well. However, in some cases there may be a certain level of confusion with fallow areas. The data is all publicly available on the web platform, as well as the accuracy evaluation for each mapped class.” The annual maps so far published cover the period 1985-2019 for the Brazilian Pampas, and 2000 to 2019 for the Pampas in Argentina and Uruguay (AE, EV).

To address the latter, Velez added “We (**MapBiomas**) make a good distinction of natural grasslands from so-called "Pasturelands", either as monocultures or mix of exotic species (including the much-used Ryegrass), planted in places where the native vegetation was previously removed.” He further acknowledges that the resulting maps are not considered 100% accurate and warns that a certain level of confusion can occur between these mapping

classes. But he points out that the main confusion can emerge when comparing pasturelands and agriculture due to their similar seasonal production cycles with marked peaks in the variation of the vegetation indices that they use in the classification.

Comparison between Plowprint and MapBiomas

In synthesis, the following offers a side-by-side depiction of the tool publicly offered by **Plowprint** and **MapBiomas.**

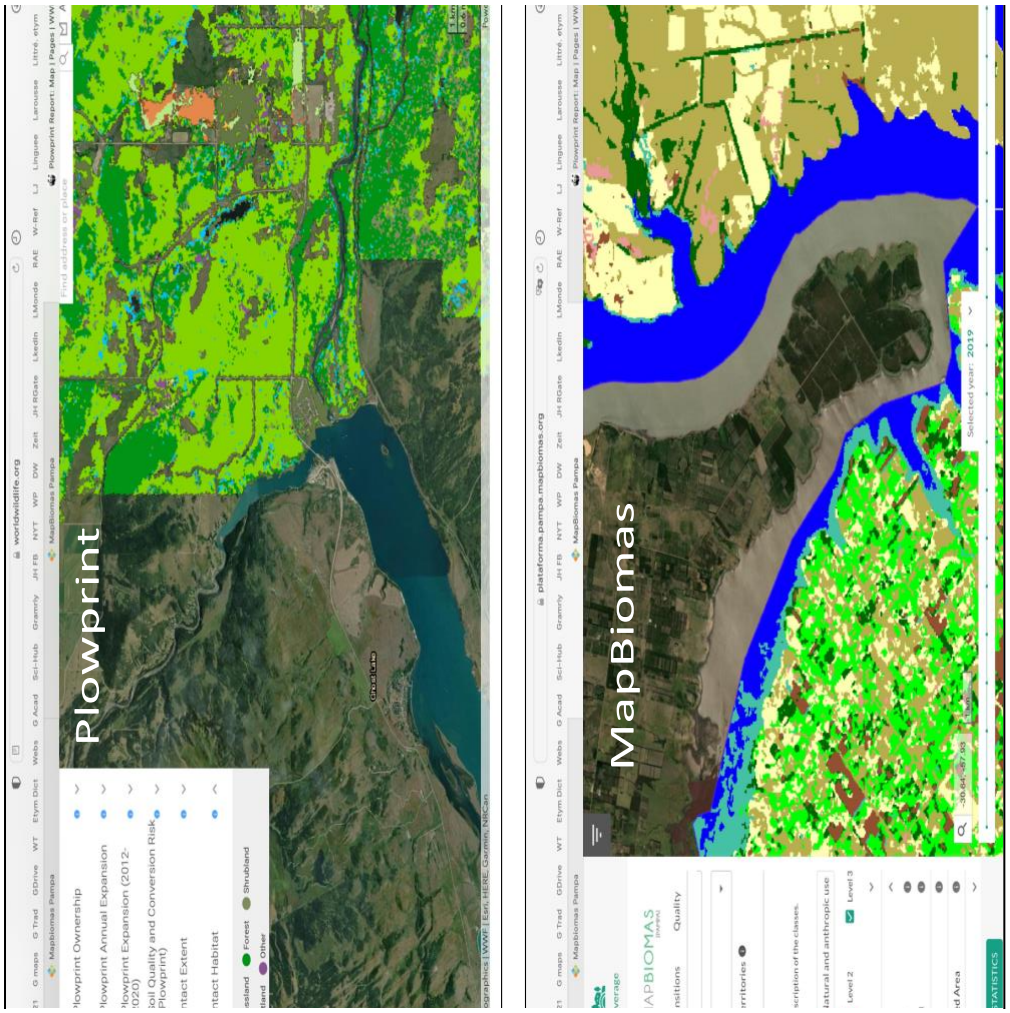

Figure 3. On-screen comparison of the publicly available information offered by **Plowprint** (top) and **MapBiomas** (bottom). Both images were taken at the same scale. The sources of these outputs are, respectively, https://www.worldwildlife.org/pages/plowprint-report-map. and https://plataforma.pampa.mapbiomas.org

The following Table 1 offers a more detailed comparison among both approaches:

Table 1. Overall comparison between **Plowprint** and **MapBiomas**

	Plowprint (PP)	MapBiomas (MB)	References
Goal	1. Identify remaining intact grasslands habitat; and, conversely, 2. Track cumulative grassland conversion to cropland.	Understand land use and land cover change dynamics in South American biomes	PP: Gage et al., 2016; WWF-US 2016. MB: Souza & Azevedo, 2017: 5
website	Great Plains https://www.worldwildlife.org/pages/plowprint-report-map#plowprint	Pampas https://plataforma.pampa.mapbiomas.org	
Language	English	English and Spanish	
Institutional arrangement	WWF-US	Collaborative network. NGOs, universities and technology companies	PP: Gage et al., 2016 MB: Souza & Azevedo, 2017:
Main source of information	USDA National Agricultural Statistics Service Cropland Data Layer; Agriculture and Agri-Food Canada Annual Crop Inventory.	Landsat imagery made accessible via Google Earth Engine (imagery from1985 onwards).	PP: Gage et al., 2016 MB: Souza & Azevedo, 2017
Ecoregional application	Great Plains	Amazon, Chaco, Catinga, Cerrado, Mata Atlántica, Pampas (and growing)	PP: WWF-US MB: FA, Souza & Azevedo, 2017
Countries involved	Canada, USA	(Pampas) Argentina, Brazil, Uruguay	MB: https://pampa.mapbiomas.org
Temporal coverage	2015-2019	2000-2019	PP: WWF-US, 2021 MB: https://pampa.mapbiomas.org
Institutional arrangement	WWF-US	Informal setting among multi-sectorial and international organizations	PP: Olimb et al., 2017: 14 MB: Sparovek et al., 2019
Resolution	30 m (Currently)	30 m (Currently)	PP: Gage et al., 2016:113 MB: Sparovek et al., 2019: 38
Key advantages	Uses already available detailed land use maps generated by the US and Canadian governments.	Relies on Google Earth Engine. Does not depend on the availability, reliability or accessibility of government information.	PP: Olimb & Lendrum 2021:111 MB: FA
	Provides a consistent and accurate record of cumulative grassland conversion across the ecoregion.	Fast, reliable, user-friendly interphase, publicly available/on-line and low-cost approach, updated on a yearly basis.	PP: Olimb & Lendrum 2021 MB: Souza & Azevedo, 2017; https://mapbiomas.org/en
	Annual updates	Yearly assessments of land use with various degrees in its characterization.	PP:Olimb & Lendrum, 2021: 112 MB: EP
	Allows disparate agencies and organizations to align their goals, strategies and activities, and measure progress in a uniform way.		Gage et al., 2016: 113
Key limitations	Dependent on the accuracy of satellite-derived data intended for identification of planted crop.	No scientific publication so far produced but thje first one is about to being released	PP: Olimb et al., 2017: 14 MB: EV
	It cannot distinguish natural grasslands from "improved" grasslands seeded with exotic grasses.	Limited capacity to separate human-modified landscapes from natural landscapes, such as natural grassland from pastureland	PP: PL MB: Sporovek et al., 2019: 38.

Finally, it is worth considering that there is already experience in using **MapBiomas** in Mexico and the Caribbean through the National Autonomous University of Mexico (UNAM) and WWF-Mexico (EP), which may offer additional opportunities for assessing the status and trends of native grasslands at a continental scale.

Costs

In general, **MapBiomas**´ overall annual budget assigned to the objective of updating the grasslands component ranges in the order of $150,000 USD (FA, EV). Considering that **MapBiomas**´ technical setting is already well-established, the two main elements that determine cost are:

- Pay for the time needed by one or several researchers to address a specific question.
- Training staff in the MapBiomas approach.

Birdlife could be interested in having **MapBiomas to** address specific LUC/LCC questions and on that basis assess the cost would be determined related to addressing that theme. This would require defining BirdLife´s key **information needs** to confer with what is already available and then ascertaining what additional work would be needed to be done. According to the researchers interviewed, there is interest and willingness in North and South America to work on grasslands- LUC/LCC themes-– and its link to bird populations– especially considering that this work would be supported by the existing regional technical capacity.

For further enquiries related to specific collaboration between BirdLife and **MapBiomas** related to the Pampas´ grasslands, the key contacts are Eduardo Vélez and Tasso Azevedo (see directory). The main access to this initiative is contato@mapbiomas.org

Overall, the map **MapBiomas** approach could be the best option for BirdLife in South America to monitor the status of the region's grasslands. The following are some of the advantages:

- **Mapbiomas** already has its own institutional, programmatic and financial momentum.
- Grasslands is currently a priority biome and their first grasslands report is about to being published, led by Santiago Baeza.
- In conversation with Patrick Lendrum (2021 12 08), WWF US is considering adopting **MapBioma**´s approach which very likely may soon become a preferred approach not only throughout South America but in other regions of the world.

Moreover, the progress made by **MapBiomas** in terms of regional LUC/LCC offers a unique opportunity to link BirdlIfe´s database of the grassland birds, accumulated over the last 15 years, to better assess potential correlations.

IV Potential role for Birdlife

All persons interviewed coincide in indicating that to monitor the status of the South American grasslands, **MapBiomas** already offers a well established and functional institutional framework and has already amassed key information to help understand the changes in the region´s grasslands. Currently, the information that is already available for most biomes covers the last 20 years and the next phase is expected to cover from 1985 onwards.

Some thematic areas that BirdLife may want to consider exploring with **MapBiomas** could include:

- ☐ Complement the existing satellite imagery with historic aerial photography of photogrammetric value.
- ☐ Assess the usefulness of protected areas as points of reference of “pristine” grasslands habitats (FA)
- ☐ Support palynological analyses to help rebuild ancient environments and complete the picture of regional changes (e.g., Behling and Pillar, 2007; Spalding and Lorscheitter, 2015).
- ☐ Assess the changes that have taken place overall in South America´s grasslands compared to changes that have taken place on the IBAs and KBAs, and their relationship with the trends of bird populations.
- ☐ Evaluate the representativeness of Protected Areas in terms of the ecoregional biodiversity.
- ☐ Convene a workshop with the key players to agree on the definitive base map representing the Pampas´ grasslands
- ☐ Assist in completing the Pampas´ grasslands assessments from 1985 to 1999 for Argentina and Uruguay to be a la par with Brazil.

Moreover, a potential common theme to be addressed by Birdlife and **MapBiomas** jointly with ongoing assessments underway with **Plowprint** in North America which and what size of priority native grassland areas may need to be restored to revert the trend of bird loss throughout the region (PL).

Funding and partnership opportunities

The following are some of the key financial sources that support **MapBiomas** (Sparovek et al., 2019: 16):

- The Gordon and Betty Moore foundation
- Norway´s International Climate and Forest Initiative (NICFI)
- The Nature Conservancy (TNC)
- World Resources Institute (WRI)

Key videos

2014, (**Plowprint**)Targeting grassland conservation: An estimate of land use conversion risk in Northern Great Plains https://www.youtube.com/watch?v=LU0N36lHuOI

2017, Iniciativa **MapBiomas** (9:33 min). In Portuguese.
https://www.youtube.com/watch?v=QmwI5b8aTSg

This excellent video highlights the multi-institutional collaborative effort and presents in a very didactic way the MapBiomas cartographic process.

2019, Lanzamiento de la Colección 1 de Pampa Sudamericano (2000-2019)
https://www.youtube.com/watch?v=jc8feUF7eY4

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Directory

Diego De Abelleyra MapBiomas
Investigación Clima y Agua
Instituto National de Tecnología Agropecuaria
Argentina

Fabiana Arévalos. MapBiomas
Coordinadora del Programa Hábitat y Paisajes
Guyra Paraguay / Biocentro
Parque Ecológico Asunción Verde
Avda Carlos Bóveda – Viñas Cue
Asunción – Paraguay
Tel: (595 21) 229097 Cel (595 976) 369977
fabiana@guyra.org.py
www.guyra.org.py

Tasso Azevedo. MapBiomas
General Coordinator MapBiomas
Member of Sustainability Committee
Santander Brasil

Ana Eljall MapBiomas
Analista en gestión de la información socioambiental
ana.eljall@vidasilvestre.org.ar

Anne M. Gage PlowPrint
Anne Gage
anne.gage@wwfus.org
Sarah Olimb
sarah. olimb@wwfus.org
Jeff Nelson
jeff.nelson@wwfus.org
Northern Great Plains Program, World Wildlife Fund–US

Patrick Lendrum PlowPrint/Mapbioma
Science Lead
NGP
WWF US
patrick.lendrum@wwfus.org

Mayra Milkovic MapBiomas
Responsable del Área
Sistemas de información geográfica (SIG) y Teledetección
Fundación Vida Silvestre Argentina
mayra.milkovic@vidasilvestre.org.ar

Maria Eugenia Periago MapBiomas
"Euge"
Coordinadora
Manejo y Producción Sustentable
Fundación Vida Silvestre Argentina
Defensa 251 6toK (C1065AAC)
Ciudad Autónoma de Buenos Aires, Argentina
T (+54) 011 4331-3631 interno 138
C (+54) 911 38132083
Skype maria.periago
maria.periago@vidasilvestre.org.ar

Marcos Rosa MapBiomas
Technical Coordinator MapBiomas Brazil

Eduardo Vélez MapBiomas
Geokarten
Brazil
evelezmartin@gmail.com