Conserving aquatic ecosystems in the Amazon

Wildlife Conservation Society

FIU Florida International University

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Amazon Waters

Citizen Science for the Amazon

With the support of

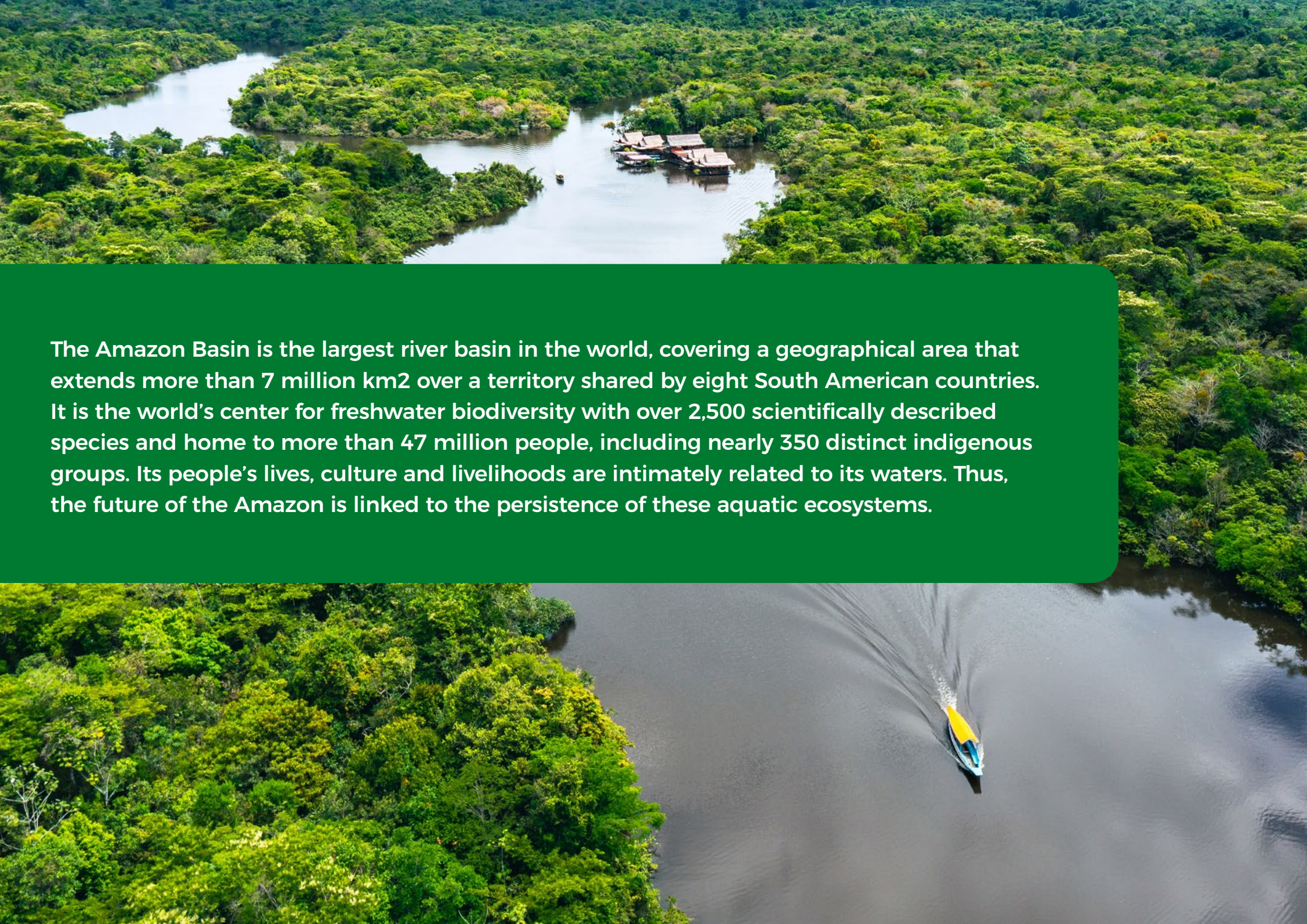
Gordon and Betty Moore Foundation

A team of 25 experts convened by the **Wildlife Conservation Society (WCS)** under the Amazon Waters Initiative identified the following large-scale conservation targets for aquatic ecosystems in the Amazon Basin:

1. **Conserve connected riverscapes of the Western Amazon to maintain Andean influences and protect biocultural diversity.**
2. **Maintain biodiverse and functional floodplains[1] that provide critical ecosystem services.**
3. **Sustain freshwater commercial fish and fisheries to support biodiversity and human wellbeing.**

These targets seek to guide conservation and development actions in the Amazonian to ensure the sustainability of the largest river basin in the world.

[1] Also called alluvial plains, these are the areas that are seasonally covered by water during the rainy or high water season.



The Amazon Basin is the largest river basin in the world, covering a geographical area that extends more than 7 million km2 over a territory shared by eight South American countries. It is the world's center for freshwater biodiversity with over 2,500 scientifically described species and home to more than 47 million people, including nearly 350 distinct indigenous groups. Its people's lives, culture and livelihoods are intimately related to its waters. Thus, the future of the Amazon is linked to the persistence of these aquatic ecosystems.

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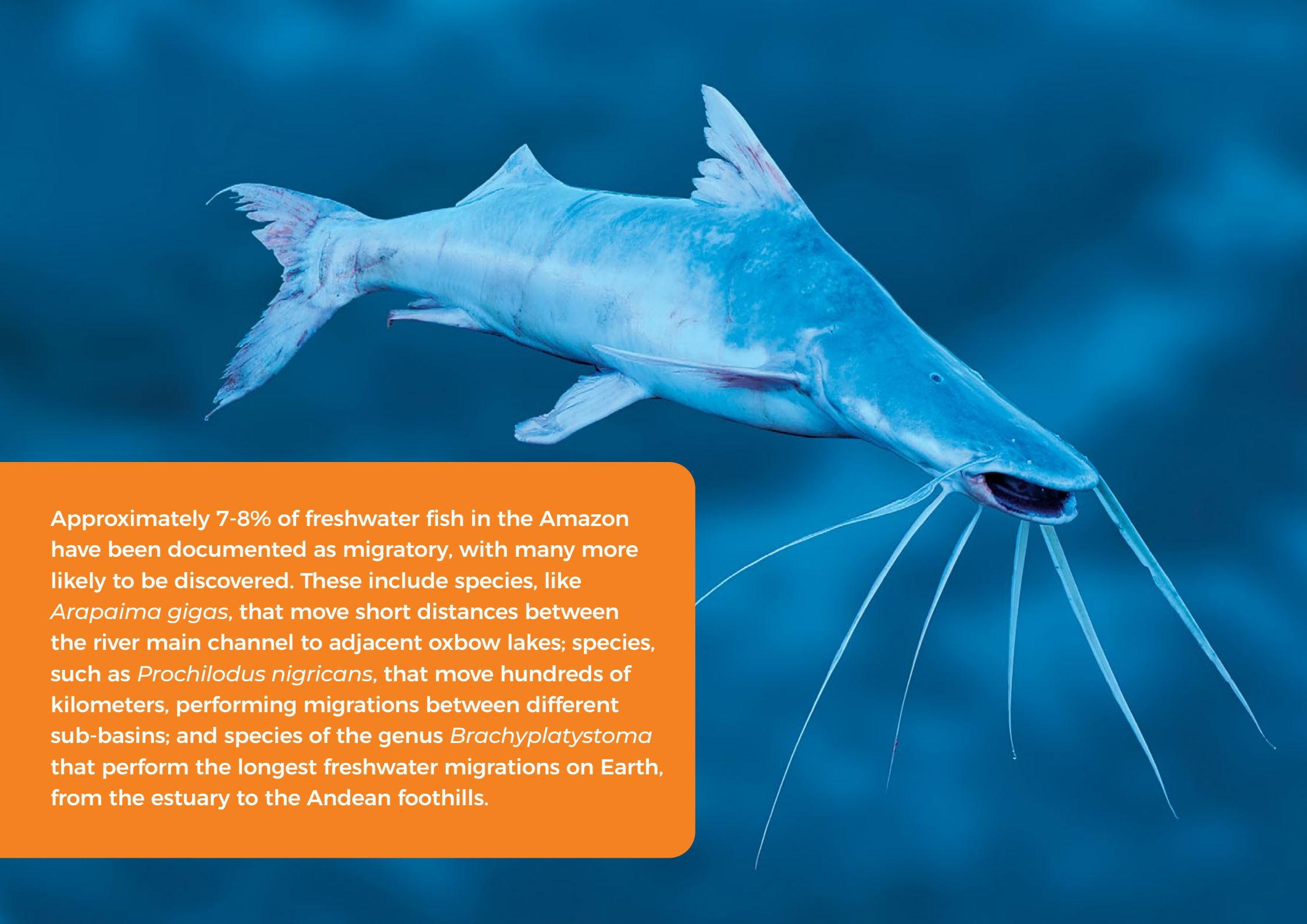
The waters that become part of the main course of the Amazon River begin high in the Andes Mountains, more than 4,500 meters above sea level, where groundwater springs up and glaciers melt to form a network of streams. As they flow down the eastern slopes of the mountain range, these streams erode the landscape gathering large amounts of sediments, nutrients and organic matter, which is then deposited in the Amazonian lowlands.

The Andean influences in the Amazon are evident thousands of kilometers from their mountainous origins downstream, from diverse lowland floodplains to the the unique estuary where the Amazon river meets the Atlantic Ocean.

The combination of high gradients, extreme climates and unique geology in the Andes create a constellation of freshwater habitats, which harbor thousands of aquatic species, from fish to birds and insects.

People's livelihoods and culture are also intimately linked to the diversity of aquatic ecosystems that exist in the Amazon Basin. Rivers provide navigable routes connecting rural and urban people across the basin. The floods that occur during the high water season carry sediments that provide the nutrients necessary to support floodplain agriculture. The basin's productive and diverse fisheries support people's food security and regional economies. Rivers also provide a basis of spirituality for many of the basin's Indigenous People, with origin stories rooted in rivers and their biological diversity.



Approximately 7-8% of freshwater fish in the Amazon have been documented as migratory, with many more likely to be discovered. These include species, like *Arapaima gigas*, that move short distances between the river main channel to adjacent oxbow lakes; species, such as *Prochilodus nigricans*, that move hundreds of kilometers, performing migrations between different sub-basins; and species of the genus *Brachyplatystoma* that perform the longest freshwater migrations on Earth, from the estuary to the Andean foothills.

The future of the Amazon is linked to the conservation of its aquatic ecosystems. Rivers integrate processes that occur across the landscape. Deforestation, roads, hydroelectric dams, fires, overfishing, agricultural expansion, among other factors, affect ecosystem integrity and river connectivity. Despite accelerating change, the Amazon remains one of the least altered rivers on Earth, with thousands of kilometers of unimpeded flow. There is still an opportunity to protect its aquatic ecosystems and ensure a sustainable future for the biodiversity and people that depend on them.

Available data indicates that as of 2020 there were around 326 dams in operation throughout the Basin and an estimated 562 more in various stages of planning. Dams reduce river connectivity, disrupt migratory fish pathways, and alter sediment delivery from the Andes to the lowlands.

STILL A LOT TO DO

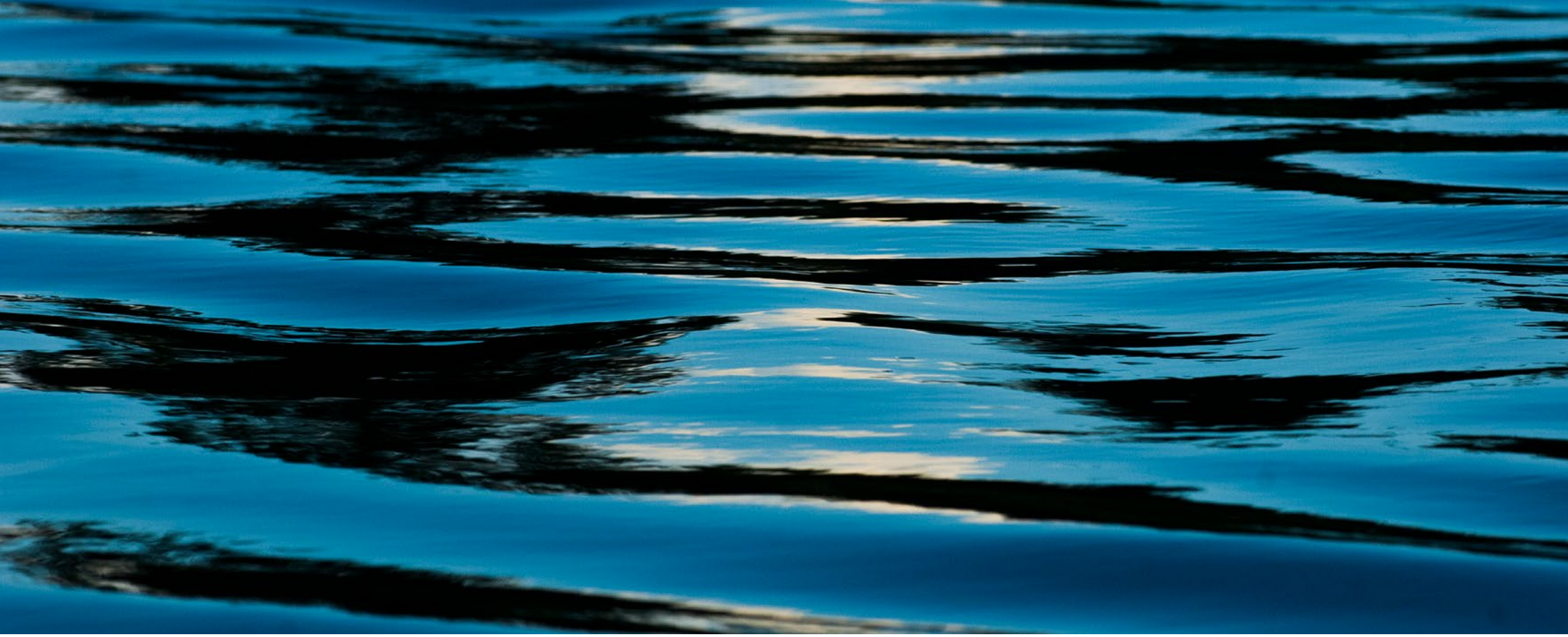
Over the last few decades, high rates of deforestation in the Amazon have attracted the interest of both the scientific community and general public. This has also generated collaborative action which has been decisive in catalyzing important conservation achievements, including the creation of large protected areas. Thanks to these numerous public and private initiatives, millions of hectares of Amazon forests have been saved from destruction.

Aquatic ecosystems, however, have been often overlooked.

To catalyze a similar investment in Amazon waters, a group of 25 experts met between December 2019 and October 2021 to identify broad-scale targets for Amazon conservation and highlight the unique nature of the basin's aquatic ecosystems.

First, the group highlighted the important role of the Andes and the rivers originating in the mountain range in shaping the ecology of the Basin as a whole. Andean rivers mobilize massive amounts of sediment, nutrients and organic matter to the Amazonian lowlands, which is why the footprint of the Andes is so visible downstream.

Second, the group highlighted the importance of the natural flood pulse regime for the functioning of the aquatic systems throughout the Amazon Basin. The magnitude, duration and seasonality of the flood pulse modulates the connection between the main river and the floodplains, affecting biodiversity and the ecosystem services rivers provide.

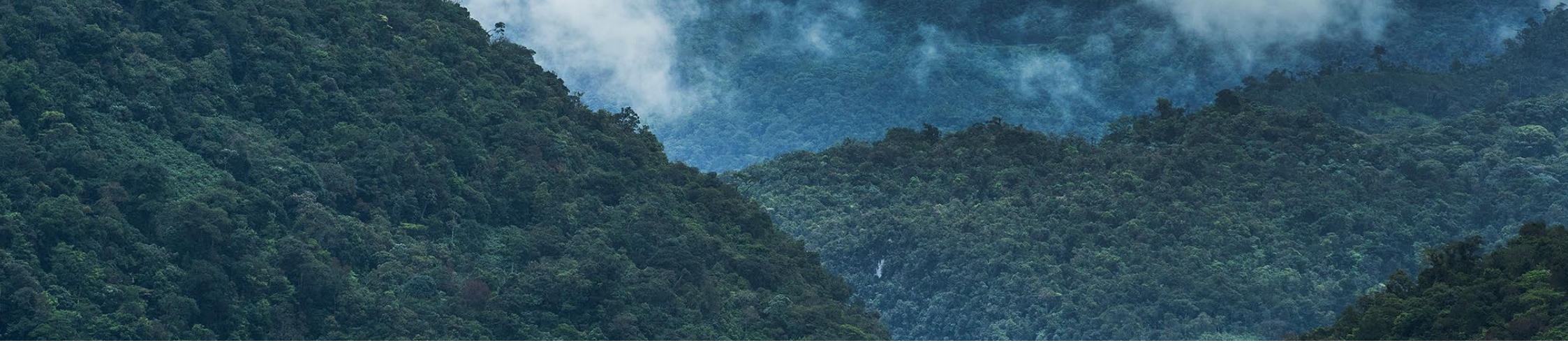


Third, the group highlighted the extraordinary diversity of fish species that inhabit the Amazon and the important links between fish and human well-being. Fisheries in the basin provide an irreplaceable source of income and food for millions of people who call the Amazon home. The species that sustain these fisheries depend on the integrity of the basin's aquatic ecosystems.

> **"The report issued by the scientific team seeks to draw attention Amazon's aquatic ecosystems and the need to conserve them."**

CONSERVATION TARGET 1

Conserve connected riverscapes of the Western Amazon to maintain Andean influences and protect biocultural diversity.



The Western Amazon is the region encompassed by the basins of all Andean-origin rivers that drain toward the mainstem Amazon. This region extends from Colombia through Ecuador and Peru to Bolivia along the eastern slopes of the Andes, and into western Brazil in the lowland parts of Andean origin river basins.

The major basins of the Western Amazon include the Caquetá-Japura, Putumayo-Iça, Napo, Marañon, Ucayali, Javari, Purus, and the Madre de Dios, Beni, and Mamoré which form the headwaters of the larger Madeira River basin. These river basins are characterized by strong elevational and climatic gradients.

The Western Amazon as a region, and specifically the slopes of the Andes, harbor biological diversity unparalleled by other places on Earth. The region is a known global center of species richness and endemism across plants, birds, small mammals, amphibians, and fishes, and rivers are an important influencing factor on biological diversity.

Beyond biodiversity, the region's rivers also influence the livelihoods, culture and society of the people who live in the Western Amazon. **Rivers and freshwater biota are prominent in the cosmologies of several Indigenous groups and the daily life of riparian human communities is tightly linked to the rhythmic nature of river flows.**

Although **the area covered by river basins of Andean origin above 500 m is only 13% of the whole Basin**, their influence extends well beyond the Western Amazon. The contributions of sediments and nutrients from this area are disproportionate to its relatively small size.

Most of the suspended sediments found in the main channel of the Amazon come from Andean sources. Andean tributaries provide much more nitrogen and phosphorus to the Amazon than its lowland tributaries.

The productivity of the Amazon floodplains depends on nutrients derived from the Andes. Without this contribution, these lowland aquatic ecosystems would not support diverse assemblages of fishes and provide nursery areas for many migratory species.

Finally, the contributions of the Western Amazon to the greater Amazon are not one-directional: **the rivers of the Western Amazon provide migratory corridors for fish species that move from the lowlands to the Andean foothills to reproduce and feed.**

Conservation Target

To conserve connected riverscapes of the Western Amazon to maintain Andean influences and protect biocultural diversity.

The scientific underpinnings of this target are: (1) that the Andes mountain range exerts strong regulatory controls on the ecological characteristics of downstream Amazon river reaches, floodplains, and estuary, as facilitated by connectivity along riverine pathways; and (2) that the Western Amazon is a global center of biological and cultural diversity, and this diversity is tightly linked to river ecosystems.

Baselines for this target include longitudinal connectivity, hydrology and freshwater biota.

Longitudinal Connectivity

Two main factors affect the connectivity of Andean-Amazon rivers: hydroelectric dams and road crossings.

Currently, there are 888 locations along rivers that are associated with dams, with 326 having existing dams and 562 in various stages of planning. Three-hundered and ninety six of these existing and planned dams are located in the Western Amazon. New dams are concentrated in the Marañon, Ucayali, Napo and Madre de Dios river basins. Only the Putumayo and Javarí have no existing or proposed projects.

> **Achieving this target depends on maintaining longitudinal connectivity along the main Amazonian Andean rivers and preventing the introduction of physical barriers to these systems in the future.**

For road crossings, headwater streams tend to be the most vulnerable to fragmentation. In the Western Amazon there are 13,734 road crossings that potentially impose barriers to longitudinal connectivity.

Hidrology

Streamflow patterns in the Western Amazon are largely driven by precipitation. Precipitation and, consequently, stream flow is highest in the northern tributaries of the Western Amazon (Caquetá-Japura, Putumayo Iça, Napo), and decreases towards the south-east (Beni, Mamoré). Precipitation is generally lower in high Andean sub-basins compared to lower elevations.

Driven by a combination of precipitation patterns and geology, **the Andes supply most of the sediment discharged by the Amazon River.** Of the rivers in the Western Amazon, the Marañón, Ucayali, Madre de Dios, Beni and Mamoré contribute the most sediment to the lower Amazon.

Freshwater biota

The biodiversity of the Western Amazon was mapped based on (1) fish richness and endemism patterns; and (2) species distribution and migratory fish routes. **A total of 1,772 fish species inhabit rivers of Andean-Amazon origin** with the Madeira basin having the highest number of total species and the Javari and Juruá having the lowest.

Considering the basin size, the Napo basin has the highest density of species, while the Caquetá and Juruá have the lowest. The number of Amazonian endemic species mirror these species density patterns. However, patterns differ when considering only the number of species endemic to each Andean basin, with the Madeira having the highest number and density of unique species, followed by the Marañón and Ucayali.

707 species inhabit stream sites over 500 masl in the Andean Amazon region, but richness decreases with higher elevation. High elevation sites are dominated by

reange-restricted species, especially the Madeira and Putumayo-Içá basins.

Across the entire Amazon basin, migratory fish species richness peaks along the lower mainstems of the Amazon and the Madeira rivers, and decreases towards the Amazon headwaters and estuary. The mainstems of all the major basins that originate in the Andean Amazon are used by a variety of migratory species. Some species reach areas over 500 masl, notably in the Madeira, Marañón, and Ucayali basins.

Recommendations for monitoring

Monitoring changes in river longitudinal connectivity, especially as a result of new dams and road crossings, by updating the a database of fragmentation points and re-running the analysis every 2 years is imperative. The impact of road crossings on longitudinal connectivity also needs to be better understood.

It is also recommended to monitor biodiversity, and the number of non-observed and extinct species, updating a database every two years. Broadening analysis to other aquatic groups, including amphibians, birds, mammals and invertebrates will help gain a more complete picture of biodiversity in the Western Amazon.

CONSERVATION TARGET 1

Conserve connected riverscapes of the Western Amazon to maintain Andean influences and protect biocultural diversity.

The Western Amazon is the region encompassed by the basins of all Andean-origin rivers that drain toward the mainstem Amazon. These river basins are characterized by strong elevational and climatic gradients, and contain an array of unique habitats. The Western Amazon as a region, and specifically the slopes of the Andes, harbor biological diversity unparalleled by other places on Earth.

This target recognizes the importance of conserving the rivers of the Western Amazon because of their influence on the ecosystems of the Amazon basin in general.

The area of the Andean origin river basins above 500 m is only about 13% of the Amazon Basin, but the contributions of sediments and nutrients from this area are disproportionate to its relatively small size.The region is also known as a global center of biodiversity, with high species richness and endemism across plants, birds, small mammals, amphibians, and fishes. Aquatic ecosystems are essential in harboring this biodiversity.

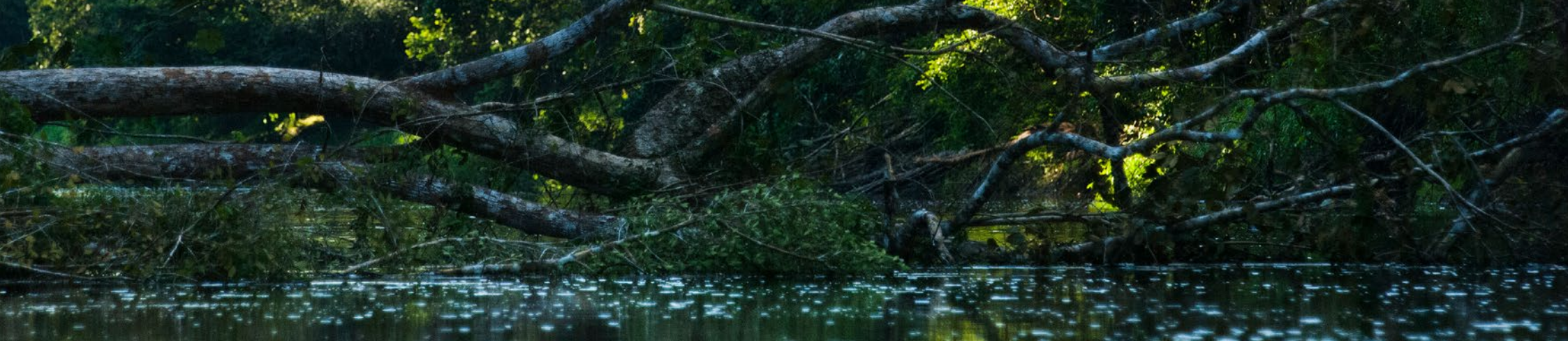
Rivers of the Western Amazon offer critical migration corridors for fish species that move from the lowlands into the Andean piedmont and foothills for spawning.

Rivers in the Western Amazon also influence culture and livelihoods of the people who live in the region. Rivers and freshwater biota are prominent in the cosmologies of several Indigenous groups and daily life of riparian human communities is tightly adapted to the rhythmic nature of river flows.

Factors that fragment rivers and decrease longitudinal connectivity can disrupt these myriad social and ecological processes. Therefore, monitoring the construction of dams and roads and their impact on biodiversity in the region is critical to achieve this conservation target.

CONSERVATION TARGET 2

Maintain biodiverse and functional floodplains that provide critical ecosystem services.



The Amazon floodplains are among the most biologically diverse and productive ecosystems on Earth and provide a huge variety of services to humanity.

Floodplain biodiversity and productivity stems from natural flooding that occurs when water rises above the river-channel into the alluvial plain, carrying sediments and replenishing nutrients.

The Amazon Basin has some of the largest floodplains in the world. However, they are **under pressure from stressors that could push them to a tipping point, where the ecosystem could reach a transformed and irreversible state.**

Modifications in the flood pulse can disturb Amazonian floodplains sufficiently and induce a transition from biodiverse and functional ecosystems that provide essential ecosystem services to depauperate ecosystems. **Such state change would cause a reduction or loss of biodiversity and vital ecosystem services.**

As ecosystems approach critical thresholds, they can manifest characteristics that serve as early-warning signals. Detection of these early-warning signals in the short term can help foresee and prevent future drastic changes in floodplains.

> **Climate change, deforestation and the development of hydroelectric dams are factors capable of altering the regime of some Amazon rivers, which may cause the interruption of the flood pulse in several river basins.**

Conservation Target

The conservation target is to maintain biodiverse and functional floodplains that provide critical ecosystem services. The scientific underpinnings of this target are fourfold: (1) alterations to the flood pulse regime reduce lateral connectivity between habitats and the size of the floodplains; (2) floodplains are mosaics of multiple interconnected habitats and changes in floodplain land cover reduces biodiversity; (3) longitudinal floodplain connectivity supports the dispersal of plants and animals, sediment depositional processes, and nutrient recycling; and (4) species interactions are an integral part of the functionality of floodplain ecosystems.

Achievement of this target depends on maintaining three attributes of the flood pulse regime — predictability, duration, and magnitude — together with ensuring the persistence of floodplain forests, which support both aquatic and terrestrial plants and animals and numerous ecosystem services.

Baselines for this target include characteristics of floodplain ecology and hydrology.

Characterization of the Amazonian floodplains

Floodplains form along lowland tributaries under 500 masl, occupying 16.8% of the lowland Amazon basin. The annual floodpulse drives lateral connectivity, linking ecological processes in river channels and floodplains.

Floodplains extend over thousands of kilometers and have distinct geomorphology, water quality, and seasonally flooded plant communities. Lateral and longitudinal connectivity, and the associated ecological processes (e.g., flood pulse, sediment and nutrient loads, and plant and animal dispersal), create dynamic systems that support complex habitat mosaics. The persistence of these dynamic habitats for over 110 thousand years has facilitated the evolution of a unique biodiversity.

Recommendations for monitoring

The long-term conservation of aquatic biodiversity in the lowland rivers of the Amazon basin depends on maintaining the key attributes of the flood pulse: timing, duration, and magnitude. There is a need to expand the monitoring network of river hydrology across the Amazon basin. Although numerous gauges record streamflow in river channels, creating a basin-wide network of automated data loggers is imperative.

Such effort needs to be coupled with monitoring of biotic indicators, covering fish, bird, reptile and plant communities together with floodplain specialists and fisheries that rely on floodplains. Species with short life cycles should be focal, as they respond to environmental changes more quickly. Additionally, satellite data could help monitor land use change and forests in the flooplain.

Floodplain forests are a key aquatic ecosystem and can serve as sentinels to understand responses to environmental change in the Amazon. In order to monitor these changes, a monitoring network that adopts standardized protocols is needed.

CONSERVATION TARGET 2

Maintain biodiverse and functional floodplains that provide critical ecosystem services

Floodplains in the Amazon are some of the most biologically diverse and productive ecosystems on Earth, providing a wide variety of economic and cultural services. However, they are under pressure from stressors that could push them to a tipping point, where ecosystem could reach a transformed and irreversible state.

As ecosystems approach critical thresholds, features are observed that serve as early warning signals. Detection of these signals can help predict future drastic changes.

The working group identified climate change, deforestation and the construction of hydroelectric dams as factors capable of altering the hydrological regime, disrupting the flood pulse and reducing lateral connectivity of rivers with the floodplain.

Achieving this target depends maintaining three attributes of the flood pulse regime —predictability, duration, and magnitude— together with ensuring the persistence of floodplain forests, which support both aquatic and terrestrial plants and animals, and numerous ecosystem services.

Floodplain forests are a key aquatic ecosystem and can serve as sentinels to understand the responses of environmental change in the Amazon.

CONSERVATION TARGET 3

Sustain freshwater commercial fish and fisheries to support biodiversity and human wellbeing.

Migratory species are the most important fish captured in the commercial fisheries of the Amazon. This is due to a combination of factors that make them vulnerable to exploitation, such as their abundance, size and schooling behavior. There are ominous indications of the collapse of several important migratory fish species, especially of iconic long-distance migrants. **The decline of these long-distance migratory species would represent a tipping point not only for Amazon fisheries, but also for aquatic biodiversity in general.**

The management of migratory fish species in the Amazon faces major challenges including: lack of a legal framework, regulations and appropriate government interventions; poor understanding of species life cycles and population status; and lack of continuous monitoring of fishery landings, among others. **If overfishing of long-distance migratory species is not controlled, then there will be little incentive to protect other migratory species and their wetland habitats, and thus fisheries in general.**

Three criteria were applied to select species that would be representative of the overall challenges and opportunities for achieving this conservation target. First, because there are dozens of migratory fish species captured in commercial fisheries, we chose to focus only on those that make long-distance migrations. Second, the species selected are among the most important commercial species, at least based on historical fisheries landings. Third, a combination of overfishing, wetland deforestation, and dams now places these species at their tipping point of biomass collapse. This approach allowed us to consider ecosystem connectivity from the Andes to the Atlantic, but also lateral connectivity from the river channels to the floodplain.

Conservation Target

The overall conservation target is to sustain freshwater commercial fish and fisheries to support biodiversity and human wellbeing. Under this umbrella, the three subtargets are: (1) Maintain relative importance of migratory fish species at about 80% of sustainable total commercial catch; (2) Fish migrations uninterrupted in main channels of all seven remaining undammed major Andes-Amazon rivers, and Madeira dams mitigated to allow fish passage to Bolivia and Peru; and (3) 80% of remaining upland and flooded forest conserved in sub-basins critical to commercial fisheries.

Baselines for this target were established focusing on the status of emblematic species and wetland deforestation.

Importance and overexploitation of emblematic species

Considering the species selection criteria, the targets focused on three emblematic species: gilded catfish or dorada (*Brachyplatystoma rousseauxii*); piramutaba (*Brachyplatystoma vaillantii*) and tambaqui or gamitana (*Colossoma macropomum*). The three species have been or are currently among the most important commercial food fishes in the Amazon.

Data from fishery landings across urban centers in the Amazon, although imperfect, can be useful for understanding the status of some species. These data indicate that all three target species are significantly overfished in the Amazon.

Although there is less data on size, which provides complementary information on species status, some studies have also found that individuals caught are becoming smaller. This is particularly evident near large cities, such as Iquitos, Manaus and Belém, ultimately underscoring that fisheries in the Amazon could be approaching a tipping point.

Wetland deforestation

Large-scale deforestation of wetland forests is most pronounced from just west of the Negro River to western Marajó Island in the estuary. The floodplains in much of this area suffered deforestation beginning with the jute boom in the 1930s and later with widespread zebu cattle and water buffalo ranching.

Floodplain deforestation has impacted Tambaqui in the eastern Amazon River where there are large floodplain lake nurseries and once extensive floodable forests.

Recommendations for monitoring

To acheive this target and prevent fishery collapse based on migratory species, a series management recommendations were identified.

Improving the regulatory environment and strengthening governance around fisheries is imperative. This requires reestablishing the governments responsibility to monitoring urban fish landings. This information is critical to asses stocks and help agencies make informed management decisions. Expanding these efforts to rural areas would be a step towards unifying urban and rural fisheries management.

Establishing market regulations to reduce fishing effort and pressure on large migratory catfish, especially for the industrial fishing fleet in the estuary, is critical. Sustainable fisheries will also rely on implementing species catch quotas and eliminating subsidies that incentivize overfishing.

Because rivers and the fish that live in them transcend international boundaries, Amazonian countries need to establish agreements on fisheries management and governance.

Finally, there are other factors that affect fisheries, migratory fish and fisheries biodiversity, such as floodplain deforestation, and dams. Historically, floodplain deforestation has been concentrated west of Manaus along the Amazon River, but if it continues at a similar rate in the next three to five decades, it will soon spread to the Andean countries. Monitoring and mitigating the impacts of deforestation, dams and overexploitation is essential to ensure a sustainable future for fisheries and the human populations that depend on them.

CONSERVATION TARGET 3

Sustain freshwater commercial fish and fisheries to support biodiversity and human well-being.

Migratory species are the most important fish captured in the commercial fisheries of the Amazon. However, there are ominous indications of the collapse of several important migratory fish species, especially of iconic long-distance migrants.

If overfishing of long-distance migratory species is not controlled, then there will be little incentive to protect other migratory species and their wetland habitats, and thus fisheries in general. The elimination of these long-distance migratory species would represent a tipping point not only for Amazon fisheries, but also for aquatic biodiversity.

Management of long-distance migratory fish species can only be effectively and realistically addressed at the regional level through integrated and centralized government actions that monitor and evaluate fish stocks, implement fisheries regulations, mitigate the impacts of dams, and preserve the wetlands that fish depend upon.

Recommendations to acheive this conservation target include: (1) Unite urban and rural fishery management; (2) Reinstate government responsibility to collect urban fishery market data; (3) Reduce fishing effort through enforced market regulations; (4) Eliminate fishing subsidies; (5) Foster interstate and international fishery agreements; (6) Mitigate impacts of the Madeira dams; (7) Monitor deforestation in floodplains; and (8) Monitor ecosystem level impacts of overfishing.

PEOPLE AND WATER

Freshwater conservation in the Amazon is not possible without people, yet establishing metrics or indicators that consider human, social, and cultural dimensions of freshwater conservation is challenging. We know that Amazonian people's lives and livelihoods are intimately linked to freshwater ecosystems, which provide major sources of food and income security, routes for transportation and communication, and connections to biocultural heritage.

Although conservation targets specific to human-freshwater interactions were not defined, each of the three previous conservation targets recognizes ecological attributes of the Amazon Basin upon which people depend, such as fisheries, seasonal flooding regimes, and river connectivity.

Instead, the working group explored the human dimensions of Amazon freshwater conservation in 2021 by meeting with experts on these topics (both individually and as a group). These meetings were intended to provide guidance on what issues are important to focus on, given the timeline and conditions of the working group, as well as to begin to envision collaborations for the future. Based on these meetings, certain things stood out: where people live; biocultural diversity; policies that govern people's interactions with rivers.

Approximately 47 million people live in the Amazon basin, and people are increasingly concentrated in urban areas. **Human populations are concentrated in two main areas: in the Andean Amazon region**, particularly at middle and high elevations, where large cities are found along major river courses; or **in large cities along main river courses in the lowlands.** The cities of Manaus and Belém, for example, have more than two million inhabitants each.

Of the tributary sub-basins, the Madeira has the highest human population, which is concentrated in large cities like Cochabamba and Santa Cruz de la Sierra, Bolivia, and Porto Velho, Brazil. The Marañon sub-basin also has a relatively high human population compared to many parts of the Amazon, much of it contained in urban areas of the high Andes, like the Latacunga-Ambato-Riobamba metropolitan area of Ecuador, and in cities in the Peruvian lowlands, like Iquitos and Yurimaguas.

Outside of cities, more rural Amazonian human populations reside in riparian villages, some outside and others within protected areas.

Where people reside in the Amazon is likely to change as the Amazon changes. Many parts of the basin are experiencing rapid urbanization, either from the expansion of large cities like Manaus, Belen, or Iquitos, or from the growth of human populations and industry in smaller cities.

Urbanization and the growth of cities in the Amazon has implications for Amazonian flora and fauna. For freshwater fishes, previous studies have demonstrated that major cities cast a large shadow of defaunation. Changes to historical river flow patterns and geomorphology of Amazonian rivers that occur as a consequence of climate change or human activity may also affect cities along river courses, leading to increased flooding and damage to urban infrastructure.

Potentially increased frequency and magnitude of droughts, which affect Amazon freshwater ecosystems and their biota, could also compromise quality of life and human health for Amazonian populations that depend on freshwaters.

As important as where people live in the Amazon is who lives in the Amazon. Amazonian people are described by many different terms: Indigenas, ribereños, caboclos,

riparian human populations, colonos, afro-descendants, and more. These terms are not exclusive of one another as many Amazonian people could be described by multiple terms.

Urban areas in the Amazon bring together these diverse human populations. Freshwater ecosystems are intimately linked to and strongly influence the lives and livelihoods of Amazonian people. Food and income security of Amazonian people depends on freshwater fisheries, as recognized in the third target described here. Freshwater fishes also feature prominently in the origin stories of numerous Indigenous groups in diverse ways.

Rivers, especially in the lowlands, are the main thoroughfares for transportation and communication, critical connectors of riparian human populations in remote areas and in cities. Even many large Amazonian cities, such as Iquitos, Peru, are only accessible by river or air, not by road.

Additionally, the natural variability in river flows influences the timing and nature of human life events across the year. The flood pulse, for example, makes areas for collection of non-timber forest products or fishing areas more accessible by water, or facilitates faster transportation to distant human populations. Seasonal calendars from Amazonian communities, such as the Tukano in the Rio Negro sub-basin of Brazil and the Shawi in the upper Marañon sub-basin of Peru, illustrate how important cultural practices and even just the rhythms of daily life are tied to the rhythms of river

flows across the year.

Language diversity is an example of the biocultural connections between humans and freshwater ecosystems in the Amazon. At least 350 different Indigenous groups are thought to inhabit the Amazon and they speak at least 300 different languages.

There are numerous linkages between freshwater ecosystems, their species, and languages across the Amazon.

These linkages would also depend on longitudinally and laterally connected riverscapes, whose importance was articulated in the first two conservation targets presented here. **Connections between language diversity and freshwater ecosystems in the Amazon merit to be further studied and incorporated into conservation targets.**

The size, diversity, and transboundary nature of the Amazon Basin create both opportunities and challenges for freshwater governance at a basin scale. Eight countries and one territory share the Amazon; these national boundaries are further subdivided by other in-country political jurisdictions. At a basin level, knowledge gaps and political and economic barriers constrain effective transboundary governance, despite the existence of Pan-Amazonian organizations like The Amazon Cooperation Treaty Organization or agreements like the Leticia Pact.

There are examples of freshwater-focused legal frameworks that recognize the natural dynamism of rivers; these include Colombia's Protected River Framework and a new effort in Ecuador that aims to recognize the rivers and their basins as River Reserves. As part of the effort to develop freshwater conservation targets, an inventory of freshwater-related policies in the Amazon is being undertaken. Efforts to expand inventory and understanding of freshwater policies should be considered for further study.

Acknowledgements

This work was made possible thanks to the support of the Gordon and Betty Moore Foundation (GBMF) through the Wildlife Conservation Society (WCS). We extend our thanks to the GBMF colleagues for their comments throughout the process, especially to Kristina McNeff, Avecita Chicchón and Paulina Arroyo. We appreciate the coordination and guidance of Mariana Varese and Mariana Montoya by WCS, and the assistance of Gina Leite and Tatiana Onzaga for administrative and communications support. We thank the many colleagues who work or live in the Amazon who offered their knowledge to this work. The information in this report is the product of the effort, time and experience of numerous colleagues, with centuries of collective experience and understanding of the Amazon Basin. Finally, we acknowledge the freshwaters of the Amazon itself, as a source of continuous inspiration and intellectual curiosity.

Suggested citation

Anderson E, Correa S, Couto T, Goulding M, (Eds). 2022.
Conserving aquatic ecosystems in the Amazon. Lima,
Wildlife Conservation Society.

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First edition
December 2022

This publication has been made possible thanks to the generous support of the Gordon and Betty Moore Foundation (GBMF) under the project "Understanding the freshwater ecosystems of the Amazon through science and collaboration at scale".

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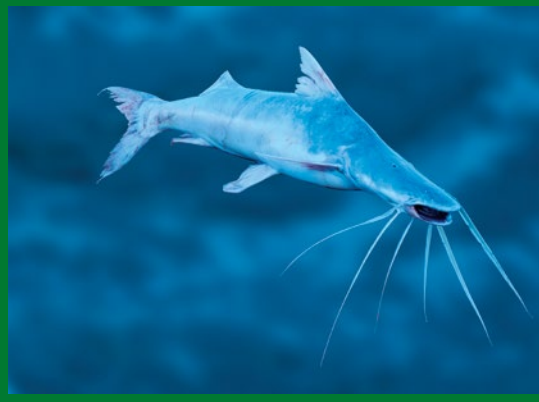

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