BRAZILIAN ACTION PLAN FOR THE CONSERVATION OF AMAZON FRESHWATER TURTLES

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FRESHWATER TURTLES

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Presentation

The use of Amazon freshwater turtle by people that live in the Amazon is millennial. Try to interrupt this relationship is an almost impossible task and, maybe, it would not even be necessary if consumption remained only for eating and did not become an industrial activity, which occurred, when its fat started to be used to illuminate the streets of big cities. The struggle for preservation of the Amazon freshwater turtles started in the XIX century when governing authorities, in the service of the Portuguese Crown, realized that this resource could end. At that time, there were reports that it was difficult to navigate in some rivers without hitting turtle hooves, such was the amount of them.

A lot has happened since then. Fauna is no longer considered a resource and eating turtle has become a crime. Even so, the populations of turtles continued to reduce drastically, to the point where some species almost enter the Brazilian List of Endangered Species. This did not occur, perhaps, thanks to the efforts of great pioneers like José Alfinito, Cléber Alho and Luiz Pádua who, in the 1970s, who started a conservation program that is still alive, the *Programa Quelônios da Amazônia* – PQA (Amazon Turtle Program).

At the time of its creation, IBAMA inherited the task of continuing this program. Throughout its development, it became apparent that simply banning the use would not be enough to recover the populations of Amazon freshwater turtles.

The Plano de *Ação Nacional* – PAN (Brazilian Action Plan) for the Conservation of Amazon Freshwater Turtles was proposed with the intention of achieving conservation by reconciling preservation actions with sustainable use. This idea was raised 40 years ago by the renowned ecologist Russel Mittermeier.

IBAMA, with its expertise in managing the PQA, and ICMBIO, with great experience in coordinating national action plans for conservation, created this Brazilian Action Plan in 2014, with the collaboration of other institutions that also dream, one day, of being able to navigate a river in the Amazon Basin stumbling (gently) on turtle shells.

In memoriam

by Camila Rudge Ferrara[1]

In 1989 was the first time that the American – almost Mexican – Richard Carl Vogt, better known as Dick, arrived in the Amazon and since this first contact, he soon began a long technical partnership with the Amazon Turtles Program (PQA – IBAMA), which would last for over 30 years. In 2014 he started another partnership with IBAMA, as part of the Brazilian Action Plan for the Conservation of Freshwater Turtles, where he could contribute with his knowledge of the species, their habitats, study methods, training of managers and strategies for protection and management of the nesting sites of these animals.

Besides his rich contribution to public policies, his legacy was even greater in the academia, where he generated a lot of knowledge through his research and, consequently, in the publications of more than a hundred articles, books, and book chapters. I would venture to say that to date no other researcher in Brazil has contributed as much to the knowledge of the Amazon turtles as Dick. However, his greatest contribution was in the formation of 37 masters and 16 doctorate specialists who are today continuing his legacy and fighting for the conservation of the Amazon turtles.

Dick was a peculiar and special person who would never want to be described as super cool or kind. Whoever met Dick never forgot him, because there was no other like him, he was always very original. I had the great privilege of living next to him for 17 years, learning from every conversation, but what I admired most about him, besides the knowledge he had, was his endless enthusiasm for chelonian studies. Dick had a thirst for knowledge and the will to live to understand more and more how the dynamics of this enigmatic group works.

Dick, thank you for all your teachings and contributions including this book, both in chapters and in translation. Unfortunately, you are not here today to see one more of your contributions reaching the world, but you can count on me and the whole group of people who are part of Brazilian Action Plan for the Conservation of Freshwater Turtles to continue your fight! Miss you always.

1 PhD in Freashwater Ecology and Inland Fisheries at INPA. Wildlife Conservation Society Ecologist.

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1.1 The Amazon Biome

The Amazon Biome is the largest of the six Brazilian biomes, representing about 30% of all the tropical forests remaining on the planet, extending for an approximate area of 4.5 million km^2 within Brazil. This biome has an enormous environmental diversity, with 53 vast ecosystems with more than 600 different types of freshwater and terrestrial habitats, resulting in a rich biodiversity with thousands of species of plants and vertebrate animals (SAYRE et al., 2008; SFB, 2010). The Amazon Forest is the showcase of the biodiversity of the world, with 10% of the total diversity of the planet occurring in this region (VIEIRA et al., 2001).

In addition to its natural richness, the Amazon also has a wide cultural diversity. Among the 25 million residents, there are about 170 indigenous tribes, with a population of about 180,000 individuals 357 remaining communities of former quilombos[2] and thousands of rubber tappers, Brazil nut collectors, riverside dwellers, babaçu coconuts collectors, fishermen communities among others, demonstrating that abundance and social and environmental diversity are characteristics that mark this area of the planet (CAPOBIANCO, 2001; MONTEIRO; SAWYER, 2001).

The vegetation that characterizes the Amazon Biome is the dense ombrophilous forest and the open ombrophilous forest. In addition to these forests there are also types of vegetation typical of savannas, *campinaranas*[3], pioneer formations, and vegetation refuges (IBGE, 2004). Ab'Saber (2002) makes an interesting explanation about the variety of the Phyto physiological characteristics of the Brazilian Amazon, showing a complex mosaic of this landscape, which includes several transition systems from tablelands to *Cerrado*[4] and from *Cerrado* to dryland forest, among other ecotonal areas.

The *várzea* and *igapó*[5] forests (floodplains) are also important areas that constitute this biome.

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2 A secret place where escaped slaves stayed, usually hidden in the forests.
3 Translator's note: Campinarana is a region-specific term for a type of vegetation of the Amazon region. It differs from the Amazon Forest itself by the distinct flora and the smaller size of the trees and thinner stems.
4 Translator's note: The Cerrado is a vast tropical savanna ecoregion of some states of Brazil.
5 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

The várzea is characterized by a seasonal flooding of sediment-rich river and the igapó is characterized by flood of dark waters. In the region, they are respectively called whitewater rivers and blackwater rivers (SIOLI, 1951; FERREIRA, 1997). The presence of fertile soils allied to the great biodiversity of the aquatic fauna made the flood plains forests the priority places for occupation by traditional populations (indigenous and riverine peoples), even before the colonial period (REBÉLO, 2002). The great availability of fish and aquatic vertebrates made these areas chosen as the ideal habitat by these populations (GOULDING, 1990; MCGRATH et al., 1993; BODMER et al., 1997; REDFORD, 1997).

The Amazon River Basin is the largest in the world with just over 7 million km^2. It covers nine countries, being the largest concentrations in Brazil (60%) and in Peru (13%) (MEIRELES FILHO, 2004). This basin is characterized by the Amazon River, its tributaries and floodplain lakes that interact with the rivers. Water level fluctuations are important characteristics that drive the ecological functioning of the system. During the period of flooding of the rivers, the whole system is subject to inundation. The rivers and the Amazon floodplain (*várzea*) constitute a complex of channels, rivers, lakes, islands and depressions permanently modified by the sedimentation and transport of suspended solids, also influencing the succession of terrestrial vegetation, by the constant modification, removal and deposition of material in the soils (BECKER, 2004)

The Amazon Basin begins in Peruvian territory, with the Vilcanota River, which upon entering Brazilian territory becomes known as Solimões. When it meets the Negro River, it receives the name Amazon. This basin is located in a plain region and has approximately 23 thousand kilometers of navigable rivers, which enable the development of water transportation. Navigation is important in the large tributaries of the Amazon River such as Madeira, Xingu, Tapajós, Negro, Trombetas and Jari (BITTENCOURT, 1957; DOURADO JÚNIOR, 2014).

In the Brazilian territory, this hydrographic region consists of the basins of the Amazon River, the rivers on the island of Marajó, and the rivers in the state of Amapá that flow into the North Atlantic (CNRH, 2003). Of these basins, the Amazon is the most important in terms of extension and volume of water, contributing, on average, with values of around 132,145 m^3/s (73.6% of the country total) (ANA, 2013). The main rivers that make up the Amazon Basin are Amazon, Negro, Solimões, Xingu, Madeira, Tocantins, Japurá, Juruá, Purus, Tapajós, Branco, Jari and Trombetas.

Another important watershed partially present in the Amazon Region is the Tocantins-Araguaia. This system is one of the largest in terms of water availability, covering just over 10% of the Brazilian territory (918,273 km^2) and includes the states of Goiás, Tocantins, Pará, Maranhão, Mato Grosso and the Federal District. The basin is located mainly in the Midwest Region, from the sources of the Araguaia and Tocantins Rivers to their confluence (MMA, 2006).

A relevant area for biodiversity conservation that is formed in the middle portion of the Araguaia River is Bananal Island. With an area of approximately 2,000,000 hectares, 80 km wide (east-west) and 350 km long, Bananal Island is considered the largest river island in the world and has all of its extension fully protected by the Karajá Indigenous Land and the Araguaia National Park (RODRIGUES et al., 1999; SALERA JÚNIOR, 2005; NASCIMENTO, 2007).

The complex of these watersheds has great importance for the protection of the Amazon freshwater turtles of the region, being considered as the reproductive nursery of these animals and it is the focus of action of the *Programa Quelônios da Amazônia* – PQA (Amazon Turtle Program). This program acts in the areas of natural occurrence of turtles, in the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins, Goiás and Mato Grosso, keeping under protection reproduction areas distributed in the following rivers: Purus, Juruá/ states of Acre – AC and Amazonas – AM; Amazonas, Aporema, Flexal, Pracuúba Lake/ state of Amapá – AP; Tapajós, Xingu, Trombetas, Amazonas/ state of Pará – PA; Guaporé/ state of Rondônia – RO; Branco, Anauá/state of Roraima – RR; Javaés/state of Tocantins – TO; Araguaia, Crixás-Açu/state of Goiás – GO and Rio das Mortes/state of Mato Grosso – MT (IBAMA, 1989; CANTARELLI et al., 2014).

1.2 Threats to the Amazon Biome and to the Turtles

Most of the Amazon Biome is considered relatively well preserved. However, the losses in biodiversity related to the advance of the agropastoral frontier to replace native forests and the processes of environmental degradation are invaluable. In this context, the construction of hydroelectric plants, paving of highways, waterways, disorganized human occupation, overexploitation of fauna and flora resources, fires, irrigation projects and canalization of water bodies, which add new threats to natural ecosystems, stand out. The influences of global climate change on the balance of the Amazon ecosystems are still little known.

With regard to the conservation of turtles of the Amazon, the direct effects of these threats potentialize alterations in the water regime of the region, favoring floods or prolonged droughts and silting up of rivers, which can cause severe disturbances in the reproductive, migratory and feeding processes of these animals, among others.

1.3 Strategic areas for the conservation of Amazon freshwater turtles

The main nesting environment for turtles consists of beaches formed during the ebbing of rivers, where females use to lay their eggs. Several authors demonstrate the complexity of the reproductive behavior of some Amazon freshwater turtles, including the aggregation of several females in shallow waters near the beaches and the thermoregulatory behavior during this period (VANZOLINI, 1967; ALHO et al., 1979; PRITCHARD; TREBBAU, 1984; VOGT, 2008).

The nesting behavior of these animals is triggered by the ebbing of rivers, when the beaches chosen for breeding emerge during the dry season and nesting usually occurs in the months of greater drought. The beaches are influenced by the natural dynamics of the Amazonian rivers, which remove and deposit sediments on the sandbanks, increasing and decreasing the nesting areas. The geological aspects of these beaches vary along the rivers, or even along the course of the same channel, being controlled by the characteristics of the substrate and the hydrologic regime, being able to form varied sandy deposits (FERREIRA JÚNIOR, 2003). The diversity of shapes, dimensions and granulometry of sediments are large, suggesting a wide range of water and thermal environments on these beaches. The nesting of turtles, however, occurs in specific points that are apparently carefully chosen by the species, being considered strategic areas of conservation (FERREIRA JÚNIOR; CASTRO, 2005).

The selection of nesting sites by female turtles is one of the most important factors for the survival of the hatchlings and the maintenance of the species (PANTOJA-LIMA, 2007; REFSNIDER; JANZEN, 2010), and this choice can significantly interfere with the reproductive parameters of freshwater turtles (SPENCER; THOMPSON, 2003; NOVELLE, 2006). Such parameters as hatching success, incubation time, litter size, survival and sex ratio of the hatchlings depend directly on factors related to the characteristics of the nests and the external environment (FERREIRA JÚNIOR, 2003; FERREIRA JÚNIOR; CASTRO, 2006), which determine reproductive success and specificity for each nesting region and are essentially important for the activities of conservation and management of turtles.

In this sense, the Amazon Region is a mosaic, whose cycles of nature and biological, environmental and social diversity form a holistic model that integrates nature and human population. The biodiversity of the Amazon, especially that of turtles, has been used for decades by traditional populations for symbolism, food and commercial purposes, representing a vital role in the survival and regional economy (REBÊLO; PEZZUTI, 2000; PEZZUTI et al., 2010).

1.4 History of Amazon turtles conservation in Brazil

The Amazon Region is known as a large freshwater turtle nursery. Its discovery as an important faunal resource occurred when, during the period of colonization of Brazil, the Portuguese collected the turtles' eggs for the production of butter, and oil, which were used in cooking. The oil, extracted from the fat and eggs, was used in lighting systems, especially in Europe, where almost all the production was exported. Manaus, capital of Amazonas, even had its streetlamps supplied with turtle oil (SMITH, 1979).

Turtles were also used for food. The females were collected after nesting and stored in large corrals to serve as food during the flood season, when fishing became more difficult. The shells were used as bowls, agricultural instruments or burned to obtain ash that, mixed with clay, produced a byproduct for the manufacture of pots and other objects. The neck skin was used as a tobacco pouch or stretched for the manufacture of tambourine. The fat mixed with resin was used to caulk boats (SMITH, 1979; REBELO; PEZZUTI, 2000).

At that time, the exploitation of turtles, especially Amazon turtles, was intense and the governing authorities at the service of the Portuguese Crown adopted several initiatives to rationalize the use of these animals. One of them was the appointment of a "judge", as representative of colonial authority, who remained vigilant on the nesting beaches, demanding that no one approach such places during the posture of eggs. When the posture was over, the butter manufacturers, accompanied by an inspector and his assistants, proceeded to capture the mother turtles. According to this rule, all the excess in live animals had to be returned to freedom and replaced in the river. One third of the nests with eggs had to be spared for the conservation and propagation of the turtles and only the other two thirds could be used for the manufacture of butter. However, little by little, these and other measures ended up being disrespected, so that exploitation intensified in a disorganized manner.

The concern with the protection of the Amazon freshwater turtles had continuity with the arrival of the Republic. In 1932, the Hunting and Fishing Division was created in the Ministry of Agriculture and then the Hunting and Fishing Service was established, which was previously managed by the Ministry of the Navy. In 1934, the Hunting and Fishing Code was enacted for the protection of fauna and fishing resources, which restricted the use and capture of turtles. The Hunting and Fishing Service was responsible for the protection of fauna, including turtles, but again, as the first initiatives taken during the Colonial Period, this measure had little effect on the protection of these animals. In 1962, the Hunting and Fishing Division was extinct and the *Superintendência do Desenvolvimento da Pesca* – SUDEPE (Superintendence of Fishing Development) was created, subordinated to the Ministry of Agriculture, a change that did little to benefit the Amazon freshwater turtles, mainly because of the difficulty of its operation due to the lack of structure, personnel and articulation of this Superintendence in the States. Because of these factors, the turtle protection work was restricted only to patrolling during the nesting period (PORTAL; BEZERRA, 2013).

The Brazilian Federal Government, in order to reverse this situation, started, in 1964, the first actions to protect the turtles in the Rivers Trombetas (Pará), Purus (Amazonas) and Branco (Roraima) (IBAMA, 1989). In general, the actions on the Purus and Branco Rivers were also restricted to patrolling during the nesting period. Only on the Trombetas River did these initiatives continue, as they were supported by researchers and other institutions. These actions were initiated by the *Agência do Departamento de Recursos Naturais Renováveis* – DRNR (Agency of the Department of Renewable Natural Resources), of the Ministry of Agriculture. With the edition of Law Nº 5,197, on January 3, 1967 (Fauna Protection Law), which prohibits the capture of wild animals for the commercialization of skins and meat, an attempt was made to mitigate the extermination of important species for the ecosystem. Even so, the clandestine trade of turtles continued to exist.

In 1967, the *Instituto Brasileiro do Desenvolvimento Florestal* – IBDF (Brazilian Institute of Forest Development) was created and the DRNR was extinct, and their archives, assets and financial resources were transferred to the new institute. Thus, the actions for the protection of turtles were left to IBDF. However, in 1968/69, under Decree Law Nº 221 of February 28, 1967, which provides for protection and incentives for fishing, the turtles were once again considered as fish, which forced the transfer of projects to protect turtles in the Trombetas, Purus and Branco Rivers to the jurisdiction of SUDEPE. However, in 1970, as SUDEPE in Belém/ state of Pará – PA was devoid of technical, human and financial resources, the turtles protection service had to return to IBDF.

In the early 1970s, turtles, especially the species giant South American river turtle (*Podocnemis expansa*) and yellow-spotted river turtle (*P. unifilis*), were indicated for the list of Brazilian animals in the process of extinction. But in the first list, published in 1973 (IBDF Ordinance Nº 3.481, May 31, 1973), the Amazon freshwater species were not included.

That same year, IBDF presented at the International Symposium on Amazonian Fauna and Lake/River Fishing, held in Manaus/state of Amazonas – AM, the experiences accumulated in the first years working with the protection of the Amazon freshwater turtles. After this presentation, a large team composed of professionals from various institutions and states was created to carry out a broad survey of the areas of occurrence and nesting of these animals. This work was carried out in the following two years and culminated in the publication of IBDF Technical Bulletin Nº 5, in November 1978. The survey provided an increase in knowledge related to the distribution, abundance and main threats of these animals, and contributed to the inclusion of the giant South

American river turtle and the yellow-spotted river turtle in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES, through Federal Decree Nº 76.623, in 1975. Another important contribution of this work was the resumption and expansion of the actions to protect turtles. In the early 1970s, only two rivers (Trombetas and Tapajós), both in the state of Pará, were actually under the protection regime. Other areas were then effectively protected, such as the Branco River (1977-78) and the Xingu River (1979).

In 1979, the Project for the Protection and Management of Amazon freshwater turtles was created, coordinated by IBDF, today it is called *Programa Quelônios da Amazônia* – PQA (Amazon Turtles Program), which aimed at the protection and the reproductive management of freshwater turtles. With the PQA, these actions were strengthened and expanded and, with the knowledge accumulated over the years, IBDF defined a basic methodology for the protection and management of these animals. In 1989, almost 10 years after the creation of the Amazon Turtle Program, the *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) was created, with the merger of IBDF and three other federal agencies, the *Secretaria Especial de Meio Ambiente* – SEMA (Special Secretariat of Environment); the *Superintendência da Borracha* – SUDHEVEA (Superintendence of Rubber) and the *Superintendência do Desenvolvimento da Pesca* – SUDEPE (Superintendence of Fisheries Development). In order to expand and integrate the actions of the PQA, IBAMA created, in 1990, the *Centro Nacional de Quelônios da Amazônia* – CENAQUA (National Center of Amazon freshwater turtles), through Ordinance Nº 870, whose purpose was to expand the activities, creating specific coordination for areas of research, protection and management, captive breeding and environmental education, related to the conservation of continental turtles.

Because of taxonomic expansion and functional reorganization at IBAMA, CENAQUA became a *Centro de Conservação e Manejo de Répteis e Anfíbios* – RAN (Reptile and Amphibian Conservation and Management Center) in 2001 and began to manage and license, throughout the national territory, all management and conservation activities for continental Brazilian reptiles and amphibians, giving priority to species threatened with extinction and economic interest.

In 2007, with the restructuring of IBAMA, the *Instituto Chico Mendes de Conservação da Biodiversidade* – ICMBIO (Chico Mendes Institute for Biodiversity Conservation) was created and the RAN became part of the structure of this Institute, now under the name of National Center for Research and Conservation of Reptiles and Amphibians, with the mission of carrying out scientific research and actions for the conservation and recovery of threatened species of reptiles and amphibians, and monitoring their state of conservation, as well as assisting in the sustainable management of these species in conservation units.

Despite the new institutional link between RAN and ICMBIO, the *Programa Quelônios da Amazônia* – PQA (Amazon Turtle turtles Program) remained under the responsibility of ICMBIO until 2010, and was later reintegrated into IBAMA, submitted to the *Coordenação de Gestão, Destinação e Manejo da Biodiversidade* – COBIO (Coordination of Administration, Destination and Management of Biodiversity), linked to the *Diretoria de Uso Sustentável da Biodiversidade e Florestas* – DBFLO (Directorate of Sustainable Use of Biodiversity and Forests), of IBAMA.

RAN, through the Program for Monitoring and Conservative Management of Amazon freshwater turtles, has been implementing a series of actions, through research projects aimed at the conservation of these animals, in federal conservation units. These projects are carried out thanks to the technical support of important conservationist and research entities such as the *Instituto Nacional de Pesquisa da Amazônia* – INPA (National Institute of Amazonian Research), *Empresa Brasileira de Pesquisa Agropecuária* – EMBRAPA (Brazilian Agricultural Research Company), *Universidade Federal do Pará* – UFPA (Federal University of Pará), *Universidade Federal do Amazonas* – UFAM (Federal University of Amazonas), *Universidade Federal do Tocantins* – UFT (Federal University of Tocantins), *Associação de Ictiólogos e Herpetólogos da Amazônia* – AIHA (Association of Ichthyologists and Herpetologists of the Amazon), Mamirauá Sustainable Development Reserve, *Pé-de-Pincha* Project, Amazon Turtle Project, among others. In their areas of operation are protected, monitored and managed, primarily the giant South American river turtle, the yellow-spotted river turtle and the six-tubercled Amazon River Turtle (*P. sextuberculata*); and, secondarily, the red-headed Amazon river turtle (*P. erythrocephala*), the big-headed sideneck turtle (*Peltocephalus dumerilianus*) and the scorpion mud turtle (*Kinosternon scorpioides*), due to the socioeconomic and cultural importance they represent in their regions of occurrence. The synthesis of turtles' management can be seen in Figure 1.

In four decades of the PQA (1979 to 2019), more than 80 million hatchlings were managed and about 800,000 females were monitored during the breeding process, in 11 areas and 212 nesting sites, in the states of the North and Midwest regions, highlighting the giant South American river turtle, the yellow-spotted river turtle and six-tubercled Amazon river turtle. These actions have provided the protection and recovery of the natural populations of these species and, consequently, contributed to the conservation of the biodiversity associated with them.

Thanks to the efforts of this program, in its several interfaces, the protection of the main Amazon freshwater turtles populations and their feeding and

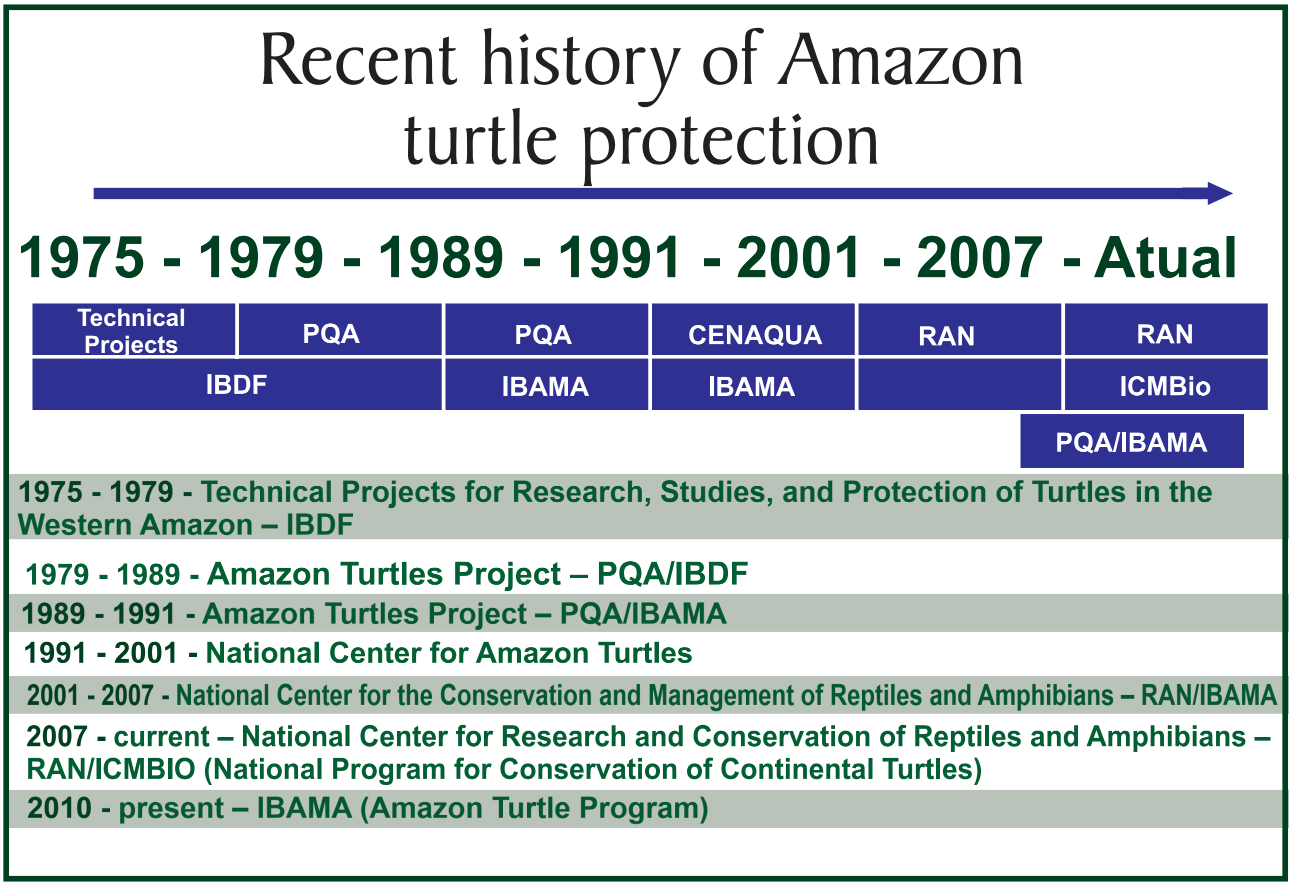

Figure 1 – Synthesis of the history of protection of Amazon turtes made by the Federal Government in the last four decades (BALESTRA et al. 2016).

reproduction habitats in the national territory was assured; research linked to the conservation of turtles *in situ* and *ex situ*, especially in the areas of ecology, reproduction, nutrition, populations dynamics and genetics were encouraged; environmental education actions aimed at training for conservationist management of these species were implemented in the riverside communities. It should also be noted that the greatest success of this program was that the results achieved led to the non-inclusion of the target species in the List of Brazilian Wildlife Species Threatened with Extinction (BRAZIL, 2014).

Despite the merit achieved, these efforts should be improved and intensified, since in the process of assessing the risk of extinction of the Brazilian herpetofauna, coordinated by RAN/ICMBIO, according to IUCN methodology, in 2010 the species *Podocnemis expansa*, *Podocnemis sextuberculata* and *Podocnemis unifilis* were categorized as Near Threatened (NT) (ICMBIO, 2018).

In practice, these actions are effectively materialized from the integration of inter-institutional efforts, highlighting IBAMA and ICMBIO, with the collaboration of various sectors of society, directly involved in the Brazilian Action Plan for the Conservation of Amazon freshwater turtles, which translates into short-, medium- and long-term strategies for conservation and recovery of populations of target and benefited species.

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Chapter 2

Target Species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles

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Giant South American river turtle (*Podocnemis expansa*)

Other common names: capitari (male), tartaruga (female) (Brazil)

Figure 1 – Head of an adult female *Podocnemis expansa* (Photo: Roberto Lacava).

Description of the species: its head has a large interparietal shell, with the presence of an interorbital groove. Males, juveniles and hatchlings present yellow spots on the head, while adult females have an ontogenetic variation that turns the head dark brown with advancing age (Figure 1). The carapace is flattened and wider in the posterior region and has a brown, gray or olive-green coloration. In adults, the plastron is yellow, cream or brown (VOGT, 2008; FERRARA et al., 2017).

It is the largest species of the genus *Podocnemis*. The rectilinear length of the female carapace varies from 500 mm to 1,090 mm, while that of the males varies from 400 mm to 500 mm. Males have a proportionally longer and wider tail, and a more circular carapace than females, which is more oval. The anal shell opening is U-shaped in males and V-shaped in females. And the head of the females is dark brown and that of the males has yellow spots (VOGT, 2008; FERRARA et al., 2017).

Current category in international evaluation: In the International Union for Conservation of Nature (IUCN) Red List (TFTSG, 2016a), the species was considered as Low Risk/Conservation Dependent (LC) and in the ongoing global assessment, the species, according to the Tortoise Freshwater Turtle Specialist Group (TFTSG) (IUCN/SSC), is considered Critically Endangered (CR) (RHODIN et al. 2018). In the Convention on International Trade in Endangered

Species of Wild Fauna and Flora (CITES), the species is listed in Appendix II (CITES, 2019).

Current category in the national evaluation: not on the Official National List of Endangered Species" but is classified as Nearly Threatened (NT) (BRAZIL, 2014; ICMBIO, 2018).

Geographic distribution: it presents a wide distribution in South America (Figure 2), occurring in the largest tributaries of the Orinoco, Essequibo and Amazon River drainage in Colombia, Venezuela, Guyana, French Guyana, Suriname, northeastern Peru, eastern Ecuador, northern Bolivia and northern and central-western Brazil (Figure 2) (RHODIN et al., 2018, FERRARA et al., 2017). The range of occurrence of the species is 7,718,409.97 km^2 and for the Amazon Basin it is 4,937,814.03 km^2 (FERRARA et al., 2017). Most of its distribution (68%) is in national territory.

Population status: In April 2014, a workshop was held with researchers and conservation professionals from six countries – Brazil, Colombia, Bolivia, Peru, Venezuela and Ecuador – to discuss best conservation practices, create a common management protocol for P. *expansa* and understand its state of conservation. From data generated during the workshop the conclusion is that there are currently 141,750 matrices managed throughout the Amazon territory, with the exception of Guyana and Suriname, and 77% of these females are in Brazilian territory (FORERO-MEDINA et al., 2019).

Population structure: in the Javaés River, tributary of the Araguaia River, 645 giant South American river turtle were captured, 41% were adult and the sexual ratio was 1.4 male for each female. The average length of the carapace of adult males was 41.9±5.7 cm (range: 26 – 55.9 cm) and the average weight was 6.6±2.6 kg (range: 1.6 – 15.5 kg). The average carapace length of adult females was 64.7±7.1 cm (range: 50 – 77 cm) and the average weight was 24.7±7.8 kg (range: 10.5 – 40 kg). The size class with higher frequency for males was between 30 and 35 cm carapace length and for females it was between 30 and 35 cm (PORTELINHA et al., 2014).

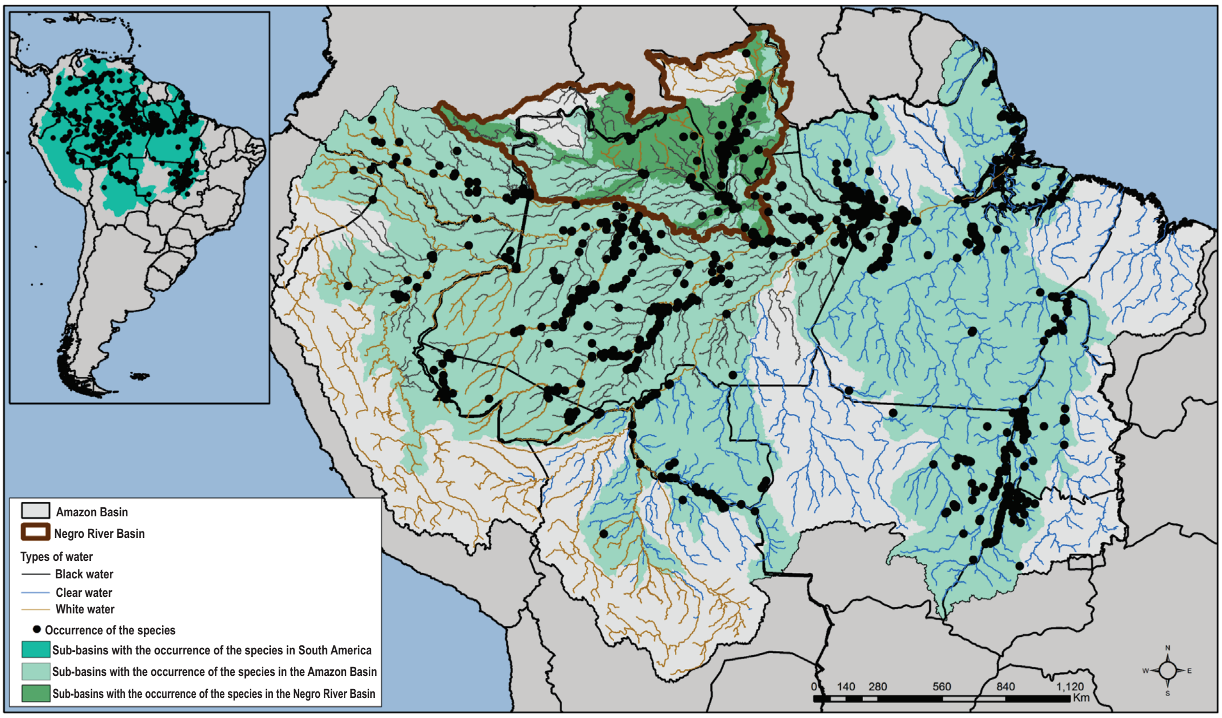


Figure 2 – Map of geographical distribution of *Podocnemis expansa* (FERRARA et al., 2017).

Habitat and ecology: aquatic species that inhabits large rivers, flooded forests and lakes. It is found in all three water systems – white, clear and black. During the rainy season, it enters the flooded forest to feed on fruits and seeds that fall into the water. In the dry season, they migrate to the rivers in search of sandy beaches that form in middle and low courses, to reproduce. Hatchlings and juveniles remain in lakes and large puddles during this period (RUEDA-ALMONACID et al., 2007; VOGT, 2008; FERRARA et al., 2017), but do not enter the *igapó*[6] and the *várzea*.

Females reach sexual maturity with about 450 mm (ALHO; PÁDUA, 1982; CHINSAMY; VALENZUELA, 2008; PEÑALOZA et al., 2013) and males with 321 mm (PEÑALOZA et al., 2013). In the dry season, females' nest, alone or in large groups (Figure 3) (ALHO; PÁDUA, 1982; SOINI, 1996; FERREIRA JÚNIOR; CASTRO, 2003), only once, during their reproductive period, on high beaches (RUEDA-ALMONACID et al., 2007), preferably of coarse sand (VOGT, 2008). They spawn on average 100 eggs (FERRARA et al., 2017), usually at night (PRITCHARD; TREBBAU, 1984), but nesting, eventually, may occur in the morning, as verified in Xingu, Tapajós, Crixás-Açu and Trombetas Rivers (BATAUS, 1998; VOGT, 2008). Nesting does not necessarily occur every year on the same beach, but in the same region of the river, as observed in the Trombetas River (state of Pará – PA), Xingu River (state of Pará – PA) and Guaporé River (state of Rondônia – RO) (VOGT, 2008; CARNEIRO; PEZZUTI, 2015).

At Abufari Beach, on the Purus River (State of Amazonas – AM), nesting were recorded with 106.7±28.38 eggs on average (up to 189 eggs) (PANTOJA-LIMA, 2007). The incubation period varied from 38 to 80 days, depending on the region (MOSQUEIRA MANSO, 1945; MITTERMEIER, 1978; BRITO, 1978; FERRARINI, 1980; NASCIMENTO, 2002; FERREIRA JUNIOR; CASTRO, 2003; BONACH et al., 2011). The sex of the embryo is determined by the incubation temperature (TSD) (ALHO et al., 1984; VALENZUELA et al., 1997). Males are expected to have an incubation temperature around 30.5°C and females when the temperature reaches 34.5°C (FERRARA et al., 2017).

In a 14-year population monitoring study in the middle Orinoco River (Venezuela), it was estimated

Figure 3 – *Podocnemis expansa* group nesting in Tabuleiro do Monte Cristo, Tapajós River/State of Pará – PA (Photo: Roberto Lacava).

6 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

that females reproduce from 11 years and that the longevity of the species can reach 80 years (MOGOLLONES et al., 2010). Considering these biological parameters, the generational time (time for the renewal of breeding individuals in the population) of 45.5 years for the species was calculated using the following equation: [age of 1st reproduction + (longevity - age of 1st reproduction)/2].

Bataus (1998) reported the vocalization between females and males during the courtship period in the Crixás-açu River (State of Goiás – GO). In 2012, Ferrara and collaborators published the first study on acoustic communication of turtles and adults and hatchlings were recorded in the wild and in captivity, during the reproductive period (from the migration to the nesting beaches until the birth of the hatchlings). In this study, 11 types of sounds were found among individuals, in and out of the water, which are used from the embryonic form (inside the egg). Parental care was also registered for this species, through acoustic communication (FERRARA et al., 2012).

Threats: it is considered one of the most threatened species in the Amazon, due to the excessive collection of eggs and adults for consumption and sale, mainly in urban centers. A conservative analysis suggested that in the 1980s and 1990s, 59-145 thousand individuals from *Podocnemis expansa* were consumed annually by rural populations in the Amazon (PERES, 2000). Deforestation, the construction of hydroelectric plants and global warming are considered notable threats to the species, although the consequences of these impacts for the maintenance of populations are still unknown, since they generate changes in the hydrological regime and interfere in the determination of sex. *Podocnemis expansa* disappears from areas of influence of hydroelectric dams, where beaches remain submerged (FELIX-SILVA, 2009).

Although the capture of individuals and the collection of eggs has been prohibited by Brazilian legislation since 1967 (BRAZIL, 1967), the illegal use of the species persists to this day. Between 2000 and 2015, IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) filed 1,803 reports of seizures of turtle specimens and/or byproducts, resulting in a total of 61,623 individuals and 4,626 kg of seized byproducts (Figure 4) (OCTAVIO VALENTE, personal communication, 2016).

Use: The Normative Instruction Nº 7 of April 30, 2015 (BRAZIL, 2015) authorizes and regulates the commercial breeding of *Podocnemis expansa* in intensive manner in the regions of its occurrence, aiming to reduce the pressure of clandestine hunting. The breeding herds are made up of hatchlings that IBAMA managed in the wild. Currently, there are 16 commercial *Podocnemis expansa* breeders legalized in SISFAUNA/IBAMA, located in the states of Amazonas (n=13), Bahia (n=1) and Ceará (n=1) (OCTÁVIO VALENTE, personal communication, 2016) and in Acre (n=1) (RICHARD CARL VOGT, personal communication, 2016), and only the latter, according to

Figure 4 – Seizure of a vessel carrying hundreds of *Podocnemis expansa* (Photo: IBAMA's archive).

a personal report by RICHARD CARL VOGT (2015), has achieved sustainability in terms of reproductive self-sufficiency, where it has the complete reproductive cycle of the species (birth – nesting).

Need for research: although *P. expansa* is one of the best studied species in the Amazon, basic studies are still lacking to understand some aspects of its biology and long-term studies on population structure and dynamics are essential, in addition to knowledge of the impacts related to the main threats to the species, such as sustainability of consumption/use, intensity of traffic and impacts of hydroelectric plants and global warming on populations (FERRARA, et al., 2017).

Yellow-spotted river turtle (Podocnemis unifilis)

Other common names: zé-prego (male) and tracajá (female) (Brazil).

Figure 5 – Hatchling of *Podocnemis unifilis* in the Negro River Basin (State of Amazon – AM) (Photo: Camila Ferrara).

Description of the species: head with two large frontal parietal scales and interparietal grooves. Hatchlings (Figure 5) and adult males (Figure 6) present yellow-orange patches on the head, while adult females (Figure 6) lose their coloration, presenting a dark-brown head. Convex and oval carapace with a dark grey, brown or black coloration. In hatchlings and juveniles, the carapace is brown or greyish green, with orange or yellow edges. Plastron is yellow or gray and may have dark patches (VOGT, 2008; FERRARA et al., 2017).

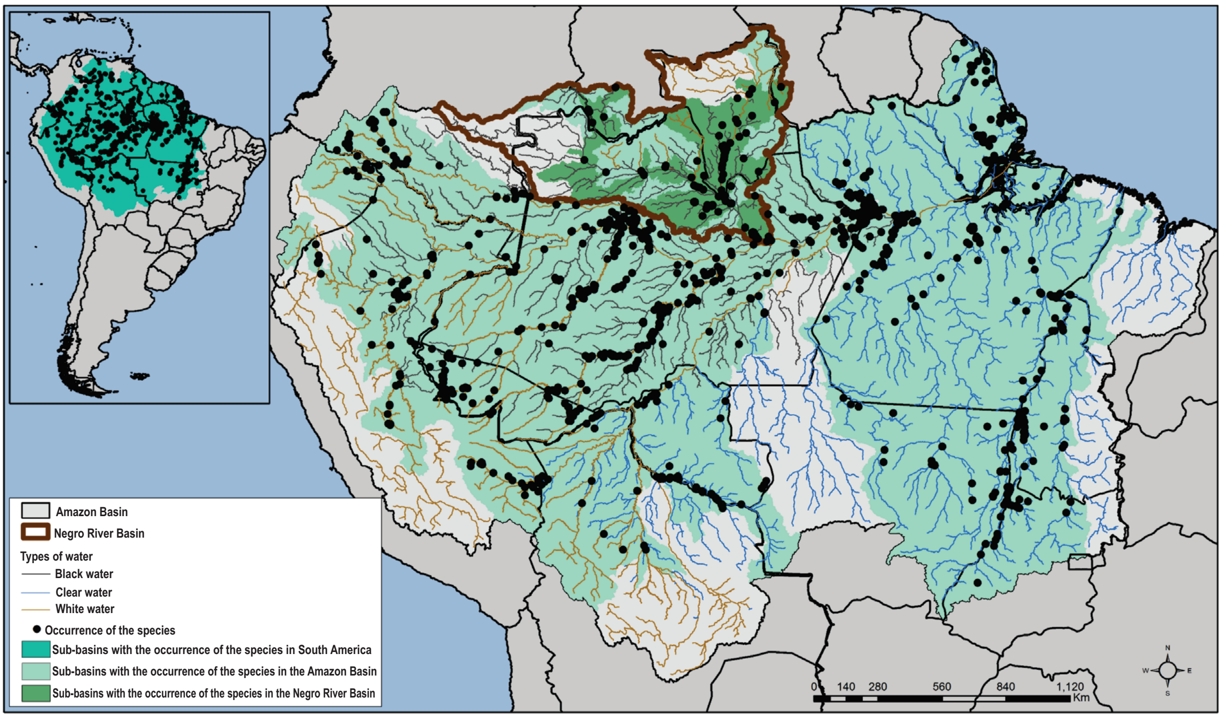
Figure 6 – Male (left) and female (right) adult *Podocnemis unifilis*, Negro River Basin (State of Amazonas – AM) (Photos: Camila Ferrara).

This species, like the others of the genus *Podocnemis*, has dimorphism between the sexes. Mature females measure between 350 mm and 500 mm and males between 250 mm and 390 mm. Males have a tail proportionally longer and wider than females. The anal shell opening is "U" shaped in males and "V" shaped in females (VOGT, 2008; FERRARA et al., 2017).

Current category in international evaluations: in the IUCN red list (TFTSG, 2016b) the species is Vulnerable (VU) and in the global evaluation that is underway, the species, according to the TFTSG, is preliminarily considered Endangered (EN) (RHODIN et al., 2018). In CITES, the species is listed in Appendix II (CITES, 2019).

Current category in the national evaluation: it is not on the Official National List of Endangered Species" but is classified as Nearly Threatened (NT) (BRAZIL, 2014; ICMBIO, 2018).

Geographic distribution: it has a wide distribution in South America (Figure 7), occurring in the Venezuelan basins of the Orinoco and Amazon Rivers, and also in Colombia, Ecuador, Peru, French Guyana, Suriname, Brazil and Bolivia (Figure 7) (FERRARA et al., 2017; RHODIN et at., 2018). The extent of the species occurrence area is 8,458,381.99 km^2 and for the Amazon Basin is 5,606,630.6 km^2 (FERRARA et al., 2017). Most of its distribution (61%) is in national territory.



Figur 7 – Map of the geographical distribution of *Podocnemis unifilis* (FERRARA et al., 2017).

Population status: it is the most common species in South America (VOGT, 2008). Abundant populations are known in many locations in Brazil, highlighting the Trombetas (state of Pará – PA), Guaporé (state of Rodônia – RO), Purus, Juruá, Jaú (state of Amazonas – AM), among others (VOGT, 2008). Brazil is the only country that still has abundant populations of this species and this is possible due to the control of human impacts.

Population structure: 837 yellow-spotted river turtle were captured in the Guaporé River and tributaries in 10 months, being 747 males, 88 females and 2 with undetermined sex. Of these, 73.4% were adults (males, 74.4%, and females 64.8%) and 26.6% were juveniles. The sexual ratio was 9.8 males per female. The average length of the male carapace was 26.4±3.28 cm (range: 9.8 – 39.6 cm). The average weight was 2.254±0.69 kg

(0.15 – 4.3 kg). The average length of the female carapace was 35.0±7.73 cm (12.4 – 46.5 cm). The average weight was 5.769±2.74 kg (0.3 – 11.2 kg). Individual size and carapace length showed normal distribution for males, with most frequent sizes in classes between 22 cm and 26 cm. For females, although not presenting a defined pattern, the highest frequencies occurred between size classes 38 cm and 40 cm (FACHÍN-TERÁN; VOGT, 2004).

In the Iriri River, tributary of the Xingu River, above the Belo Monte hydroelectric dam, 728 males, 296 females and 4 yellow-spotted river turtle (young) were captured with hand nets and diving (MIORANDO et al., 2015). The sex ratio was 9.15♂:1♀. The average carapace length for females was 268.9 ± 46.7 mm (165 – 403) and for males was 232.7 ± 24.8 mm (167 – 303) (MIORANDO et al., 2015).

Habitat and ecology: this is a common species, easily found in large rivers, lakes, swamps, wetlands, *igapós*[7] and floodplains of clear, muddy and black waters. The juveniles are registered more frequently in small lagoons and bays. Adults live in large bodies of water (VOGT, 2008).

During the rainy season, they migrate to flooded vegetation areas and in the dry season, when it is the nesting season, they migrate to the large rivers (RUEDA-ALMONACID et al., 2007). This period occurs once a year, between June and February (FACHÍN-TERÁN; VON MÜLHEN, 2003; VOGT, 2008), and is synchronized with the river ebb tide, as occurs in the other species of the genus *Podocnemis* (ALHO; PÁDUA, 1982; BATISTELLA, 2003). They usually nest at night, individually, but there are records of synchrony from 2 to 46 females nesting simultaneously (SOINI, 1996; RUEDA-ALMONACID et al., 2007; ESCALONA et al., 2009). Nesting can occur in beach, steep river banks, *matupá*[8] (floating vegetation) (FERRARA et al., 2017).

The species nests on average 50 cm from the margin, in areas with herbaceous plants, or in shadows at the edge of the forest. The incubation period varies from 66 to 159 days (VOGT, 2008), with an average time of approximately 65 days (FACHÍN-TERÁN; VON MÜLHEN, 2003; ARRAES; TAVARES-DIAS, 2014). The number of eggs and their sizes vary according to the location studied. Nests with 4 up to 52 eggs, measuring between 34 mm and 48 mm in length have being found (VANZOLINI, 1977; SOINI, 1996; HALLER, 2002; PANTOJA-LIMA, 2007; VOGT, 2008; ARRAES; TAVARES-DIAS, 2014).

Sex is determined by the incubation temperature of the eggs (SOUZA; VOGT, 1994; PÁEZ; BOCK, 1998). Temperatures between 28ºC and 32 ºC produces between 78% and 80% of males, while temperatures higher than 32.1 ºC produce more females (SOUZA; VOGT, 1994; PÁEZ; BOCK, 2004).

The sexual maturity of the species is related to the size of the animal, and males mature before females (PRITCHARD; TREBBAU, 1984). Females reach sexual maturity with about 270 mm rectilinear length of the carapace (VANZOLINI, 1977; FOOTE, 1978; FACHIN-TERÁN; VOGT, 2004; RUEDA-ALMONACID et al., 2007), and males with about 250 mm (MEDEM, 1964; FACHIN-TERÁN; VOGT, 2004; RUEDA-ALMONACID et al., 2007). The maximum size found for females was 518 mm rectilinear length of the carapace, with a body mass of 11.6 kg, while for males the maximum rectilinear length of the carapace was 423 mm and 4.5 kg of body mass (SOINI, 1996; ESCALONA, 2003).

Threats: the main threats are habitat loss and excessive consumption of eggs and adult individuals by human populations. In the state of Tocantins, for example, the habitat of the species has been reduced and fragmented due to the implementation of waterways and reservoirs of hydroelectric power plants. The construction of dams also blocks the movement of *P. unifilis* downstream or upstream from the nesting beaches, and deforestation of the floodplain area affects the species' diet during the flood season (ANDRADE, 2008; FÉLIX-SILVA, 2009). Downstream of the Belo Monte dam, 53 individuals of both sexes died trying to cross the dam stony areas. The individuals were trapped between the edges of the stones and apparently

7 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.
8 Translator's note: A large floating island, covered with vegetation, which detaches itself from the banks of rivers and is carried by the river current.

died from heat stroke (NORTE ENERGIA, 2018). In addition, disorderly tourism in reproductive areas can cause disturbances during the nesting process of the species in the states of Goiás, southeast Pará, Tocantins and Mato Grosso (VOGT et al., 2015).

The Madeira River hydroelectric plants do not seem to affect the diversity of turtles, even the populations of *P. expansa* and *P. unifilis* that could be affected by the lack of connectivity between the upstream and downstream dams, since they depend on the river and its tributaries for migration (KELLER et al., 2016).

Use: meat, eggs and by-products of the yellow-spotted river turtle have been consumed by the riverside populations and commercialized since the beginning of the occupation of the Amazon Region until today, in a legal and illegal way (Figure 8). However, consumption and trade of this species vary throughout its distribution (ATAÍDES et al., 2010; PANTOJA-LIMA, 2012).

Figure 8 – Seized vessel carrying turtles, among them the yellow-spotted river turtle (*Podocnemis unifilis*) (Photo: IBAMA's Archive)

The Normative Instruction Nº 7 of April 30, 2015 (BRAZIL, 2015) authorizes and regulates the commercial breeding of *Podocnemis expansa* in an intensive manner, in the regions of its occurrence, aiming to reduce the pressure of clandestine hunting. The breeding herd are made up of hatchlings managed by IBAMA in the wild. In 2016, there were eleven commercial *Podocnemis unifilis* breeders legalized in SISFAUNA/IBAMA, all located in the state of Amazonas (OCTÁVIO VALENTE, personal communication, 2016), but only one breeder in the state of Acre reached the sustainability of its enterprises, in terms of reproductive self-sufficiency, where it has the complete reproductive cycle of the species (birth – nesting) (VOGT, personal communication).

In addition, this species is also collected to be used as a pet. Thousands of hatchlings arrived in the United States, Europe and Japan, via Colombia and Brazil, to serve as pets before the implementation of CITES (VOGT, 2008).

Need for Research: existing programs are directed at population structure assessment and conservation of populations, as well as environmental education and nesting beach management actions. The focus only on the protection of hatchlings at the nesting beaches is not sufficient for the conservation of the species, because if the mortality of sub-adults and adults is high, there will be a drop in the recruitment rate of the population. Despite the few studies on the effects of hydroelectric plants construction, deforestation and global warming on the species, it is known that these factors generate changes in the hydrological regime, which may interfere in determining the sex and, consequently, the population structure (FERRARA et al., 2017).

Six-tubercled Amazon river turtle (*Podocnemis sextuberculata*)

Other common names: pitiú, anori, cupiso, iaçá (Brazil) (IVERSON et al., 2017).

Figure 9 – Female (above) and male (below) adult of *Podocnemis sextuberculata* in the Branco River Basin (State of Roraima – RR) (Photos: Richard Vogt and Camila Ferrara).

Description of the species: its head has enlarged interparietal scale that completely separates the parietal scales, in the females, with a dark gray to light gray coloration. Males (Figure 9) and juveniles (Figure 10) also present light-yellow patches in different parts of the head. Adult females in Rio Branco/state of Roraima – RR have patches on the head. The plastron presents six tubercles in the pectoral, abdominal and femoral scales in hatchlings and juveniles, which disappear in adult individuals. Males measure, on average, 210 mm (110 – 250) rectilinear length of the carapace and females 240 mm (170 – 310). Males have proportionally longer and wider tails than females and have light yellow patches on the head (VOGT, 2008; FERRARA et al., 2017).

Figure 10 – Hatchlings of *Podocnemis sextuberculata* in the Branco River Basin (State of Roraima – RR) (Photos: Richard Vogt).

Current category in international evaluation: in the IUCN red list (TFTSG, 2016c) the species is Vulnerable (VU) and, in the ongoing global evaluation the species, according to the TFTSG, is still considered Vulnerable (VU) (RHODIN et al. 2018). In CITES, the species is listed in Appendix II (CITES, 2019).

Current category in the national evaluation: it is not on the Official National List of Endangered Species, but it is classified as Nearly Threatened (NT) (BRAZIL, 2014; ICMBIO, 2018).

Geographic distribution: the distribution is more restricted than the other species of the genus *Podocnemis*, occurring in South America (Figure 11), southeastern Colombia, in Brazil and northwestern Peru (Figure 11) (VAN DIJK et al., 2014; FERRARA et al., 2017; IVERSON et al., 2017; RHODIN et al. 2018). The extent of occurrence of the species is 3,675,241.17 km^2 and for the Amazon Basin it is 2,672,692.16 km^2 (FERRARA et al., 2017). Most of its distribution (78%) is in Brazil.

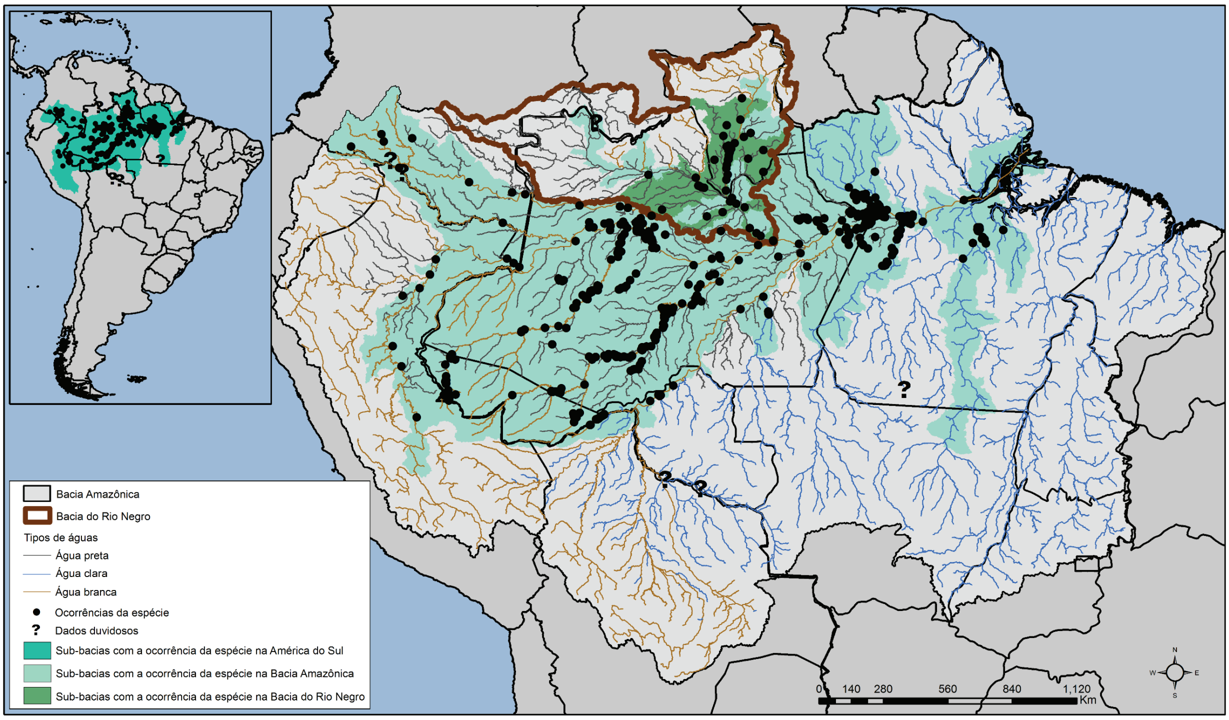


Figure 11 – Map of the geographic distribution of *Podocnemis sextuberculata* (FERRARA et al., 2017; IVERSON et al., 2017).

Population status: the species occurs in the Amazon Biome and is easily found in its habitat. It is considered abundant in the *Reserva de Desenvolvimento Sustentável Mamirauá* – RDS (state of Amazonas–AM) (Mamirauá Sustainable Development Reserve), in the Solimões, Juruá, Japurá, Trombetas and Tapajós Rivers (VOGT, 2008). In the Amazon River Basin high genetic flow was found among the subpopulations studied (SILVA et al., 2011).

In the Rivers Madeira and Aripuanã (state of Amazonas – AM), the population density found was very low (BERNHARD; VOGT, personal observation, 2010). In the RDS Mamirauá the population trend is unknown (BERNHARD; VOGT, 2004), but in a recent study it was noted that the maximum and average size of males and females are smaller than 10 years ago (FACHÍN-TERÁN, 2000; GOMES DE ARAÚJO, 2017).

In the region of Aritapera, municipality of Santarém in the State of Pará – PA, an analysis of the abundance of *P. sextuberculata* was carried out, comparing areas that had community management of hunting activity and areas without any kind of regulation, in which hunting occurs without any control. The results show that local hunting restrictions have a positive influence on turtle populations, since of the total of 354 individuals captured, 321 were registered in areas with community management and only 33 in areas that have no control of hunting activity, suggesting that in areas where there is no regulation the resource has probably decreased due to over-exploitation (MIORANDO et al., 2013).

Population structure: in an intensive study in RDS Mamirauá 2,458 *P. sextuberculata* were captured: 1,603 males and 855 females. Of these, 87 (3.5%) were recaptured once and three were captured twice (0.1%). The greatest number of captures occurred during the ebb tide in August 1997 and July-August 1998, in the backwaters near the nesting beaches. Capture was also high during the flood from December 1997 to February 1998, in the river channels and "*ressacas*" (ponds with permanent connection with a river), when the animals were entering the river. The recapture rate indicates that males are 10% more likely to be recaptured. The sexual ratio based on all individuals in the population studied was 1.87: 1 for the total focal area and 2.05:1 for the Juruá Sector. (FACHÍN-TERÁN et al., 2003). For the Jarauá sector, the sex ratio based on adults who reached sexual maturity for the entire focal area was 4.42:1, deviation to males and, to the intensive study area, located in the channels of Jarauá sector, it was 4.79:1. The size of the turtles (carapace length) *of P. sextuberculata* in the population around the focal area and the sampled area in the Jarauá sector showed normal distribution for males, with most frequent sizes between 17 mm and 22 cm. For females, the tendency was a bimodal curve, 16-19 for sub-adult females and 22 – 27 cm for adults, reaching 32 cm. The average size of males was 19.8 cm and of females 20.7 cm, with 810 g and 1,130 g, respectively. Hatchlings and juveniles under 7 cm in length are not represented because they were not captured. Seventy-two percent of captured individuals were adult animals. Juveniles and sub-adults were represented in similar proportions of 13% and 14.7%, respectively. In relation to age groups by sex, a high percentage of adult males (90.5%) was observed. Juvenile, sub-adult and adult females were well represented, with a higher number of adult females. There was a significant difference in size between males and females. Males were significantly smaller than females.

Habitat and ecology: it occurs in white and clear waters of the Amazon, including habitats such as secondary tributary channels, river channels, lakes and wetlands (FACHÍN-TERÁN et al., 2003), with rare occurrence in black water. It may also occur in mixed waters or turbid river systems, such as the Juruá River/state of Amazonas – AM, and in low-lying regions of black water rivers. At flood season, it remains in lakes, but when the water level drops, it returns to the main channel (FACHÍN-TERÁN et al., 2006; VOGT, 2008).

The nesting season is synchronized with the river ebb tide regime, as occurs with the other *Podocnemis* (ALHO; PÁDUA, 1982; BATISTELLA, 2003). Due to the variation and dynamics of the ebb tide in each location, the exposure of the nesting sites occurs at different times in the extent of occurrence of the species and, consequently, at the beginning of the nesting season. The species nests at night (RUEDA-ALMONACID et al., 2007), on beaches, at a distance of one to seven meters from the shore, producing more than three litters, with two weeks intervals each, in the same reproductive period (BERNHARD, 2001; VOGT, 2008). Nesting occurs solitarily or in groups of 20 to 50 females, but there are records of nesting of hundreds of females at the same time. The nests are found in areas of the reproductive site with an average height of 4 m above river level and, on average, between 20 m and 40 m away from vegetation (PANTOJA-LIMA, 2007). The average total depth of the nest is 17 cm (ranging from 15-23 cm) (SOINI, 1996; BERNHARD, 2001; VOGT, 2008).

The nests contain 6 to 39 eggs (BERNHARD, 2001; HALLER; RODRIGUES, 2006; PANTOJA-LIMA, 2007) and the litter size is related to female size (HALLER; RODRIGUES, 2006). The incubation period varies from 45 to 87 days (PEZZUTI; VOGT, 1999; HALLER; RODRIGUES, 2006; RUEDA-ALMONACID et al., 2007; VOGT, 2008) and the sex is defined by the incubation temperature of the eggs (VOGT, 2008).

The smallest female found nesting was 220 mm (PANTOJA-LIMA, 2007). The maximum size observed for females was 340 mm rectilinear length of the carapace and 4 kg of body mass (SOINI, 1999; VOGT, 2008). Among the males, a maximum size of 240 mm rectilinear length of the carapace and approximately 1 kg of body mass were observed (SOINI, 1999; FACHÍN-TERÁN et al., 2003).

Threats: the main threats are the consumption and trade carried out by human populations, especially breeding females and their eggs collected from the nesting beaches. As they nest only in open areas, on accessible beaches, the nests are easily detectable. In some places, egg collection is the main occupation of the human population (PEZZUTI; VOGT, 1999). The species has been widely consumed due to the decrease in populations of two other larger species, *P. unifilis* and *P. expansa* (VALSECCHI, 2005; RUEDA-ALMONACID et al., 2007).

The over-exploitation of eggs and the capture and marketing of adults affect the distribution of *P. sextuberculata* size classes in RDS Mamirauá, generating scarcity or absence of adults in some areas (FACHÍN-TERÁN et al., 2003). Official data on the illegal fauna trade in the state of Amazonas were compiled from information recorded in infraction notices issued by the environmental inspection sector of IBAMA/state of Amazonas – AM, from 1992 to 2007. In the records, 30,276 turtle specimens were registered in the Institute's inspection activities during this period, the majority being *P. sextuberculata* (n = 13,077, 43%). The species was most seized in the Purus (n = 8,266) and Solimões (n = 2,190) rivers (NASCIMENTO, 2009). In the municipality of Tapauá/state of Amazonas – AM, most turtles acquired for consumption were *P. sextuberculata* (PANTOJALIMA et al., 2014).

Besides consumption and illegal use, other threats to *Podocnemis* arise from anthropic interventions such as alteration of the species' habitat due to burning, deforestation of floodplains and riparian forests (sources of shelter and food during the flood season). Also, the Canalization and contamination of water courses, drainage, grounding and compaction of flooded areas and expansion of agropastoral activities (in place of native forests); and damming of water bodies, with the construction of dams that hinder the migration of turtles downstream or upstream of the water resource. Therefore, it is worth noting that long-term studies are needed to measure the impacts of these human activities on the six-tubercled Amazon river turtle population (MOGOLLONES et al., 2010; PANTOJA-LIMA, 2012).

Use: The Normative Instruction Nº 7 of April 30, 2015 (BRAZIL, 2015) authorizes and regulates the commercial breeding of *P. expansa* in intensive manner in the regions of its occurrence, aiming to reduce the pressure of clandestine hunting. The breeding herds are made up of hatchlings managed by IBAMA in the wild.

Currently, with no changes in their specific rules, these regulations are set forth in Annex III of Normative Instruction Nº 7 of April 30, 2015 (BRAZIL, 2015), which establishes and regulates the categories of use and management of wild fauna in captivity and defines the authorization procedures for the established categories. Until 2016, there were three commercial nurseries of *P. sextuberculata* legalized in SISFAUNA / IBAMA, all located in the state of Amazonas, in the municipalities of Manacapuru, Manaus and Iranduba (OCTÁVIO VALENTE, personal communication, 2016).

Need for research: studies are needed to assess the impacts on populations of the species from threats such as consumption and trafficking, presence of hydroelectric plants and climate change (FERRARA et al., 2017).

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Chapter 3

Species benefited by the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles

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Family: Podocnemididae

Red-headed Amazon river turtle (*Podocnemis erythrocephala)*

Other common names: Irapuca (Brazil); calalumã, chipiro (Colombia and Venezuela).

Figure 1 – Female (left) and male (right) *Podocnemis erythrocephala*, Ayuanã River, middle Negro River in the state of Amazonas – AM (Photo: Rafael Bernhard).

Description of the species: males and hatchlings of this species have a coffee-colored head with red or ochre-orange patches (Figure 1). The edge of their shells is also reddish in color. In females, this reddish color is replaced by the light brown color (VOGT, 2008). Males are smaller than females and can reach 244 mm carapace length and weight of 1,250 g, while the largest known female measured 322 mm in length and weighed 2,750g (BERNHARD; VOGT, 2012). Newborns measure between 29.5 mm and 47.4 mm maximum carapace length and weigh between 7.9 g and 15.3 g (BERNHARD et al., 2012).

Current category of international evaluation: in the International Union for Conservation of Nature (IUCN) red list and in the ongoing global evaluation by the Tortoise and Freshwater Turtle Specialist Group (TFTSG – IUCN/SSC), it is considered Vulnerable (VU) (RHODIN et al., 2018). The species is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2019).

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Data Deficient (DD) (ICMBIO, 2018).

Geographic distribution: in Brazil, it is spread throughout most of the state of Amazonas, the entire Negro River Basin, in addition to the Trombetas, Tapajós and Madeira River Basin s (Figure 2). It is also found in the extreme eastern portion of Colombia and Venezuela (MITTERMEIER; WILSON, 1974; MITTERMEIER et al., 2015). The range of occurrence of the species is 2,937,397.39 km^2 in these countries and in the Amazon Basin it is 1,439,447.84 km^2 (FERRARA et al., 2017).

Habitat and ecology: it inhabits black water rivers, but they were also found in clear water rivers such as Tapajós and Trombetas (VOGT, 2008). Although they prefer lakes and small tributaries of large rivers, some of them can occasionally be found in the channels of large rivers, such as the Negro River. They also inhabit small black water tributaries of white-water rivers, such as the Madeira or the Branco Rivers (MITTERMEIER; WILSON, 1974).

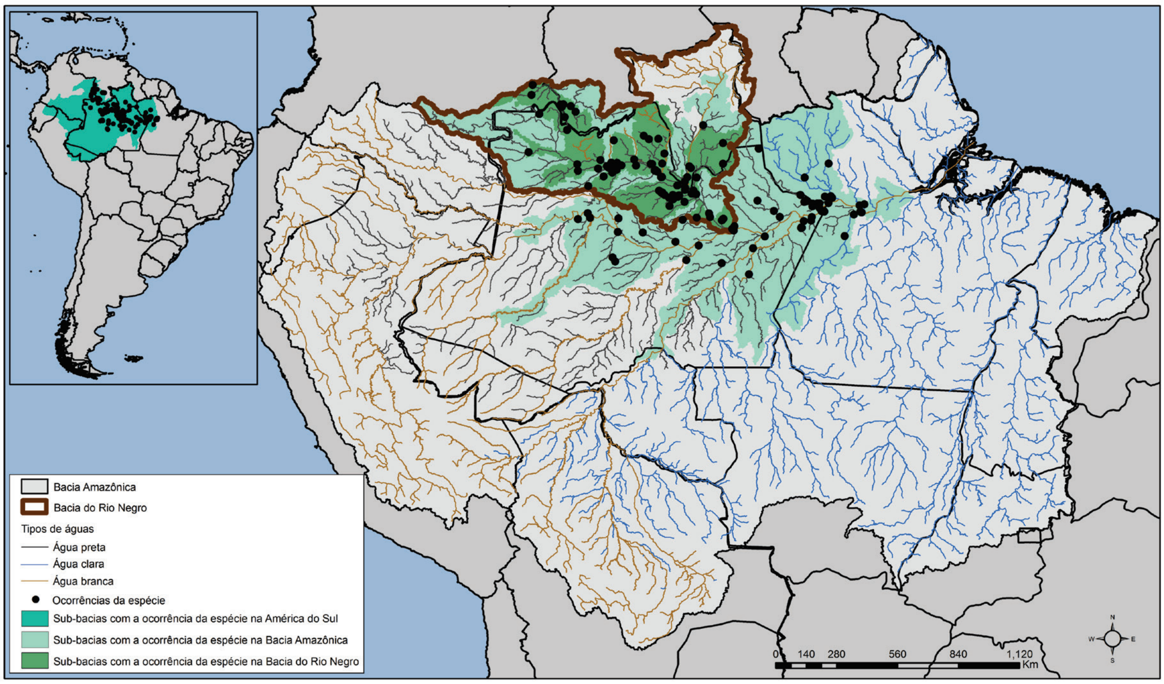

Figure 2 – Map of geographical distribution of *Podocnemis erithrocephala* (FERRARA et al., 2017).

The diet consists basically of plant material. In the flood season it feeds predominantly on fruits and seeds from the flooded forest and, in the dry season, basically on filamentous algae (BERNHARD et al., 2012; CUNHA, 2013). The nesting of this species occurs during the dry months, when the beaches, meadows and open areas appear, inside floodable forests, where the nests are dug. In the Negro River Basin this period usually occurs between August and December and may vary throughout its distribution. The females can nest up to four times and lay from 2 to 18 elliptical eggs with flexible shell. The incubation period varies from 65 to 87 days, and the sex is determined by the nest temperature during embryonic development (VOGT, 2008; BERNHARD et al., 2012).

Studies on population ecology are few and relatively recent (BERNHARD; VOGT, 2012; BERNARDES et al., 2014), and there is no historical series of data on its population dynamics that allow inferences on the impact caused by egg and adult consumption throughout its distribution areas. Although the low human population density in the Negro River Basin decreases the pressure on this food resource, some signs of over-exploitation can already be observed. A few decades ago, diving was an efficient technique for capturing adults of this species in the middle Negro River. With the possible decrease in populations, this technique was replaced by the use of "*camuri*" (hook) and drag nets (BERNHARD et al., 2012).

Threats: currently, *P. erythrocephala* is one of the three most consumed species in the Negro River (PEZZUTI et al., 2004; DE LA OSSA; VOGT, 2010). The species is also threatened by deforestation and, indirectly, by global warming (FERRARA et al., 2017).

Need for research: studies of dynamics, population trend and movement are needed. It is also important to understand how local consumption has impacted the populations of this species (FERRARA et al., 2017).

Big-headed sideneck turtle (*Peltocephalus dumerilianus*)

Other common names: Cabeçudo (Brazil); Cabezón (Colombia and Venezuela).

Figure 3 – *Peltocephalus dumerilianus*, Ayuanã River, tributary of the middle Negro River/state of Amazonas – AM. (Photo: Rafael Bernhard).

Description of the species: the only species of the genus, it has a disproportionately large head in relation to body size. Other characteristics that distinguish the big-headed sideneck turtle (*Peltocephalus dumerilianus*) from other podocnemidids are the hook-shaped beak and the absence of longitudinal groove, on the dorsal surface of the head, which extends from the nostrils to the posterior portion of the eyes (Figure 3). Regarding size, Ernst and Barbour (1989) state that the male can reach 680 mm of carapace length without, however, mentioning the source of this information or mentioning the measurement form used – rectilinear or curvilinear length. According to Iverson and Vogt (2002), males can reach 500 mm in length and females 470 mm. Adults can weigh between 8 kg and 15 kg.

Current category of international evaluation: in the IUCN Red List and in the ongoing global assessment by the TFTSG the species is considered Vulnerable (VU) (RHODIN et al., 2018). In the CITES the species is listed in its Appendix II (CITES, 2019).

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Less Concern (LC) (ICMBIO, 2018).

Geographical distribution: it is found in six countries in northern South America, in the Orinoco and Amazon River Basins (Figure 4). The species occurs in an area of 4,886,001.28 km^2 and in the Amazon Basin the area size of occurrence is 1,439,447.84 km^2 (FERRARA et al., 2017).

Habitat and ecology: it inhabits preferably rivers, lakes and black-water flooded forests, but can occasionally be found in white and clear water environments (DE LA OSSA et al., 2012). The shape of its paws, with poorly developed interdigital

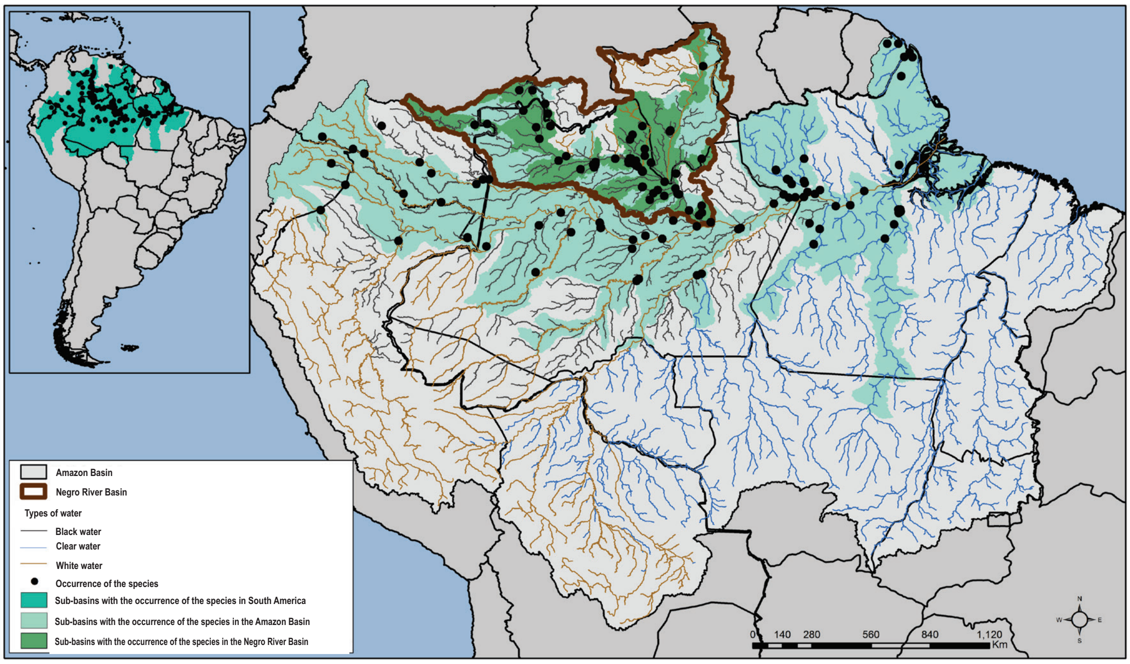

Figure 4 – Map of the geographic distribution of *Peltocephalus dumerilianus* (FERRARA et al., 2017).

membranes, indicates that the species is more associated with the substrate in areas of little or no river current. In a study carried out on the Cumicuri River, tributary of the middle Negro River, De la Ossa and Vogt (2011a) estimated from 970.18 ha to 830.80 ha the area of life of males and females of this species, respectively, without significant difference between the sexes. However, there was a difference between the sexes in the average maximum linear distance traveled. The distances were greater between females (7.42 km) than between males (5.72 km). The diet of the big-headed sideneck turtle (*Peltocephalus dumerilianus*) in this same region is varied, with predominance of plant material (76.2% of stomach content). Although less important in volume, animal material is frequently found in its diet as fish remains (72.08% of stomach contents analyzed); insects (38.81%), mollusks (27.74%) and crustaceans (24.96%) (DE LA OSSA et al., 2011).

As in other podocnemidids, the nesting period of this species coincides with the dry season of the rivers (DE LA OSSA et al., 2012). Only one nesting is carried out per year (DE LA OSSA; VOGT, 2011b), occurring, in general, in nests built mainly in burned areas and *tronqueiras*[9] present in *igapó*[10] forests (FÉLIX DA SILVA, 2004). In each nest, 3 to 25 eggs of hard and slightly flexible shells are deposited (PRITCHARD; TREBBAU, 1984; VOGT et al., 1994), and the temperature during the embryonic development determines the sex of the hatchlings (VOGT, 2001; DE LA OSSA, 2007).

Threats: the big-headed sideneck turtle is widely used as food in Brazil, especially where larger species, such as the yellow-spotted river turtle (*Podocnemis. unifilis*) and the giant South American river turtle (*P. expansa*) are preferred. In these regions the species population have been reduced. Currently, it is the most consumed species if we compare the volume of turtle meat consumed in the region of Barcelos, on the Negro River (DE LA OSSA; VOGT, 2010). This turtle can be captured manually, during free diving, or using wooden sticks, to find buried animals, as well as fishing with hooks, encircling nets, fishing traps and harpoons (PEZZUTI, 2003; DE LA OSSA et al., 2012).

Large works, such as the construction of dams, for the implementation of hydroelectric plants, construction/reactivation of roads, oil and natural gas exploration and others, potentially increase the impact on the big-headed sideneck turtle (*Peltocephalus dumerilianus*). In addition to the profound change in the habitat, there is a local increase in demand for meat, which encourages capture and illegal trade.

Need for research: studies of population dynamics and structure and genetic are needed, as well as research on the impact assessment that the species has been suffering from local consumption (FERRARA et al., 2017).

Family Chelidae

Matamata turtle (*Chelus fimbriata)*

Other common names: Mata-matá (Brazil); bachala (Colômbia)

Figure 5 – Matamata turtle (*Chelus fimbriata*) (Photo: Vinícius Tadeu de Carvalho).

Description of the species: large turtle, triangular head, small eyes, big mouth, long snout, long and wide neck, with numerous dermal expansions, especially in the lateral region. Carapace with 12 or 13 pointed projections of rust brown coloration, light yellow plastron, but in some regions, it assumes the light brown coloration (Figure 5). The

9 Translator's note: In the state of Amazonas, it is the designation for thick sticks that the current strongly tap into the riverbed, making navigation difficult.
10 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

paws have fingers with interdigital membranes and long claws on the fingers. The hatchlings have a burnt-yellow coloration on the carapace, with some black spots, and the plastron is pinkish red (RUEDA-ALMONACID et al., 2007; VOGT, 2008; PRITCHARD, 2008). Males have concave plastron and are generally smaller than females.

It is the only living species of the genus *Chelus*, and there are also two fossil species (WOOD, 1976). It is the largest species of the Chelidae family. Its scientific name derives from the Greek *Chelus* (turtle) and the Latin *fimbriata* (fringed, ornate).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG the species is considered Less Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Less Concern (LC) (ICMBIO, 2018).

Geographic distribution: inhabits the Orinoco River Basin in Venezuela and the Amazon River Basin (Figure 6), in the following countries: Bolivia, Colombia, Ecuador, French Guyana, Peru, Suriname, Trinidad, Venezuela and, in Brazil, there are records in the states of Amapá, Amazonas, Goiás, Mato Grosso, Pará, Rondônia, Roraima and Tocantins (RUEDA-ALMONACID et al., 2007; PRITCHARD, 2008; RHODIN et al., 2018). The range of occurrence of the species is 6,922,319.61 km² and for the Amazon Basin it is 3,784,598.21 km² (FERRARA et al., 2017).

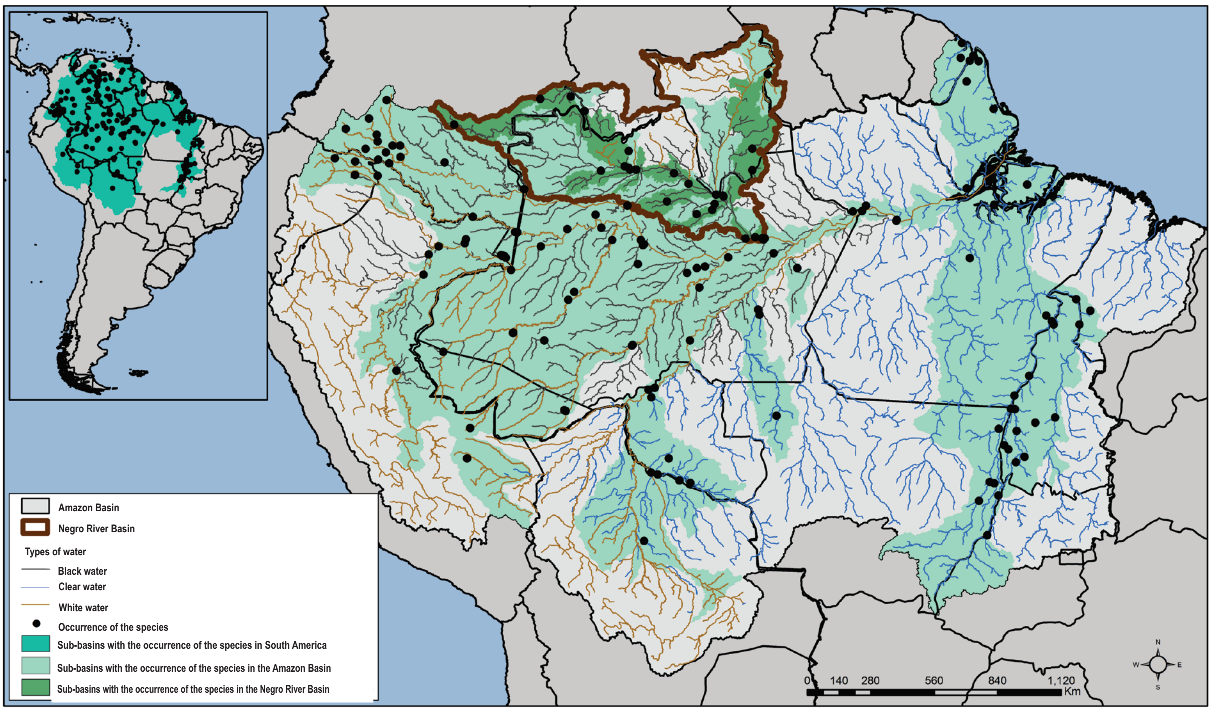

Figure 6 – Map of the geographic distribution of matamata turtle (*Chelus fimbriata*) (FERRARA et al., 2017).

Habitat and ecology: this species lives in Amazonian Rivers and flooded forests. It prefers calm waters, generally muddy, with little depth, where it can remain only with his snout on the surface, to breathe (VOGT, 2008; MORALES-BETANCOURT; LASSO, 2012a). Recently, individuals of the species have been observed in floodplain streams of the upper Negro River region. It is one of the few completely carnivorous species, with a predominantly fish diet, although there are reports of predation of birds and small rodents (RUEDA-ALMONACID et al., 2007).

Much of the reproductive biology of the species remains unclear to science. It is known that the nesting season coincides with the Amazonian summer season (MENDIZÁBAL; CORREA-VIANA; 2015). There is no social organization as such. This turtle has a solitary habit, with social contact only in the reproductive period (DAVIDSON, 2012). According to reports by riparian inhabitants, confirmed by Mendizábal and Correa-Viana (2015), females prefer ravines. They spawn from 12 to 28 eggs and the incubation period lasts around 200 days (RUEDA-ALMONACID et al., 2007; VOGT, 2008).

Due to the difficulty in finding populations of matamata turtle *(Chelus fimbriata)*, there are no works in the scientific literature about the population ecology of this species.

Threat: although it is not in great demand for meat consumption by humans, the species may be considered threatened by the pet market due to its unusual appearance (FERRARA et al., 2017).

Need for research: it is a non-widely known species, especially due to its difficult detection. Studies of population structure, movement and reproductive biology are needed (FERRARA et al., 2017).

Description of the species: it is small and can reach 230 mm of carapace length, with a narrow head when compared to the others of the genus (Figure 7). Males have a longer and thicker tail, and the invagination of the anal shell is deeper than that of females (VOGT, 2008). At the end of the rainy season, two to four eggs are laid in up to two litters. The eggs have a hard shell and measure from 40 mm to 30 mm long and weigh between 22.5 g and 32 g. The eggs hatch between 178 and 200 days (VOGT, 2008).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global

Cágado-de-poça (*Mesoclemmys gibba)*

Other common names: lalá, cágado-de-poças-da-floresta (Brazil), charapita de aguajal (Peru), hedionda (Colombia).

Figure 7 – Gibba turtle (*Mesoclemmys gibba*) (Photo: Vinícius Tadeu de Carvalho).

assessment by the TFTSG the species is considered Less Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Less Concern (LC) (ICMBIO, 2018).

Geographical distribution: widely distributed in the Orinoco and Amazon Basins (Figure 8). The range of occurrence of the species is 6,995,028.18 km^2 and for the Amazon Basin it is 3,572,205.36 km^2 (FERRARA et al., 2017).

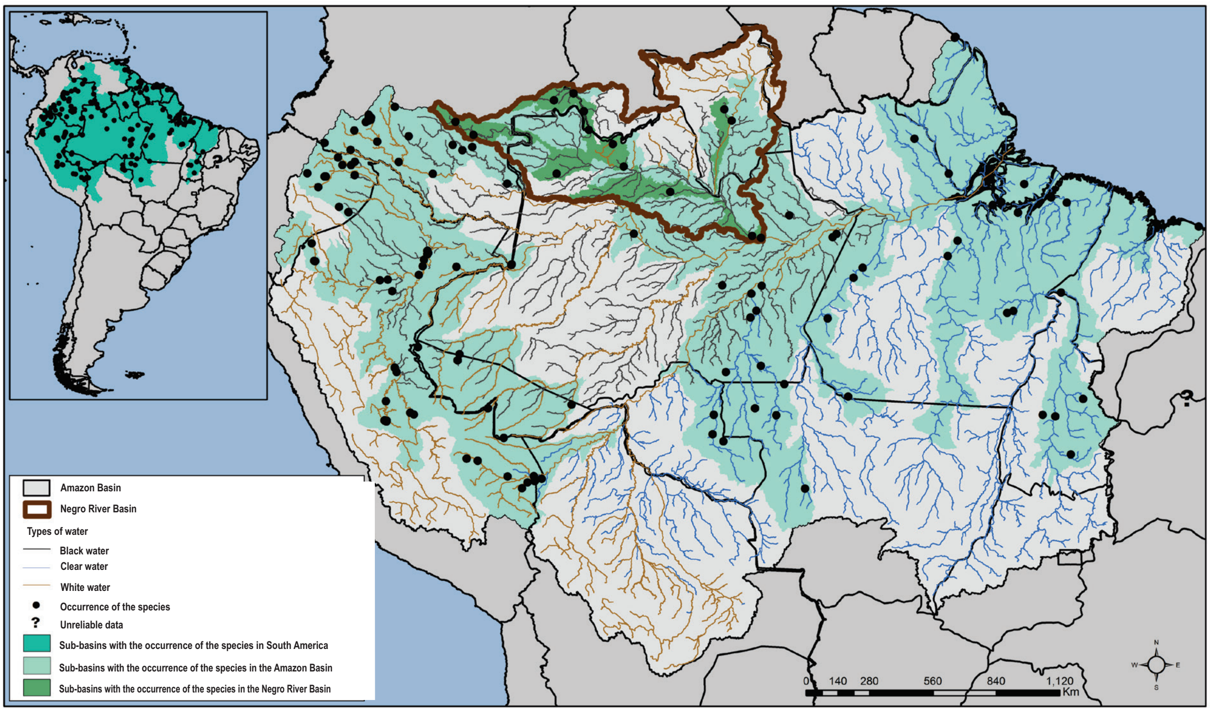

Figure 8 – Map of the geographic distribution of gibba turtle (*Mesoclemmys gibba*) (FERRARA et al., 2017).

Habitat and ecology: it can be found in permanent lagoons, shallow lakes, small streams, slow water channels, puddles, usually in places where the buriti palm (*Mauritia flexuosa*) occurs, inside the tropical forest (VOGT, 2008; MORALES-BETTANCOURT; LASSO, 2012b).

It is a species of nocturnal habits, feeding mainly on *buriti*, aquatic insects, crustaceans, tadpoles and fish (VOGT, 2008).

Threats: the exploitation of this species hardly exists, even in places with large human concentrations. This can be explained by the difficulty to find the species and by the strong odor produced by its inguinal glands (VOGT, 2008).

Need for research: because it is a poorly detected species, research on its distribution, basic elements of its biology and reproduction are very important (FERRARA et al., 2017).

Guyanan toad-headed turtle (*Mesoclemmys nasuta)*

Other common names: lalá, cágado-de-cabeça-de-sapo-comum (Brazil).

Figure 9 – Guyanan toad-headed turtle (*Mesoclemmy nasuta*) (Photo: Richard Vogt).

Description of the species: adults of this species reach 330 mm carapace length. The head width represents 25% of the carapace length in adults and 30% in juveniles (Figure 9) (VOGT, 2008).

Current international evaluation category: it is not on the IUCN red list and in the ongoing global evaluation by the TFTSG the species is considered Data Deficient (DD) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Data Deficient (DD) (ICMBIO, 2018).

Geographic distribution: its distribution is restricted to the extreme north of Brazil (states of Amapá and Pará) and French Guiana (Figure 10) (VOGT, 2008; FERRARA et al., 2017). The range of occurrence of the species is 730,135.43 km^2.

Habitat and ecology: also known as matamatá, in Colombia, this is a totally aquatic species that inhabits rivers, lakes, ponds and canals (VOGT, 2008).

The nests are built on low level areas, near lakes or rivers. Six to eight round eggs are laid in shallow nests. There are almost no records on the species, but it is believed that they have nocturnal habits and feed on fish (VOGT, 2008).

Threats: due to uncertainty about their distribution and confusion in their taxonomy, no threats to the species are known (FERRARA et al., 2017).

Need for research: because it is a species that is little detected, research on its distribution is very important. It is also necessary to carry out genetic studies to solve the taxonomic and identification problems between *M. nasuta* and *M. raniceps.*

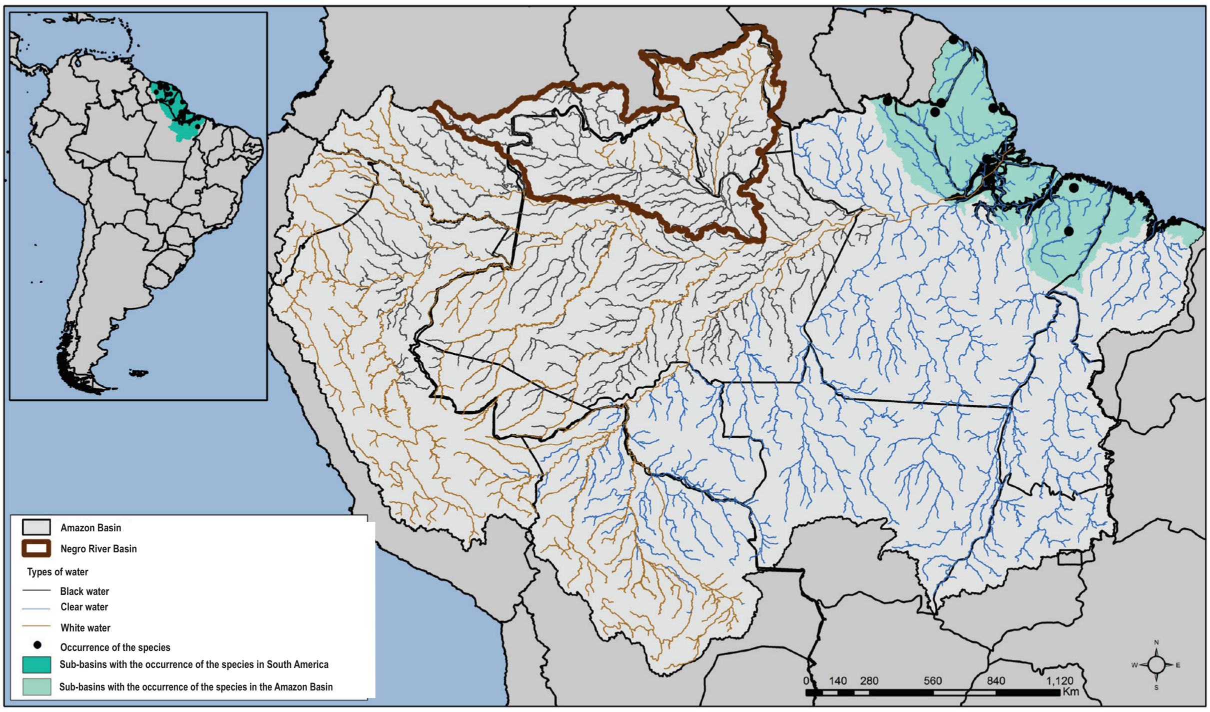

Figure 10 – Map of the geographic distribution of Guyanan toad-headed turtle (*Mesoclemmys nasuta*) (FERRARA et al., 2017).

Amazon toad-headed turtle (*Mesoclemmys raniceps*)

Other common names: Lalá; cágado-de-cabeça-de-sapo-comum, tartaruga-do-igapó, perema (Brazil), cabezón-comum (Colombia), charapa (Peru).

Figure 11 – Amazon toad-headed turtle (*Mesoclemmys raniceps*), Cuieiras River, tributary of Negro River/ state of Amazonas – AM. (Photo: Fábio Cunha).

Description of the species: considered a turtle of medium size, the shell reaches 330 mm in length (Figure. 11) (MORALES-BETANCOURT; LASSO, 2012). The width of the head is a quarter of the carapace size in length (VOGT, 2008). It has accentuated sexual dimorphism, females are larger than males, which have a thicker and longer tail and a slightly more concave plastron (RUEDA-ALMONACID et al., 2007).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG, the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Less Concern (LC) (ICMBIO, 2018).

Geographic distribution: west of the Amazon Basin and the Orinoco Basin (Figure 12). The range of occurrence of the species is 4,639,366.73 km^2 and for the Amazon Basin it is 3,524,084.43 km^2 (FERRARA et al., 2017).

Habitat and ecology: it inhabits mainly slow-water rivers, small lakes and particularly river springs or under waterfalls. They are more abundant in black water, but there are also records in clear water and muddy water lakes (VOGT, 2008). In Brazil, the species seems not to be abundant (VOGT, 2008).

It is considered a carnivorous species that feeds on crabs, shrimp (*camarão aruá* – family Ampullariidae), insects and decomposing material (VOGT, 2008).

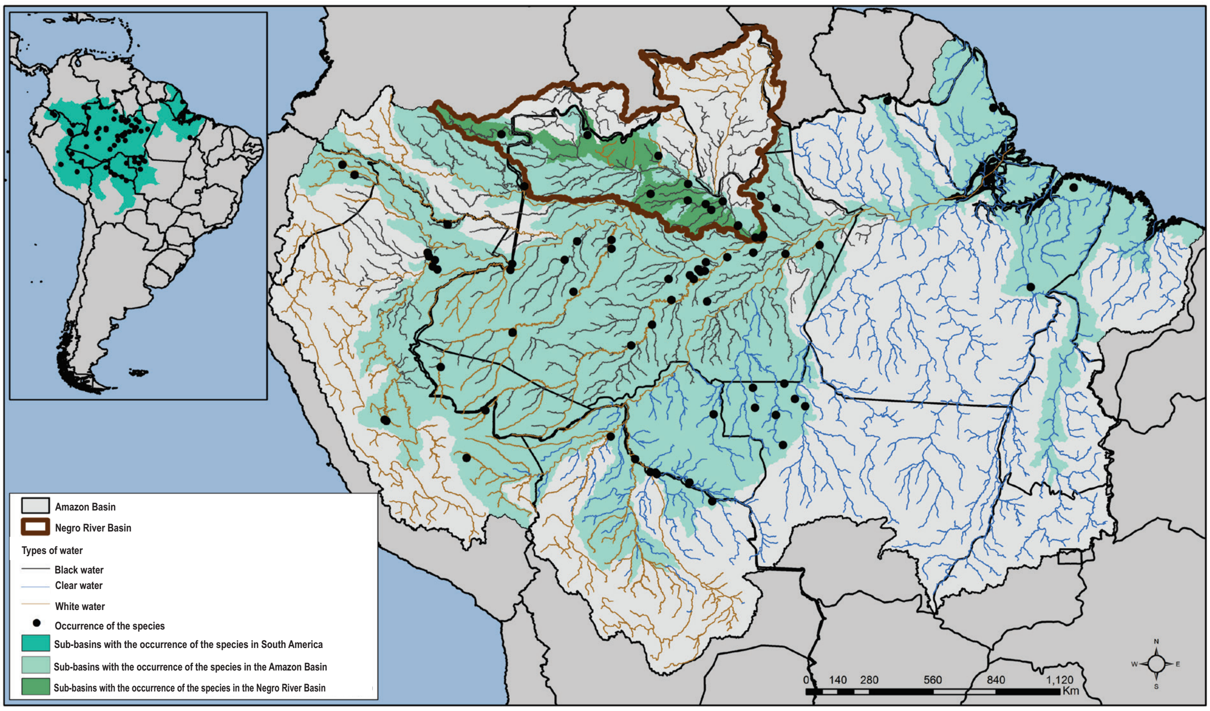

Figure 12 – Map of geographic distribution of Amazon toad-headed turtle (*Mesoclemmys raniceps*) (FERRARA et al., 2017).

Some specimens were found nesting between July and August, beginning of the dry season, near Costa Marques/State of Rondônia – RO, coinciding with the same locations of *P. geoffroanus* (VOGT, 2008). The average number of eggs per nest varies between four and six (RUEDA-ALMONACID et al., 2007). These are round and have a hard shell. Up to six nests can be produced by a female during the reproductive season (VOGT, 2008). Studies on the effect of incubation temperature on the coloring pattern of the species are necessary.

There is a record of occasional consumption by the riverside community of the Negro River region, in communities near the Jaú National Park and in the municipality of Barcelos, in the state of Amazonas (VOGT, 2008; PEZZUTI et al., 2010).

Threats: there are no known threats to this species.

Need for research: because it is a species that is little detected, research on its distribution is very important.

Description of the species: among the members of the *Chelidae* family it is the easiest species to be recognized. It has an oval and flat carapace, and a low sharp keel (Figure 13) (ERNST; BARBOUR, 1989). The hatchlings have the ventral region (plastron) orange or reddish, with black patches or streaks. In adults, this coloration becomes lighter or less evident. The females are larger than the males and can reach a size ≥ 390 mm carapace length (VOGT, 2008).

Geoffroy's side-necked turtle (*Phrynops geoffroanus*)

Other common names: Cágado-de-barbicha, tartaruga-cabeça-de-cobra (Brazil), bachala (Colombia).

Figure 13 – Geoffroy's side-necked turtle (*Phrynops geoffroanus*). (Photo: Vinícius Tadeu de Carvalho).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG, the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: the species presents the largest geographic distribution of the *Chelidae* family and can be found in the Amazon Region of Brazil, Venezuela, Colombia, Ecuador, Peru, Bolivia, Paraguay and Argentina (Figure 14) (ERNST; BARBOUR, 1989; IVERSON, 1992; RUEDA-ALMONACID et al., 2007; VOGT, 2008; RHODIN et al., 2018). In the Brazilian national territory, the species occurs in almost all regions, it is distributed in the states of Amapá,

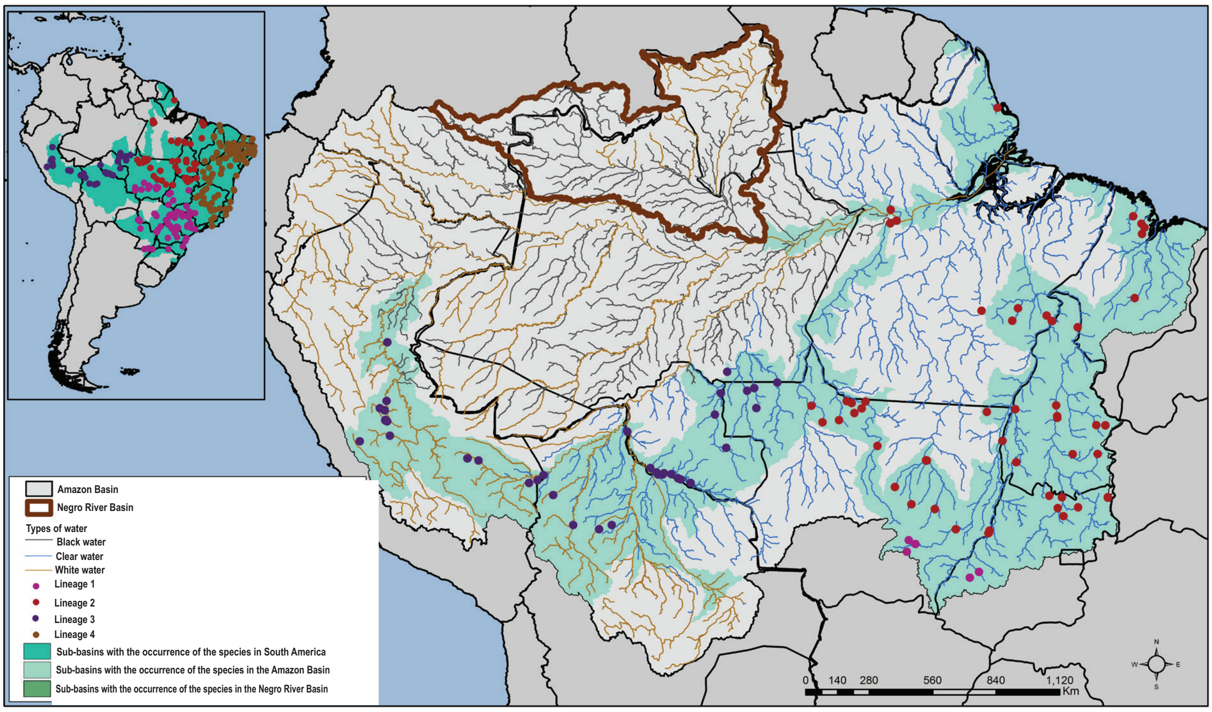

Figure 14 – Map of the geographic distribution of the Geoffroy's side-necked turtle (*Phrynops geoffroanus)* (FERRARA et al., 2017).

Pará, Maranhão, Piauí, Rio Grande do Norte, Paraíba, Pernambuco, Ceará, Bahia, Alagoas, Rondônia, Mato Grosso, Tocantins, Mato Grosso do Sul, Goiás, Minas Gerais, São Paulo, Paraná, Rio de Janeiro, Espírito Santo, Rio Grande do Sul and Santa Catarina (RHODIN et al., 2018). The species occurrence extension is 7,563,080.49 km^2 and for the Amazon Basin is 2,523,166.14 km^2 (FERRARA et al., 2017).

Habitat and ecology: popularly known by several names, in different regions of Brazil (cangapara, tartaruga-pescoço-de-cobra, lalá, cágado and cágado-de-barbicha), this freshwater aquatic species inhabits a variety of water bodies: large rivers, fast flowing rivers, small streams, lagoons and weirs, and can also be found in polluted channels in urban centers (RUEDA-ALMONACID et al, 2007; VOGT, 2008; BUJES, 2010; MARTINS et al., 2010; MORALES-BETANCOURT et al., 2012a).

It is a diurnal species and in the hottest hours of the day it is on rocks and trunks of fallen trees on the margins of water bodies (RUEDA-ALMONACID et al., 2007; VOGT, 2008).

Its reproduction occurs during the dry season, varying in the different regions of the country. It nests in open places with clay soils (ravines) where superficial pits measuring between 8 cm and 10 cm deep are dug, where turtles deposit up to 28 eggs, which can take 115 to 186 days to hatch (RUEDA-ALMONACID et al., 2007; VOGT, 2008).

The species is omnivorous, feeding basically on seeds, leaves, fruits, insects, crustaceans, mollusks and fish (FACHÍN-TERÁN et al., 1995; VOGT, 2008).

Threats: it is appreciated for food in some regions of the Northeast, by riverine populations, and its lard is used in traditional medicine (Vinicius Tadeu de Carvalho, personal communication). In the North Region, riverside communities reported that both eggs and meat cause allergic reaction (VOGT, 2008).

Need for research: Taxonomic and phylogenetic studies are crucial to classify the different origin of the species complex that this taxon represents (FERRARA et al., 2017).

Guianan Shield side-necked turtle (*Phrynops tuberosus)*

Other common names: Cangapara (Brazil); charapa, bachala, matamatá (Colombia).

Figure 15 – Guianan Shield side-necked turtle (*Phrynops tuberosus*), de Balsas/state of Maranhão – MA. (Photo: Elizângela Silva de Brito).

Description of the species: this species is easily confused with the very similar *Phrynops geoffroanus*. It has a small head, and the females can reach 350 mm of body size. Hatchlings and juveniles present a red coloration, with black patches on the neck, the bridge, the inferior surface of the marginal shell and the plastron (Figure 15). In adults these colors turn to ochre yellow or yellowish coffee (RUEDA-ALMONACID et al., 2007).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Less Concern (LC) (ICMBIO, 2018).

Geographical distribution: its distribution is restricted to the extreme northern region of South America (Figure 16). It occurs in the great Venezuelan savannah, extending to the western of Suriname, through Guyana and the north of the state of Roraima (RUEDA-ALMONACID et al., 2007; RODRIGUES; SILVA, 2015; RHODIN et al., 2018). The range of occurrence of the species is 1,908,081.07 km^2 and for the Amazon Basin it is 935,035.14 km^2 (FERRARA et al., 2017).

Habitat and ecology: it lives in rivers, canals and freshwater lakes, usually surrounded by closed canopy vegetation, but can also be found in lagoons with scarce riparian vegetation (RUEDA-ALMONACID et al., 2007).

It is a carnivorous species, feeding on fish, insects, arthropods and mollusks (RUEDA-ALMONACID et al., 2007). Its reproduction occurs in the dry season of the rivers, when sandy beaches appear where they build their nests. Each nesting has

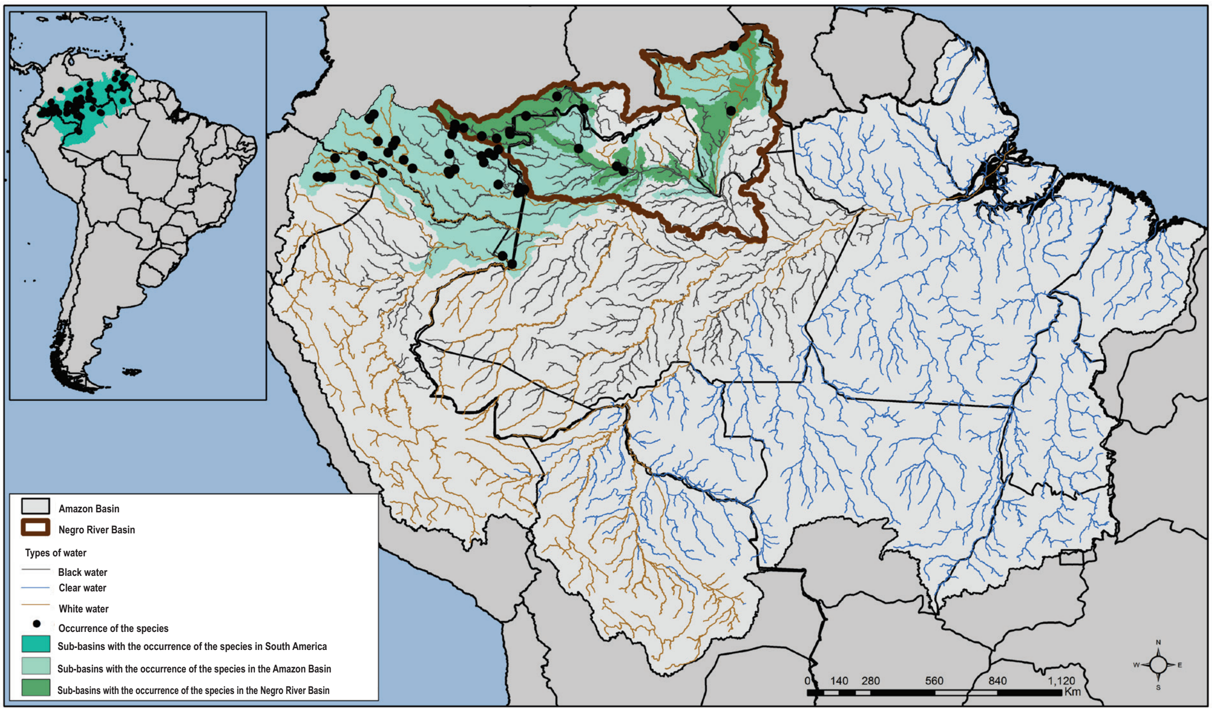

Figure 16 – Map of the geographic distribution of Guianan Shield side-necked turtle (*Phrynops tuberosus*) (FERRARA et al., 2017).

between 10 and 20 round, brittle-shelled eggs, which take approximately four months to hatch (RUEDA-ALMONACID et al., 2007). In tropical to semi-arid climates, nests are built in shaded or semi-shaded places and the hatchlings emerge at the beginning of the rainy season (RODRIGUES; SILVA, 2014). In another study conducted in the semi-arid climate of the Brazilian northeast region, a population with a sex ratio of 3.92 males per female and an estimated minimum density of 327 individuals/ha was reported (RODRIGUES; SILVA, 2015).

Threats: it is consumed, occasionally, only by some Amazonian indigenous tribes. Its meat and eggs are considered to cause an allergic reaction (urticaria) (RUEDA-ALMONACID et al., 2007).

Need for Research: taxonomic and phylogenetic revisions are necessary, in addition to studies to determine its geographic distribution (FERRARA et al., 2017).

Description of the species: it is considered small size. Males reach up to 180 mm and females 167 mm maximum carapace length (RUEDA-ALMONACID et al., 2007; DE LA OSSA et al., 2012). The carapace is elliptical and flat, with a deep median protuberance accompanied by a distinct keel on each side (Figure 17). It has sexual dimorphism. The males are larger, with a thicker and longer tail, and the plastron slightly more concave (RUEDA-ALMONACID et al., 2007).

Twist-necked turtle (*Platemys platycephala)*

Other common names: jabuti-machado (Brazil); lalá, perema, charapa (Colombia), chata (Venezuela), charapita, charapita de aguajal (Peru).

Figure 17 – Twist-necked turtle (*Platemys platycephala*) (Photo: Vinícius Tadeu de Carvalho).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG, the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and it is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: occurs along the Brazilian Amazon Basin and also in Bolivia, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela (Figure 18) (DE LA OSSA et al., 2012; RODHIN et al., 2018). The range of occurrence of the species is 7,550,386.48 km^2 and for the Amazon Basin it is 4,792,423.21 km^2 (FERRARA et al., 2017).

Habitat and ecology: inhabits mainly temporary puddles formed in the dry land forest, during the rainy season.

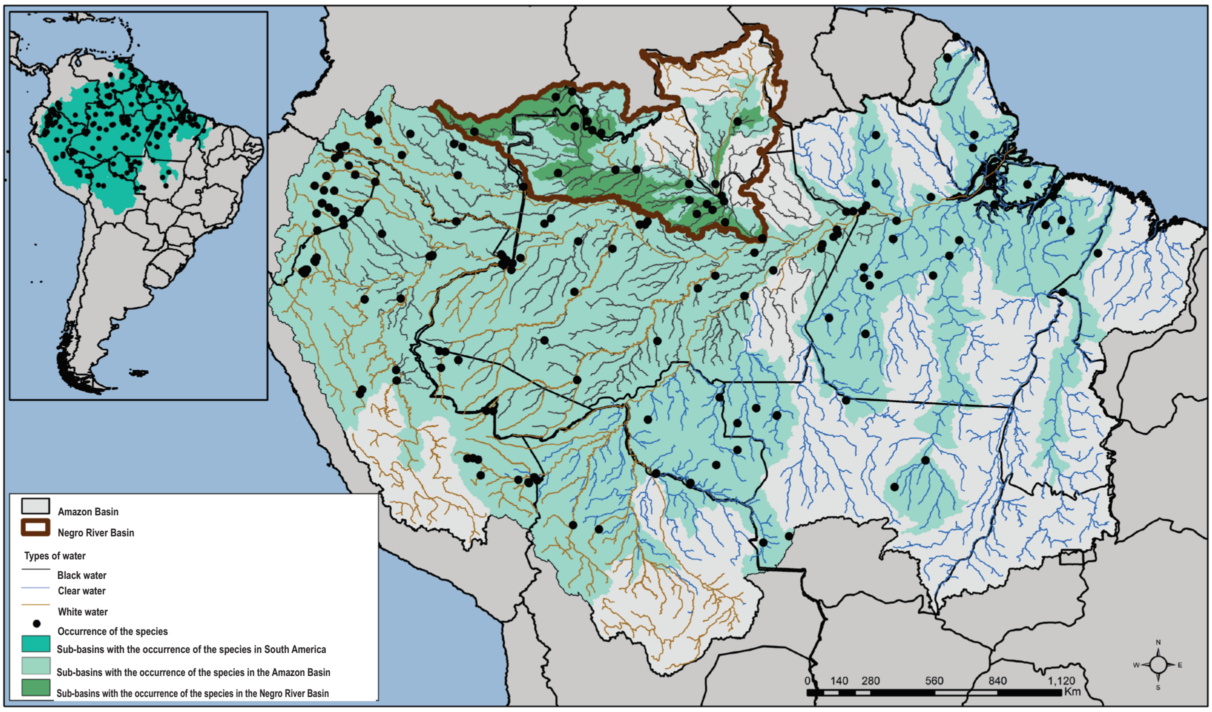

Figure 18 – Map of the geographic distribution of Twist-necked turtle (*Platemys platycephala*) (FERRARA et al., 2017).

The courtship and copulation take place in the rainy season, from December to June. It deposits only a single egg, large and elliptical, which can reach one third of the length of the female. The average incubation period is five months (VOGT, 2008). A curious fact about this species is that it is one of only two, with sex reproduction, that has diploid/triploid mosaicism, that is, in some of its populations can be found both diploid (2n) and triploid (3n) individuals (BICKHAN; HANKS, 2010). This species feeds on tadpoles, amphibian eggs, aquatic insects and small fish (VOGT, 2008).

Need for research: more studies on their geographical distribution, population structure, genetics and reproductive aspects need to be done.

Description of the species: it has an oval carapace, uniformly brown to dark, with a medial keel. Its head and paws are reddish pink in color and a black band that extends laterally on the head, from the snout to the neck, passing through the eyes, makes this species unmistakable (Figure 19) (VOGT, 2008; MORALES-BETANCOURT et al., 2012b). The females are larger than the males and can reach 270 mm carapace length and the largest male at 230 mm (VOGT, 2008). It takes six to ten years for females to reach sexual maturity (MAGNUSSON et al., 1997b; VOGT, 2008).

Red side-necked turtle (*Rhinemys rufipes)*

Other common names: Cágado-vermelho (Brazil); lalá, achiote, Tortuga roja (Colombia).

Figure 19 – Red side-necked turtle (*Rhinemys rufipes*), juvenile, in the Adolpho Ducke Forest Reserve, Manaus/ state of Amazonas – AM. (Photo: Rayath Melina Lima Bernhard).

Current category of international evaluation: in the IUCN red list it is classified as Near Threatened (NT) and in the global assessment, which is under way by the TFTSG, the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographical distribution: it occurs in the states of Amazonas and Pará and in the *departmentos*[11] of Amazonas, Guainía and Vaupés (Colombia). Its occurrence in Loreto (Peru) and Amazonas (Venezuela) has yet to be confirmed (Figure 20) (MORALES-BETANCOURT et al., 2012; RHODIN et al., 2018). The range of occurrence of the species is 1,703,184.42 km^2 and for the Amazon Basin is 993,283.5 km^2 (FERRARA et al., 2017).

Habitat and ecology: it is a species that inhabits the *igarapés* (small rivers) that are well preserved black water streams, in dry land forest, and can be found, in these same environments, near large cities like Manaus (VOGT, 2008). In these streams they occupy an area between 1 and 2 linear km (MAGNUSSON et al., 1997a) and it is estimated an abundance that varies from 6.8 to 9.2 individuals/linear km of streams (SANCHEZ, 2008).

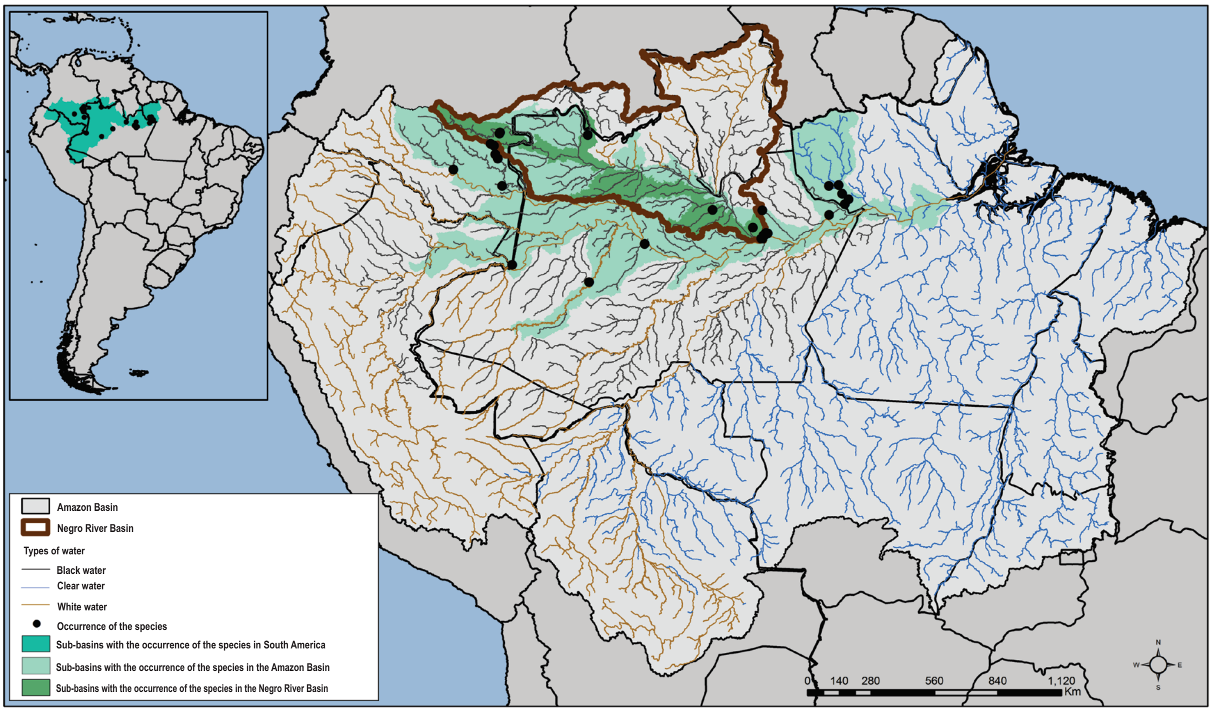

Figure 20 – Map of the geographic distribution of *Rhinemys rufipes* (FERRARA et al., 2017).

The nesting period occurs between the months of March and June, at the end of the rainy season in the Manaus region. There may be one or two nestings per reproductive season, when four to eight slightly elliptical eggs are laid. The place and type of substrate where females build the nest is still a mystery (VOGT, 2008).

This species is omnivorous and opportunistic. It feeds on palm fruits, seeds, small crustaceans, aquatic insects, lizards and fish (LIMA et al., 1997; CAPUTO; VOGT, 2008).

Threats: Although it is hunted by indigenous people in Colombia, this it is apparently an exception. In Brazil, there are still no reports of intensive hunting of this species for consumption or for the pet market (VOGT, 2008). Populations of this species are known only within streams, in well preserved dryland forests. The threats posed by the advance

11 Translator's note: Social rule of law, organized as a unitary, decentralized republic. For administrative purposes Colombia is divided into departments, districts, municipalities and indigenous territories.

of deforestation, the global change in the rainfall regime in the Amazon, and the activities that affect the water quality of the water streams need to be better studied in order to assess the impact of these factors on the species.

Need for research: studies of geographical distribution, population structure, genetics and reproductive aspects need to be performed.

Description of the species: it has dark brown oval carapace. The head is small and elongated, black to dark brown, with patches in the shape of wavy orange-red lines (Figure 21). Limbs are yellow-orange, with scattered black dots. It reaches 260 mm in carapace length and females are larger than males (VOGT, 2008; FIGUEIREDO, 2010).

Family Geoemydidae

Spot-legged turtle (*Rhinoclemmys punctularia)*

Other common names: perema (Brazil); aperema, *mocorroy negro* (Venezuela).

Figure 21 – Spot-legged turtle (*Rhinoclemmys punctularia*), municipality of Silves/state of Amazonas – AM. (Photo: Rafael Bernhard).

Current international evaluation category: it is not on the IUCN red list and in the global assessment, which is ongoing by the TFTSG, the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it does not appear in the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: it occurs in the atates of Amapá, Amazonas, Maranhão, Pará, Roraima, Piauí and Tocantins, in Brazil, and in the *departamentos*[12] of Amazonas, Bolívar, Delta Amacuro and Monagas, in Venezuela, besides Guyanas, Suriname and Trinidad and Tobago (Figure 22) (RHODIN et al., 2018). The range of occurrence of the species is 3,267,963.85 km^2 and for the Amazon Basin is 2,020,012.85 km^2 (FERRARA et al., 2017).

12 Translator's note: Social rule of law, organized as a unitary, decentralized republic. For administrative purposes Colombia is divided into departments, districts, municipalities and indigenous territories.

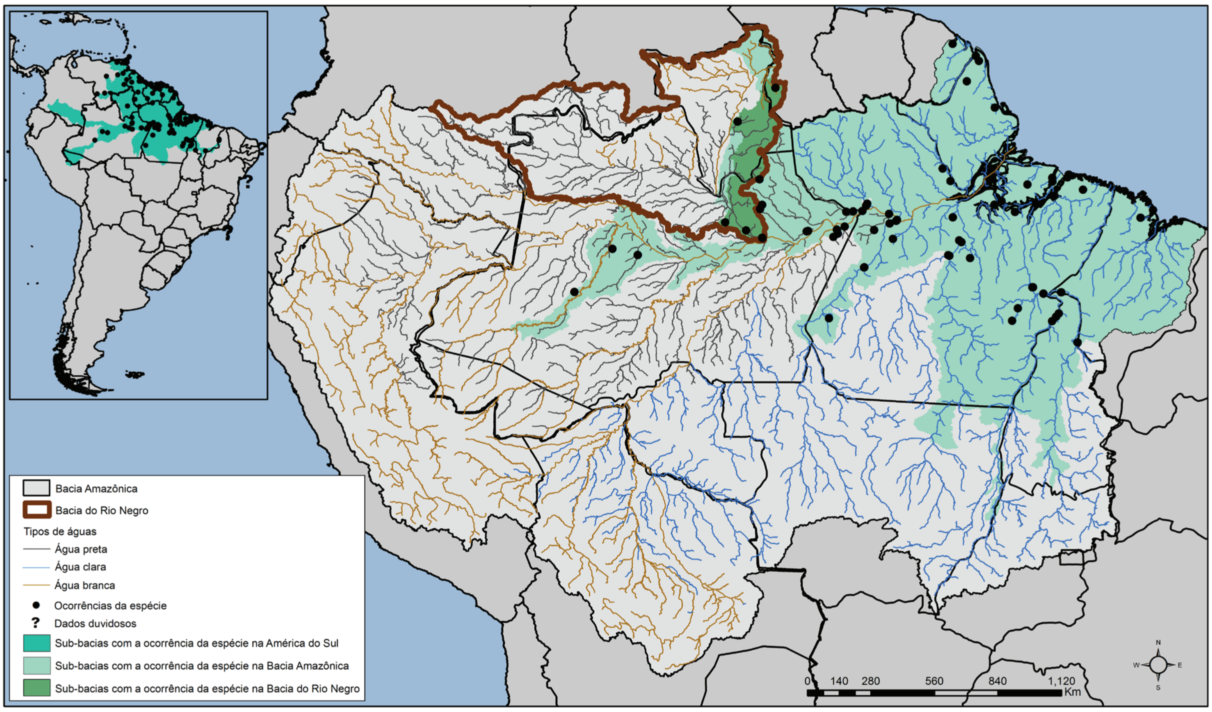

Figure 22 – Map of the geographic distribution of spot-legged turtle (*Rhinoclemmys punctularia*) (FERRARA et al., 2017).

Habitat and ecology: aquatic species, inhabiting swamps, streams and coastal wetlands. It occurs in all types of water (white, black, clear) and even in polluted waters with margins covered or not by riparian vegetation (RUEDA-ALMONACID et al., 2007; VOGT, 2008).

It feeds on both animals and plants, such as the fruit of the *Mauritia flexuosa* palm. Its eggs are elongated, quite large and with a brittle shell. Each nesting has between one and four eggs, which are hatched between the remains of roots and covered with leaf litter. The average egg size found near the city of Manaus and the state of Roraima was 65 mm long and, in the state of Maranhão, the egg size of a nesting ranged from 59.6 to 63.6 mm (CARDOZO, 2007; RUEDA-ALMONACID et al., 2007; VOGT, 2008).

There are a few population studies. In the islands of Algodoal and Maiandeua/state of Pará – PA, a population with sexual reason was found slightly out of balance in favor of females. In this study, no spot-legged turtles (*Rhinoclemmys punctularia)* were captured in environments with marine water influence. The abundance was greater in environments with plenty of food resources, such as fruits of *Annona* sp. and *Chysobalanus* (FIGUEIREDO, 2010).

Threats: the extent of its use as pet or for human consumption needs to be better evaluated. Some authors claim that this species is widely consumed by indigenous people and *caboclos*[13] (RUEDA-ALMONACID et al., 2007). Others report only sporadic and restricted consumption (PRITCHARD; TREBBAU, 1984; VOGT, 2008; FIGUEIREDO, 2010).

Need for research: little is known about this species, especially due to the difficulty of its detection and capture. Currently, distribution, population structure and reproduction studies are needed (FERRARA et al., 2017).

13 Caboclo is a person of mixed Indigenous Brazilian and European ancestry, or, less commonly, a culturally assimilated or detribalized person of full Amerindian descent. In Brazil, caboclo generally refers to this specific type of mestizo.

Family Kinosternidae

Scorpion mud turtle (*Kinosternon scorpioides)*

Other common names: Muçuã (Brazil); *peito-de-mola*, jurará*, tapaculo* (Colombia), *charapa, Tortuga bico de papagayo (*Peru*), pecho quebrado* (Venezuela)

Figure 23 – Scorpion mud turtle (*Kinosternon scorpioides*) (Photo: Rafael Bernhard).

Description of the species: the carapace is brown, beige or dark brown, with three keels on the back. The head can be brown, gray or black, with cream, orange, red or yellow pattern patches (Figure 23). At the end of the tail, it has a kind of nail, resembling a scorpion, whose characteristic gave name to the species (PRITCHARD; TREBBAU, 1984; BERRY; IVERSON, 2001; RUEDA-ALMONACID et al., 2007). The plastron anterior and posterior lobes are articulated by a central area like a spring, also called hinges, being able to move and close totally or partially the carapace, serving as protection for the head, legs and tail (PRITCHARD, 1964; FREIBERG, 1981; ERNEST; BARBOUR, 1989; PRITCHARD; TREBBAU, 1984; BERRY; IVERSON, 2001). The maximum carapace length varies between 92 mm and 270 mm, in the adults, and the hatchlings have an average length of 30 mm (PRITCHARD; TREBBAU, 1984; ERNEST; BARBOUR, 1989; BERRY; IVERSON, 2001; BARRETO et al., 2009).

Current category of international evaluation: it is not on the IUCN red list and in the ongoing global assessment by the TFTSG the species is considered Least Concern (LC) (RHODIN et al., 2018). It does not appear in the CITES annexes.

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: it has a wide distribution, occurring in countries north of South America to north of Argentina (Figure 24) (CABRERA; COLANTONIO, 1997; BERRY; IVERSON, 2001). In Brazil, it occurs in the states of Mato Grosso,

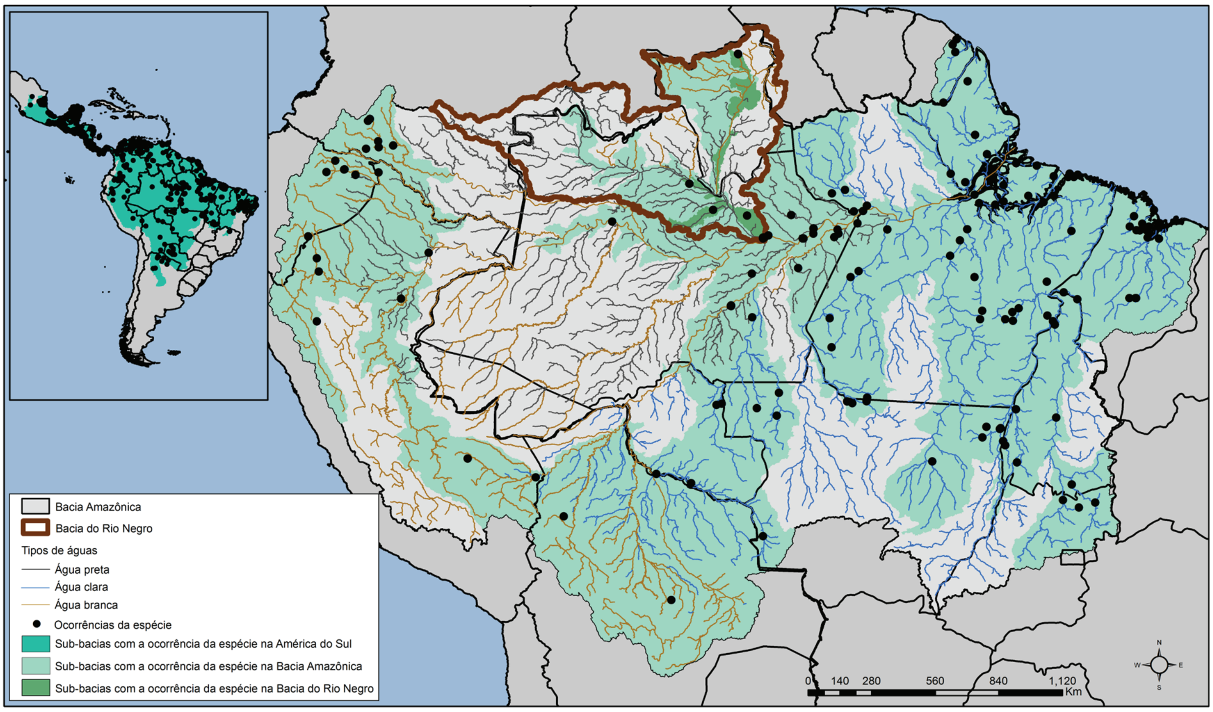

Figura 24. Mapa de distribuição geográfica de *Kinosternon scorpioides* (FERRARA et al., 2017).

Amazonas, Rondônia, in the southwest of the Tapajós River and in the Serra dos Registros de Carajás, in the state of Pará (PRITCHARD; TREBBAU, 1984; IVERSON, 1992; CABRERA; COLANTONIO, 1997; BERRY; IVERSON, 2001; CARVALHO JR. et al.., 2008; COSTA et al., 2010), being more abundant along the coast of the states of Pará and Maranhão (VOGT, 2008; BARRETO et al., 2009). In Maranhão, there were records in Curupu Island and in the cities of Pinheiro, São Bento and Turilândia, which belong to the region of Baixada Maranhense and the city of Cedral (BARRETO et al., 2009; 2010). The range of occurrence of the species is 13,467,717.07 km^2 and for the Amazon Basin it is 4,605,256.68 km^2 (FERRARA et al., 2017).

Habitat and ecology: it can be found in several types of habitats such as: streams, creeks, lagoons, lake shores, dune region, swamps and temporary lagoons (RUEDA-ALMONACID et al., 2007; VOGT, 2008, BARRETO et al., 2009). It is carnivorous, predatory, and a scavenger in nature (PRITCHARD; TREBBAU, 1984) and opportunistic omnivore, feeding on insects and their larvae, spiders, snails, worms, crabs, shrimps, fish, frog eggs, tadpoles, adult frogs, snake scales, bird eggshells, and mammalian parts, as well as plant material, including algae, fruits, seeds, flowers, and aquatic plants (FORERO-MEDINA; CASTAÑO-MORA, 2006; BUSKIRK, 2007; RUEDA-ALMONACID et al. , 2007; VOGT, 2008; CARVALHO JR. et al., 2008; TAVARES, 2011).

Females reach sexual maturity with a carapace length of 120 mm and possibly nest multiple times in the reproductive season, with an average of 2.5 eggs per laying (AZEVEDO, 2010). Each female can lay from 4 to 6 eggs per nesting, with the incubation time varying from 3 to 6 months, depending on the temperature (RUEDA-ALMONACID et al., 2007). The nests are shallow, covered with leaves and branches and located close to water bodies (MARQUEZ, 1995).

In Maranhão, on Curupu Island, the population seems to be stable, with no significant difference in male and female captures and in different size classes, presenting a sex ratio of one male to each female, even with the exploitation for consumption and commercialization carried out by the inhabitants of the island (BARRETO et al., 2009; RIBEIRO, 2009).

Threats: although hunting is forbidden, in the states of Maranhão and Pará, the *jurará* is considered a delicacy of the local cuisine and is served clandestinely in fine hotels and restaurants, where its meat is prepared with *farofa*[14] and served on the carapace, similar to a famous Brazilian dish called crab cone. On the beaches, they are sold in dozens, alive and hanging on a string, just like the fishermen sell crabs on the seaside (IBAMA, 1989; DELBUQUE, 2000; MACHADO JÚNIOR et al., 2006; BARRETO et al., 2009). Delduque (2000) and Barreto et al. (2009) found that the hunting of the *jurará* is carried out in burnings in dry fields, after the decrease in water level. Therefore, the future of this species is threatened not only by burning, but also by pollution, deforestation and indiscriminate hunting, since its capture is done on a large scale, and there are no precise estimates of the existing stocks in nature, but it is known that the population is declining sharply (ROCHA; MOLINA, 1987).

Need of Research: Distribution, population structure and reproduction studies are needed (FERRARA et al., 2017).

Family Testudinidae

Red-footed tortoise (*Chelonoidis carbonarius)*

Other common names: jabuti-piranga, jabuti-vermelho (Brazil); *mocorroy pata roja*, *mocorroy negro*, *mocorroy sabanero* (Colombia, Venezuela); *motelo* (Peru); *pata-negra* (Bolívia).

Figure 25 – Red-footed tortoise (*Chelonoidis carbonarius*), Cuieiras river, tributary of the lower Negro River/state of Amazonas–AM. (Photo: Vinícius Tadeu de Carvalho).

14 Dish consisting of corn or manioc flour with pieces of other foods, such as meat, beans, among others.

Description of the species: one of the two species of terrestrial chelonians, the *jabuti-piranga* or *jabuti-vermelho* has a high carapace in the shape of a vault, black and with small yellow or red-orange patches, with well-defined edges in the center of each scute (Figure 25). Some scales of the head also have red or orange patches, tending to yellow. It has elephant-shaped legs, which also distinguish the tortoise from other species of aquatic or semi-aquatic chelonians (RUEDA-ALMONACID et al., 2007; VOGT, 2008). It can reach 450 mm of carapace length and weigh up to eight kilos (VOGT, 2008). Males are larger than females and have a larger tail and a concavity in the plastron (MOSKOVITS, 1988).

Current category of international evaluation: it is not in the IUCN red list and in the global evaluation that is in progress by the TFTSG the species is considered Vulnerable (VU) (RHODIN et al., 2018). It is listed in Appendix II of the CITES (CITES, 2019).

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: it occurs in the following countries: Argentina, Paraguay (to the south), Bolivia, Peru, Brazil, Colombia, Venezuela, Suriname, Guyana, French Guiana and Panama (Figure 26) (RHODIN et al., 2018). In Brazil, it occurs throughout the Legal Amazon, with the exception of the state of Acre, besides the states of Alagoas, Bahia, Ceará, Mato Grosso, Mato Grosso do Sul, Pernambuco, Piauí, Rio de Janeiro, Sergipe and Tocantins (JEROZOLIMSKI, 2005; RHODIN et al., 2018). The area of occurrence of the species is 10,047,010.91 km^2 and for the Amazon Basin it is 3,861,872.95 km^2 (FERRARA et al., 2017).

Habitat and ecology: it inhabits, preferably, open and dry areas and can occur in sympatry with

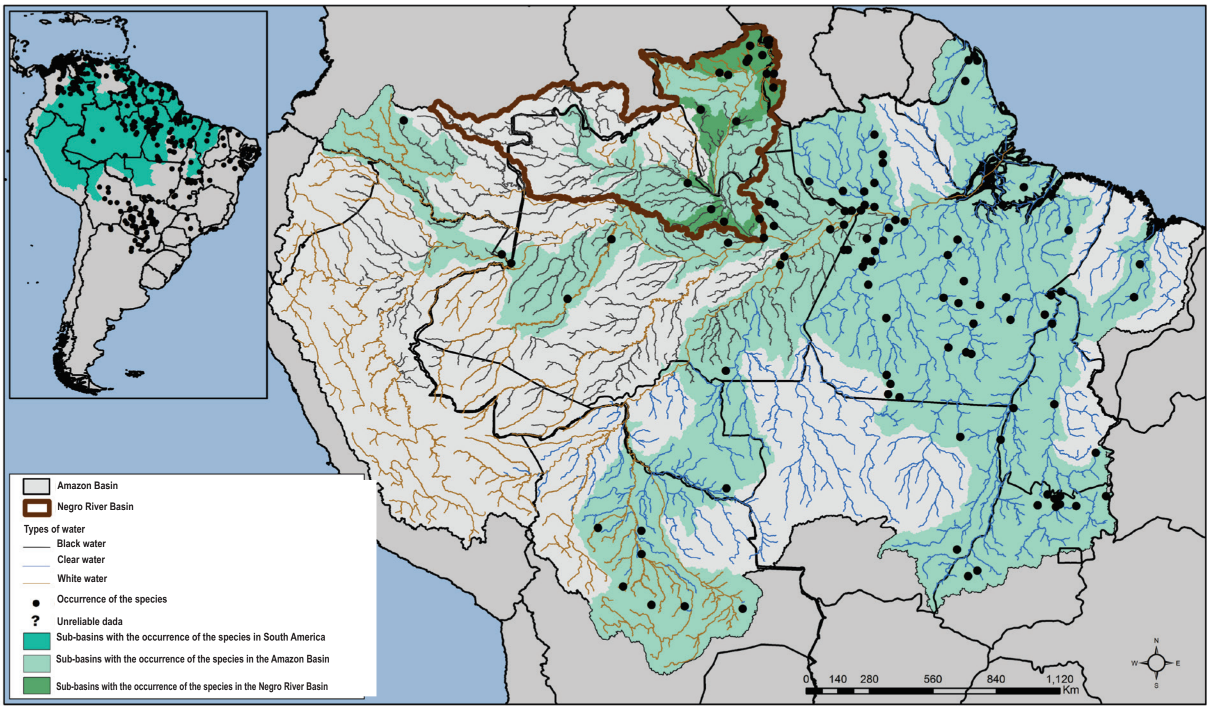

Figure 26 – Map of the geographic distribution of red-footed tortoise (*Chelonoidis carbonarius*) (FERRARA et al., 2017).

C. denticulatus (MOREIRA, 1989; JEROZOLIMSKI, 2005). The nesting of this species occurs between August and January (VOGT, 2008). Two to five nests are performed per reproductive season, when 1 to 15 eggs, spherical and hard-shelled, are laid (VOGT, 2008; GALLEGO-GARCÍA et al., 2012).

It feeds mainly on fruits that make up 70% of its diet. They also feed on flowers, live and dead parts of plants (leaves, roots), earth, fungi and sand. In a smaller amount, they feed on animals such as insects, snails, worms, and carrion (GALLEGO-GARCÍA et al., 2012). Its diet is primarily fruits, its movement pattern and its density in the environment make this species an important seed disperser (JEROZOLIMSKI, 2005; STRONG; FRAGOSO, 2006).

The estimated area of life in southern Pará was 0.45 ha to 167.73 ha (JEROZOLIMSKI, 2005). Moskovits (1985) estimates the living area at 0.6 ha to 83.3 ha for males and 1.5 ha to 117.5 ha for females.

Threats: it is a species highly appreciated as food or pet by local populations, being captured whenever it is found (VOGT, 2008; ECHEVERRY-A et al., 2012).

Need for Research: Currently, studies of distribution, population structure and reproduction are needed (FERRARA et al., 2017).

Yellow-footed tortoise (*Chelonoidis denticulatus)*

Other common names: jabuti-amarelo, jabuti-tinga, jabuti-açu and carumbé (Brazil); *mocorroy pata amarilla* (Colombia, Venezuela); motelo (Peru); *peta del monte, peta amarilla* (Bolívia).

Figure 27 – Yellow-footed tortoise (*Chelonoidis denticulatus*), Cuieiras river, affluent of the lower Negro River/state of Amazonas – AM. (Photo: Rafael Bernhard).

Description of the species: it is the largest tortoise in Brazil, it can reach 820 mm carapace length and weigh 60 kg, although the average are animals measuring 400 mm and weighing 15 kg (VOGT, 2008). Very similar to *C. carbonarius, C. denticulatus* it differs from the first one mainly by its larger size, the pattern of patches on the carapace (larger and with no well-defined pale-yellow edges) and by the yellow or orange coloring of the patches on the head and limbs (Figure 27). The presence of nuchal scales and the first serrated marginal scales (toothed) differ the hatchlings of *C. denticulatus* from the hatchlings of *C. carbonarius* (VOGT, 2008).

Current international evaluation category: in the IUCN red list it was classified as Vulnerable (VU) and in the ongoing global evaluation by the TFTSG the species is considered Near Threatened (NT) (RHODIN et al., 2018). In the CITES it is listed in Appendix II (CITES, 2019).

Current category of evaluation of the species in Brazil: it is not on the Official National List of Endangered Species (BRAZIL, 2014) and is classified as Least Concern (LC) (ICMBIO, 2018).

Geographic distribution: it has a wide geographic distribution, occurring in Bolivia, Brazil, Colombia, Ecuador, French Guyana, Peru, Suriname, Trinidad, Venezuela, besides being introduced in Guadalupe (Figure 28) (RHODIN et al., 2018). In Brazil, it occurs in all states of the Legal Amazon and in some states of the Atlantic Forest domain (Espírito Santo, Rio de Janeiro, Bahia). It can also be found in some states of Central Brazil (Goiás, Mato Grosso and Mato Grosso do Sul) (JEROZOLIMSKI, 2005; RHODIN et al., 2018). The range of occurrence of the species is 9,068,578.75 km^2 and for the Amazon Basin it is 5,572,855.33 km^2 (FERRARA et al., 2017).

Habitat and ecology: it has terrestrial habits and is usually found in dense tropical ombrophilous forests or semideciduous forests and may occur in a smaller proportion in more open and dry environments such as mangroves, fields, savannas and xeric formations (JEROZOLIMSKI, 2005). It is an omnivorous animal. Among the food they eat are grasses, leaves, fruits, flowers, seeds, shoots, mushrooms, insects and putrefying animal material (VOGT, 2008). It is also an important seed disperser (JEROZOLIMSKI, 2005; STRONG; FRAGOSO, 2006).

It reaches maturity between 12 and 15 years, with carapace length greater than 250 mm (RUEDA-ALMONACID et al., 2007). As for reproduction, copulation occurs throughout the year and nesting occurs between August and February (RUEDA-ALMONACID et al., 2007). A female can nest up to four times in a year and lay 1 to 8 eggs at a time, burying them or covering them with leaves found on the forest floor (VOGT, 2008).

Its density varied from 25.16 to 31.44 individuals/km^2 in an indigenous territory south of the state of Pará (JEROZOLIMSKI, 2005). In Colombia, two studies indicated densities ranging from 15.9 to 41 individuals/km^2 (ECHEVERRY-A. et al., 2012). The estimated living area in southern of Pará was 0.4 ha to 101.49 ha (JEROZOLIMSKI, 2005).

Threats: it is a species highly appreciated as food or pet by local populations, being captured whenever it is found (VOGT, 2008; ECHEVERRY-A. et al., 2012).

Need for Research: Currently, distribution, population structure and reproduction studies are needed (FERRARA et al., 2017).

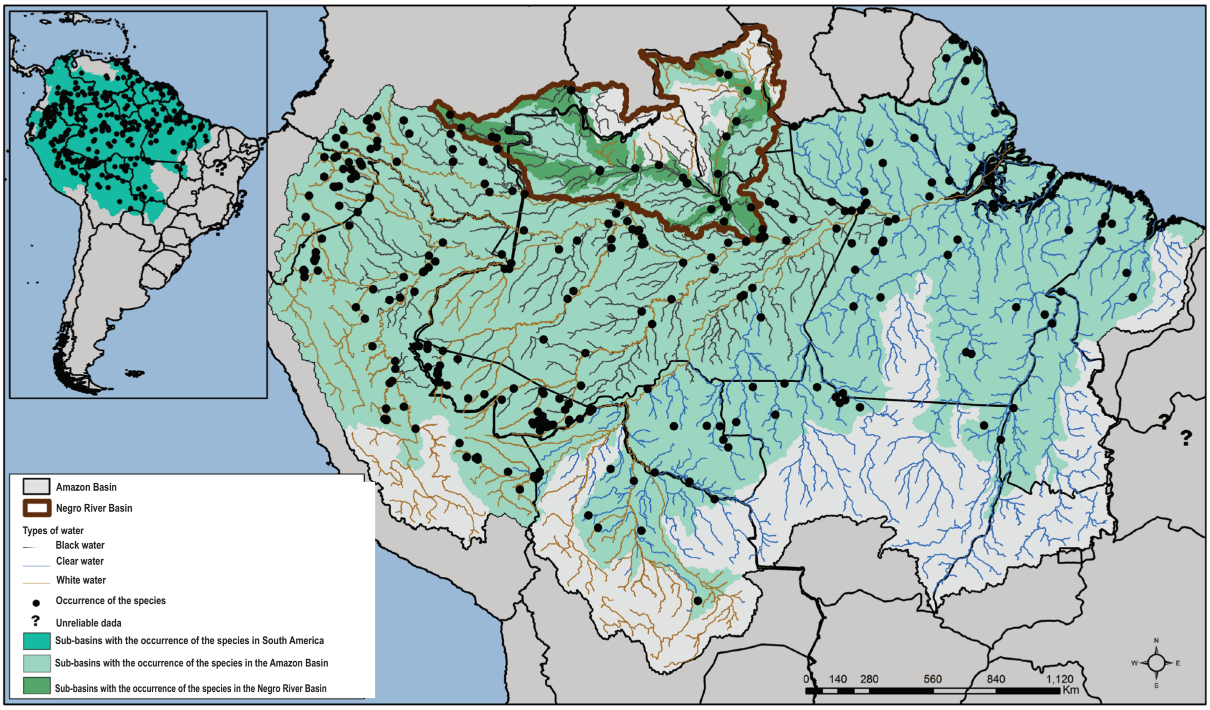

Figure 28 – Map of the geographic distribution of yellow-footed tortoise (*Chelonoidis denticulatus*) (FERRARA et al., 2017).

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Chapter 4

Vulnerability of the nesting sites of the target species of the Brazilian Action Plan for the Amazon Freshwater Turtles and effectiveness of public policies

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Introduction

Currently, turtles are among the most threatened vertebrate groups (KLEMENS, 2000), with 41.6% of the species categorized as Critically Endangered, Threatened, or Vulnerable (TURTLE TAXONOMY WORKING GROUP, 2017). The decline of the group is largely attributed to habitat loss and fragmentation (REESE; WELSH, 1998; GIBBONS et al., 2000; QUESNELLE et al., 2013) and over-exploitation (GIBBONS et al., 2000; KLEMENS, 2000).

The Amazon is an important region for the conservation of this group. The biome is rich in turtle species (BUHLMANN et al., 2009), and individuals and eggs of various species have been traded illegally and widely consumed by traditional and urban populations for many generations (PRITCHARD; TREBBAU, 1984; FACHÍN-TERÁN et al., 1996; VOGT, 2001). The greatest hunting pressure is found in the podocnemididae family (KLEMENS; THORBJARNARSON, 1995; VOGT, 2001) and has caused the reduction of its populations in much of the Amazon Basin (MITTERMEIER, 1975; VOGT, 2001), while in some areas there is still great abundance (ALCÂNTARA et al., 2013). In addition, the Amazon has been heavily impacted by increasing deforestation and loss of habitat quality, mainly from extractive, agricultural, and infrastructure construction activities (ALENCAR et al., 2004; LAURANCE et al., 2004; FEARNSIDE, 2005; SOARES-FILHO et al., 2006; PEREIRA et al., 2010).

The loss and degradation of habitats are major threats to the Amazon turtles (RHODIN et al., 2009; BERRY; IVERSON, 2011; MAGNUSSON; VOGT, 2014; MITTERMEIER et al., 2015), however, there are almost no studies that quantify such impacts on their populations. Specifically, the construction of hydroelectric dams hamper the turtle movement (POFF; HART, 2002; AGOSTINHO et al., 2008). The changes in the hydrological cycle from both infrastructure works and global warming have negative effects on the group populations. Norris et al., (2018), even taking into account nesting beaches such as the reproductive site of *Podocnemis unifilis* (yellow-spotted river turtles) and the fact that the species only nests once during the reproductive period, it was found that 25% of the current/potential nesting areas were lost upstream of the dam, with the establishment of a hydroelectric plant in Amapá. Upstream of the Tucuruí dam, the permanent submergence of beaches led to the disappearance of *P. expansa* (giant South American river turtle) in the area under the reservoir influence, while *P. unifilis* nested in the new available environments, which caused impacts on hatching rates and reproductive success (FÉLIX-SILVA, 2009). In Trombetas River, state of Pará, hydrologic changes in the last decades decreased the exposure time of the nesting beaches of *P. expansa* and, consequently, the success of nesting (EISEMBERG et al, 2016). The authors conclude that there has been a reduction of 15 days per decade in the number of days that nesting beaches are exposed.

Due to the historical exploitation of species of the podocnemididae family in the Amazon, in 1979, there was an initiative of the Federal Government to create a project aimed at their conservation – *Programa Quelônios da Amazônia* – PQA (Amazon Turtle Program) (IBAMA, 1989) – covering mainly three target species: *P. expansa, P. unifilis* and *P. sextuberculata*. Since PQA creation more than 80 million hatchlings have already been released into the wild, with the help of local communities. Following this model, several conservation actions developed for turtles in the Amazon have focused on local or regional protection of nesting sites to ensure the emergence of hatchlings. *P. expansa* and *P. sextuberculata* nest, almost exclusively, on sandbanks, on the edge of water resources and in the dry season, while *P. unifilis* also nests in abundance on clay ravines (ANDRADE, 2008; VOGT, 2008; FERRARA et al., 2017).

This strategy allowed Brazil to have significant stocks of *Podocnemis* species, and some populations managed by the government and communities show signs of recovery (MIORANDO et al., 2013; CANTARELLI, 2014). Some populations continue to decline (EISEMBERG et al., 2019) and in most of the Amazon Basin there is a lack of information about its stocks. Thus, the need for planning spatial conservation on a large scale was identified, with greater diversity of action. Thus, the federal government instituted the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtle, focusing on the same species of the PQA. The general objective of this plan is to improve the conservation strategies for the Amazon freshwater turtles, especially the target species, and promote actions for the recovery of their populations and sustainable use (BRAZIL, 2015).

An important initiative for the conservation of Amazon freshwater turtles began in 2011, when the Secretary of Environment and Sustainable Development of the State of Amazonas (SEMA/State of Amazonas–AM) formed a Working Group (WG) to develop standardization instruments that established priority areas for the conservation of turtles, as well as rules, restrictions and criteria for protection and community management in important breeding areas. The WG was formed by turtle experts, environmental institutions and representatives of civil society. Finally, in 2017, the instruments prepared by the WG were approved by the *Conselho Estadual de Meio Ambiente do Amazonas* – CEMAAN (Amazonas State Environmental Council), with more than 265 turtle breeding sites recognized as o *Zonas de Proteção Temporária de Quelônios* – ZPTQ (Chelonians Temporary Protection Zones) and protected with community participation. The ZPTQs cover areas outside conservation units (more than 80%) and areas in state conservation units (CEMAAN Resolution Nº 25/2017). This resolution considers the nesting sites of several species of turtles (*P. expansa, P. unifilis, P. sextuberculata, P. erythrocephala and Peltocephalus dumerilianus*).

Given the various threats to which the Amazon freshwater turtles are subjected, as well as the absence of large-scale systematized information, it is essential to evaluate the scope of public policy actions in the Brazilian Amazon, as well as to identify regions that are more vulnerable and require more urgent management and conservation measures. However, a bottleneck for spatial analysis and adequate planning of conservation actions directed to the group at the Amazonian scale is the amount of information available on the distribution of turtles and their nesting sites. Although knowledge about the distribution of the *Podocnemis* genus is better than for other Amazon freshwater turtles, it is still quite incomplete, given the large number of environments and areas available for nesting in this biome.

In this context, Species Distribution Models (SDMs) (ARAÚJO; PETERSON, 2012; PETERSON; SOBERÓN, 2012) can be an important tool to fill the gaps in organism distribution information (RAXWORTHY et al., 2003; COSTA et al., 2010). These models calculate the environmental adequacy for the existence of populations (GUISAN; THUILLER, 2005; ELITH; LEATHWICK, 2009; FRANKLIN, 2010; PETERSON et al., 2011), by identifying statistical relationships between their occurrences and a group of environmental predictors (GUISAN; ZIMMERMANN, 2000). The appropriate areas are projected in the geographic space to estimate the distribution of the species (PETERSON, 2001).

The use of occurrence area estimates of species or habitats facilitates the identification of areas of greater vulnerability to anthropic activities on a large scale. Frequently, the vulnerability component called exposure is used, which quantifies the variable of interest that is superimposed on the threats (DAWSON et al. 2011). The indication of regions or basins with greater vulnerability to human activities is fundamental to direct studies and prioritize populations, since there is a scarcity of human and financial resources in the environmental area and relevance of socioeconomic interests to the detriment of environmental interests. Moreover, these analyses are important for the development of effective strategies for management, mitigation or compensation of environmental impacts. In this sense, this work aims to evaluate the vulnerability of sandbanks that are possible reproductive sites of Amazon freshwater turtles, in face of anthropic activities, as well as to analyze the scope and the gaps of the actions of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles, focused on the monitoring of reproductive sites, and of the Temporary Chelonians Protection Zones regarding the area of sandbanks mapped in the Brazilian Amazon. In this way, it is expected to contribute to improving the effectiveness of public conservation policies for the group in question.

Methodology

Modeling the distribution of areas suitable for nesting

Nesting site data and environmental variables

The locations of nesting sites of the three target species of the Brazilian Action Plan were compiled: *Podocnemis. expansa* (giant South American river turtle), *P. sextuberculata* (six-tubercled Amazon river turtle) and *P. unifilis* (yellow-spotted river turtle), from a literature review, unpublished data from research groups participating in the Brazilian Action Plan and data from the Brazilian Government PQA program (BALESTRA, 2016). This process totaled 3,525 registers of nesting sites, being 1,942 of *P. expansa*, 1,033 of *P. unifilis* and 550 of *P. sextuberculata*. The area of the Amazon Biome was divided into 4 km^2 grids and, in the construction of the models of areas suitable for nesting, an occurrence record was considered for each square, with the purpose of reducing the effects of sampling bias (KADMON et al., 2004).

Forty-two environmental variables were used: 37 climatic, three variables that characterize the terrain and two related to aquatic environments, as explained in Fagundes et al. (2016) (Appendix 1). All environmental layers were transformed to a resolution of 4 km^2. The analysis of main components (PCA) of the environmental variables was performed to reduce the collinearity between them, and the results were used as predictor variables in the development of the models. Twelve main components were selected that reflect more than 95% of the variation found in the environmental variables selected (PERES-NETO et al., 2005).

Distribution models of potential nesting areas

Of the four statistical methods used for modeling, Fagundes et al. (2016) found that the Maximum Entropy algorithm was the best model for turtles in the Amazon. For this study, the "presence/background" approach of the Maximum Entropy method was employed (PHILLIPS et al., 2006; ELITH et al., 2010), using the MaxEnt program, which evaluates the relationship between the environmental variables of the local registers known and the environment throughout the study area (PETERSON et al., 2011). The models were created and evaluated for the entire Amazon Basin. The occurrence data of nesting beaches of each species were divided into training subset and tested subset groups that corresponded to between 80% and 20% of the records, respectively. The testing data were used to adjust the model and the test data to evaluate them. Ten thousand data were used to compose the background. The evaluation of the models was carried out based on measures derived from the elements of a confusion matrix (ELITH et al., 2006; PETERSON et al., 2011). To convert the environmental suitability gradient to nesting, in predictions of occurrence/non-occurrence, a threshold derived from the ROC curve was chosen. This method lists the commission and omission errors of the models in all possible thresholds and identifies the value at which such errors balance (JIMENEZ-VALVERDE; LOBO, 2007).

The models were evaluated with the method dependent on the threshold choice – True Skill Statistics (TSS) (ALLOUCHE et al., 2006; LIU et al., 2011;). The TSS ranges from -1 to 1, in which negative values or close to 0 are not better than chance; and values close to 1 indicate that the observed distribution and model are equal (LIU et al., 2009). The TSS variance equation, proposed by Allouche et al. (2006), was used to calculate the 95% confidence interval for TSS values. Best performing models usually have TSS ≥ 0.5 (FIELDING; BELL, 1997).

Vulnerability of Brazilian Action Plan target species sandbanks to anthropic threats

Mapping of sandbanks

The study area of sandbank mapping was defined from the union of the models of potential nesting areas of the species *P. expansa*, *P. unifilis* and *P. sextuberculata*. All the water bodies that overlapped the models were selected and highlighted from the main rivers and their tributaries. Buffers with variable values were used to ensure that river margins were included in the study area (Figure 1). The result was aggregated to a layer of the main rivers with a 3 km buffer, in order to allow narrower rivers that do not have a spatially explicit water mass to be also included in the analysis. Then, the area defined by the water masses and main rivers with buffer was cut to the extent of occurrence of the target species (represented by a minimum convex polygon). Finally, as the models have omission errors, important river areas for *Podocnemis* nesting in the Brazilian Amazon were also inserted, which were not selected in the model, such as the Rio Branco in the state of Roraima (Figure 2).

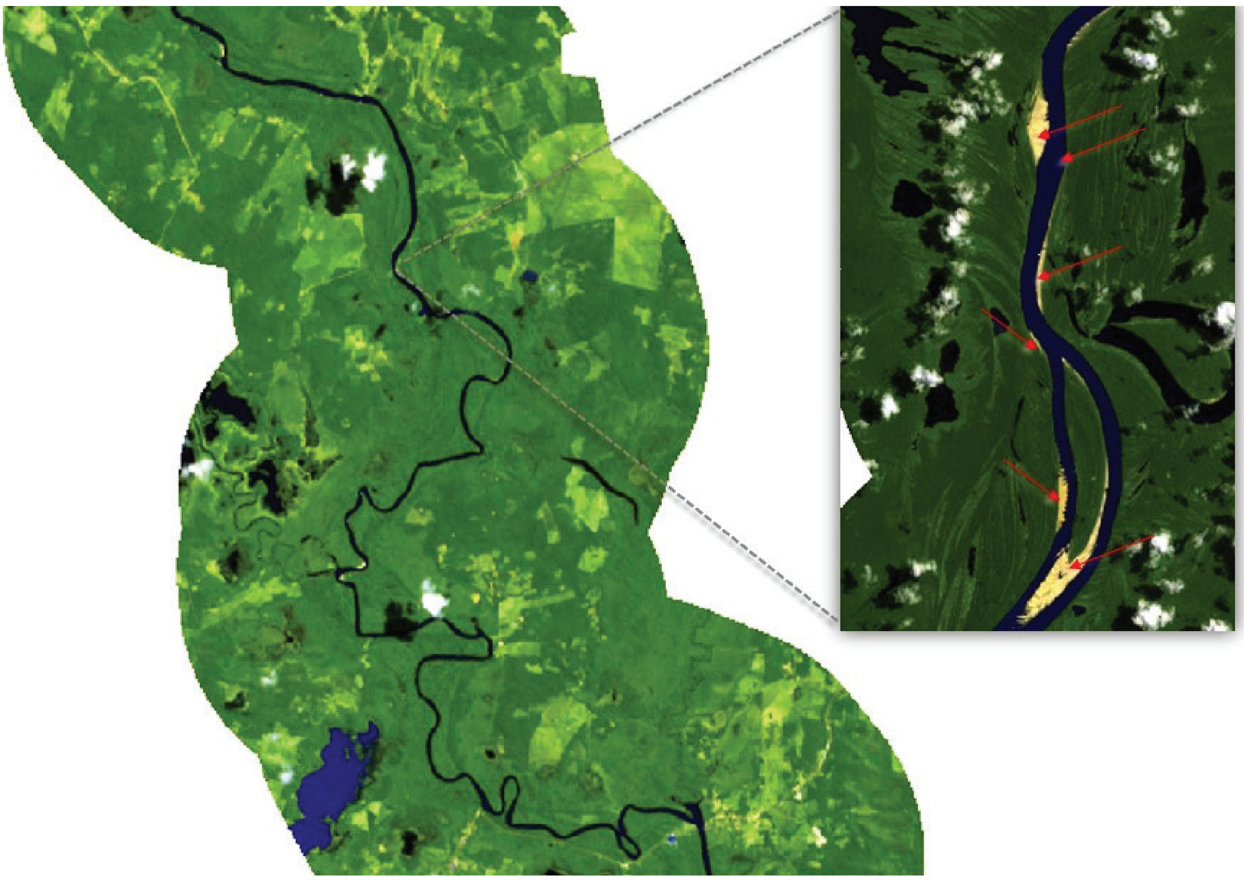

Figure 1 – Example of buffer over hydrography (left) and the detailing of mapped sandbanks (right) in satellite images, via supervised classification.

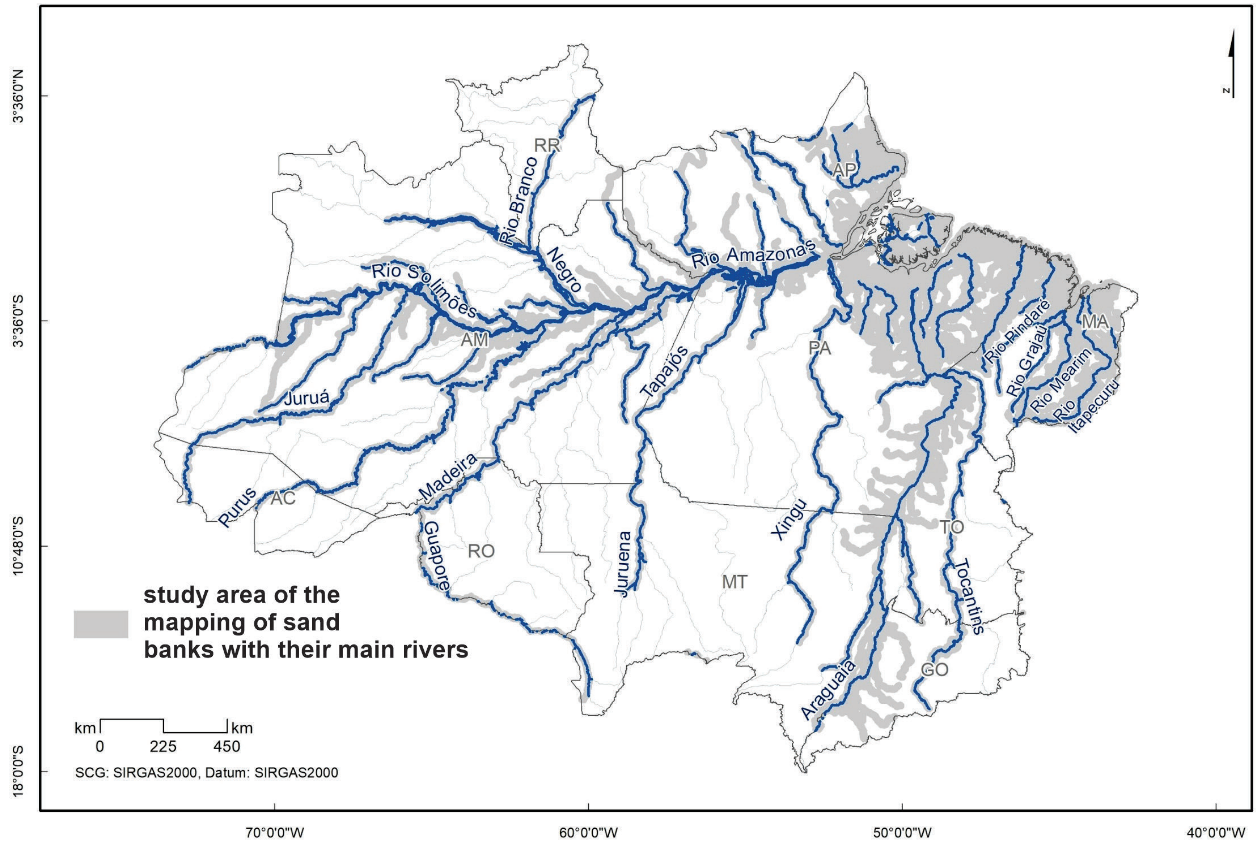

Figure 2 – Study area of the sandbanks mapping with the identification of the main rivers of the region.

The images were acquired from the Earth Explorer website (http://earthexplorer.usgs.gov/) made available by the American Geological Survey (USGS, 2017). One hundred and forty-two Landsat 8, sensor OLI (Operational Land Imager) sensor images were used to map the sandbanks in the study area, obtained during the drought period between 2014 and 2015 (orbits and point described in Annex 2). The 2016 images were not prioritized due to the large amount of clouds over the surface imaged in that period. The information about the rainy seasons that subsidized the choice of images was provided by the INPE website (http://clima1.cptec.inpe.br/estacaochuvosa/pt). Finally, in some places the analysis was done month by month, to identify the period with the largest amount of sandbanks, but this occurred sporadically. The spectral bands used are specified in Table 1.

Table 1 – Description of the Landsat sensor bands and their wavelengths.

Band	L8 - OLI		Radiometric	Temporal (days)	Spatial (m)
Red	Band 4	0.64 - 0.67 µm			
Near Infrared	Band 6	0.85 - 0.88 µm	16 bits	16	30
Short wavelengths infrared 2	Band 7	2.11 - 2.29 µm			

Adapted from USGS Landsat.

These images already have geometric correction. For the atmospheric correction of Bands 4, 6 and 7 the DOS method was used (CHAVEZ, 1988), which corrects the atmospheric spread in which the atmospheric interference is estimated directly from the digital numbers (ND) of the satellite image. After this correction, the images were stacked and selected for the study area.

The classes water bodies, sandbanks and vegetation were collected with the minimum number of 10 samples (regions of interest (ROI)), using the Semi-Automatic Classification Plugin extension and thus characterizing a supervised method of satellite image classification (Figure 3). We define as classification algorithm the Spectral Angle Mapping (KRUSE et al., 1993).

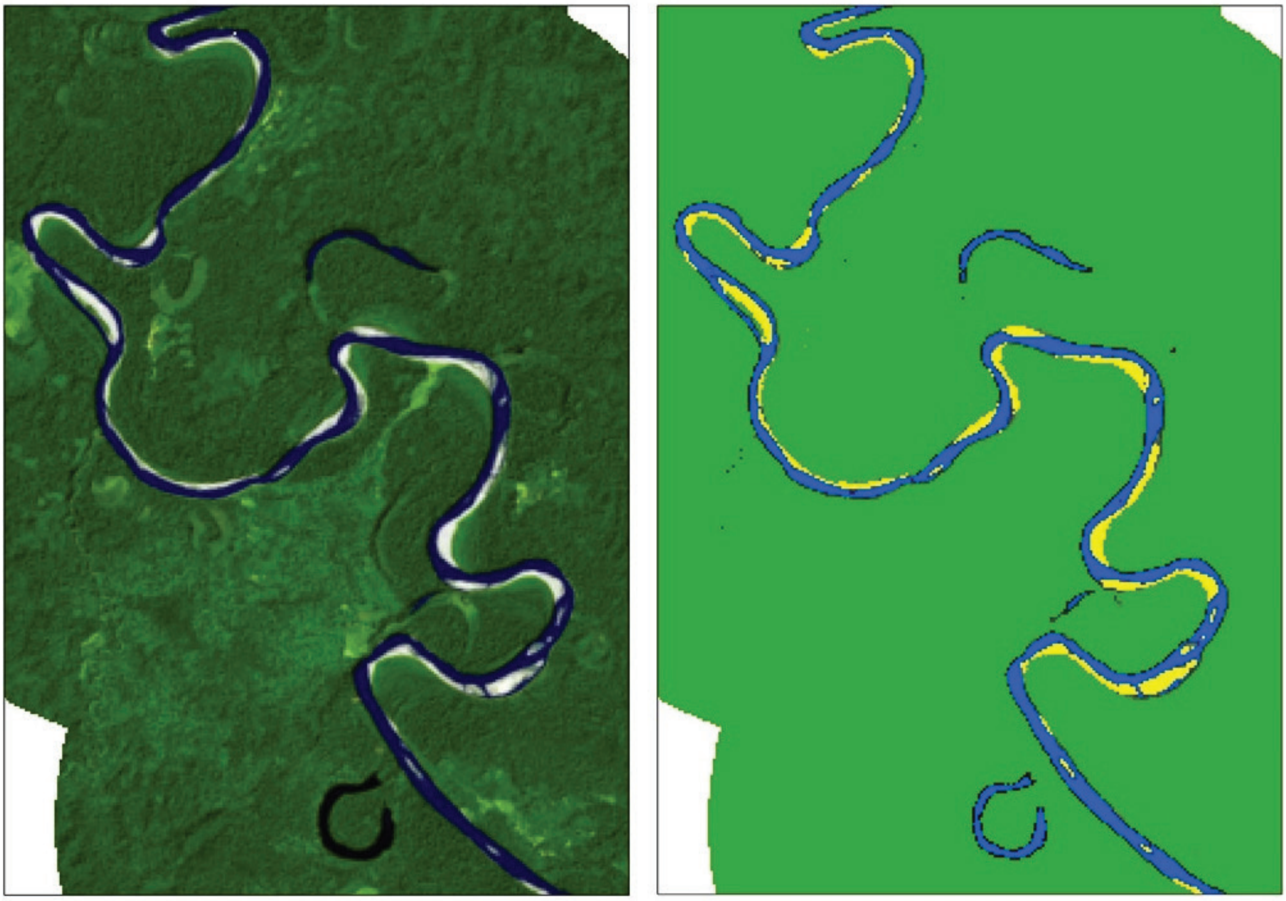

Figure 3 – Example of a satellite image classified in water bodies, sandbanks and vegetation, by the supervised classification method.

To finish this step, the classes "sandbanks" were selected and visually checked in Google Earth. All steps of digital image processing were developed in Quantum GIS – QGIS, version 2.18 (SHERMAN et al., 2017).

Anthropic threats to the target species of the Brazilian Action Plan

Four anthropic threats to the target-species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles were defined to be used in the analysis of vulnerability of sandbanks by sub-basins in their potential nesting areas: deforestation, mining, hydroelectric enterprises and human community density.

a) Deforestation

The deforestation data were obtained from MapBiomas Project (2017). Such data correspond to information mapped for 2013, referring to the Cerrado Biome, and for 2015, referring to the Amazon. Land use classes that do not represent remnants of natural vegetation or water were selected, as described in Table 2. These classes were transformed into a single class (deforestation) and the file re-sampled to the spatial resolution of 1 km (the original data are 30 m), which facilitates the conversion of the matrix file to the vector format.

Table 2 – Codes of the legends of the classes selected from the file of land use, from MapBiomas V.2.0, used as deforestation in the vulnerability analysis, showing the respective pixel values.

Class	Pixel value	Class	Pixel value
Silviculture	9	Semi perennials cultures	20
Farming use	14	Mosaics of cultivations	28
Pasture	15	Agriculture or pasture	21
Other pastures	17	Non vegetated areas	22
Agriculture	18	Urban Infrastructure	24
Annual cultivations	19	Other areas without vegetation	25

Adapted from the MapBiomas V.2.0 Project.

b) Mining

The mining data are polygons coming from the archive of mining enterprises of the *Departamento Nacional de Produção Mineral* – DNPM (National Department of Mineral Production) (DNPM, 2017) in which they were selected or excluded from the Phase 1 column specified classes in Table 3.

Table 3 – Classes selected and excluded from the Phase 1 column of the mining file (DNPM), to represent the mining projects in the vulnerability analysis.

Project	Selected phases	Excluded phases
Mining	Authorization for research/ Mining application / Requirement of mining prospecting work/ Request for extraction registration / Requirement of license/ mining prospection/granting of mining/ registration of extraction/ licensing	Availability /data not registered/Requirement for research/

c) Hydroelectric enterprises

The data from hydroelectric projects made available by the *Agência Nacional de Energia Elétrica* – ANEEL (National Electric Energy Agency) (ANEEL, 2017) were selected based on the "Stage" column in the "hydroelectric uses" file, and the stages specified in Table 4 were used for analysis.

Next, a buffer was generated with the value defined in the "AREA_NA_MAX_MONT" column of the original file. This information is similar to the hydroelectric reservoir area, calculated by the *Agência Nacional de Águas* (Brazilian Water Agency). The lowest value was assumed among the enterprises for the hydroelectric plants that had no value in this column.

d) Density of human communities

The data from human communities (rural and urban) are available in vector points format and correspond to the localities mapped by IBGE (2010). The densities of these points were estimated, within the study area, by applying a Kernel density estimator. The Kernel density estimator draws a circular vicinity around each point, corresponding to the radius of influence, and then a mathematical

Table 4 – Selected stages of the hydroelectric utilization file (ANEEL), to represent these enterprises in the vulnerability analysis.

Enterprise	Selected data	Excluded data
HPP	TEFS accepted/ TEFS approved/ TEFS in preparation/ DRIG/ grant/ PB accepted/ PB approved/ PB in preparation/ construction with grant/ construction not started/ operation/ deactivated	Inventoried/revoked shaft
SHPP	DRS/DRIG/ grant/ BP accepted/ BP approved/ BP in preparation / construction with grant / construction not started / operation / deactivated	Inventoried/revoked shaft
HGP	BP accepted/BP in preparation / construction with grant / construction not started/ operation / deactivated	Inventoried/revoked shaft

HPP= Hydroelectric Power Plant; SHPP= Small Hydroelectric Power Plants; HGP= Hydroelectric Generating Plants; TEFS= Technical-Economic Feasibility Study; DRIG= Dispatch of Registration of Intention to Grant; DRS= Dispatch of Registration of Adequacy of the Executive Summary; BP= Basic Project.

function of 1 is applied, at the position of the point, at 0, at the border of the vicinity. Its product is a matrix file in which the value for each pixel is the sum of the overlapping Kernel values and divided by the area of each search radius (SILVERMAN,1986). A standard search radius (approximately 1.333 degree or 148 km) was used.

Analysis of the vulnerability of sandbanks to anthropic threats

In order to standardize the information, a single unit of spatial representation compatible with the spatial dimensions of all variables was selected. For this reason, a regular grid with a size of 0.083 degree (an edge of approximately 10 Km) was adopted. The regular grid was built based on the limits of the study area.

The anthropic threats (deforestation, mining, hydroelectric enterprises, density of human communities) and the sandbanks were associated with the regular grid quadrats, through geoprocessing operations, and the proportion of area that a certain variable has in relation to the total area of the grid was calculated. Then, the variables were transformed to file matrix format and normalized to maximum and minimum values of one and zero (Figure 4).

The anthropic pressure of each quadrat was quantified through the multicriteria analysis of a geographic information system, allowing the variables deforestation, hydroelectric enterprises, mining and density of human communities to overlap. The result consists of a matrix file, in which the values of each pixel represent the sum of the anthropic threats in that location.

From then on, the mean value of threats and sandbanks in each hydrographic sub-basin of the mapping study area is calculated (Basin level 7 – BL7; VENTICINQUE et al., 2016). BL7s come from a new classification, with different basin levels, developed for the entire Amazon Basin, but it is important to highlight that the transformation of the information into matrix data and the subsequent calculation of the mean, for each basin, can reduce the quality of the information.

With these data, after normalization and division into three quantiles (terciles), a bivariate choropleth map was elaborated. Thus, both files were classified into three classes, being possible to build a map with nine levels of color scale. The regions with the largest sandbank area and, simultaneously, with the highest anthropic pressure, are the most vulnerable areas, represented by darker colors, indicating the priority sub-basins for conservation actions.

Effectiveness of public policies – Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles and CEMAAN Resolution Nº 25/2017

In the evaluation of the effectiveness of public policies, the geographic coordinates of the nesting beaches managed by the Brazilian Action Plan

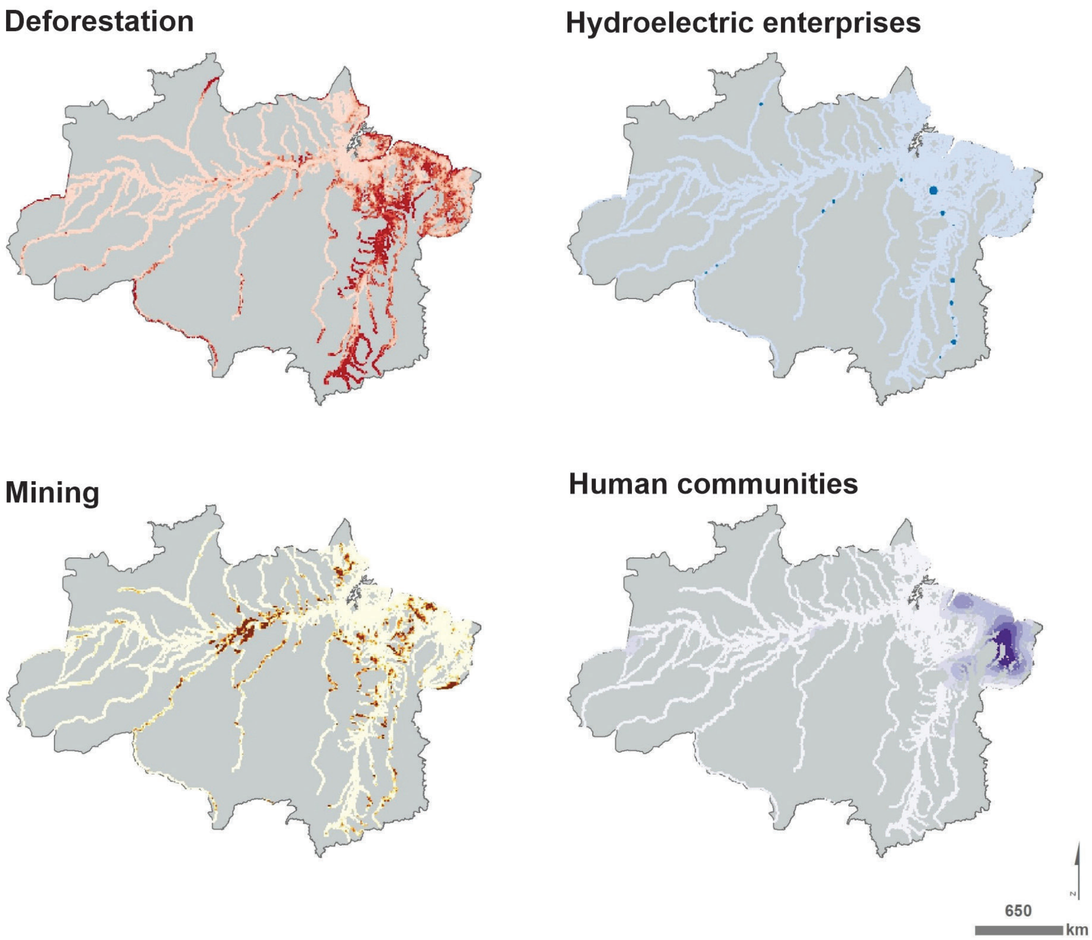

Figure 4 – Threats to the target species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtle used in the vulnerability analysis of the sand banks.

(3,525) were used and the geographic coordinates of the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) described in the CEMAAN Resolution N° 25/2017 were georeferenced. However, two locations of the CEMAAN Resolution were not identified due to lack of information.

The area of sandbanks available for the nesting of the target species of the Brazilian Action Plan in each basin on the BL7 scale (VENTICINQUE et al., 2016) was calculated, considering the entire sandbank mapping study area. Additionally, we calculated the area of sandbanks in the basins in which the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles operates and the area of sandbanks in the basins, which constitute the Temporary Protection Zone of Chelonians. In addition, it was calculated the number of basins in which the sandbanks were mapped, the number of basins in which the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles operates and the number of basins that the CEMAAM Resolution N° 25/2017 covers.

Then, it was verified the percentage of sandbanks and basins that the Brazilian Action Plan and the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) of the state of Amazonas cover, in relation to the total area of sandbanks mapped and their basins in the study area and the state of Amazonas, respectively. It was also evaluated whether the actions of the Brazilian Action Plan and the ZPTQs of the state of

Amazonas are concentrated in the basins with the highest availability of beaches (area of sandbanks mapped per basin), by means of linear regression.

Finally, by overlapping data, the most vulnerable areas were identified, which have actions of the National Action Plan and/or are included in the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians), and the most urgent conservation gaps were made explicit. As the variables proportion of the sandbank area and vulnerability were divided into three quantiles, the areas defined as most vulnerable correspond to the 3rd terciles of the first and 2nd and 3rd terciles of the second.

Results

Models of areas suitable for nesting

According to the method of evaluation of the models – the TSS – the models for *P. expansa* and *P. unifilis* were acceptable, while the model for *P. sextuberculata* was slightly below the limit value (0.50) (Table 5). The species with the largest number of nesting beaches records and the largest potential nesting area exhibited higher TSS values relative to *P. sextuberculata*. The confidence interval for TSS values can be seen in Table 5.

Table 5 – Evaluation of potential nesting area models, according to the True Skill Statistics method for each turtle species evaluated and their confidence interval.

Species	TSS
Podocnemis expansa	0.54 (0.50 - 1)
Podocnemis sextuberculata	0.4 (0.37 - 1)
Podocnemis unifilis	0,.53 (0.49 -1)

VULNERABILITY OF SANDBANKS TO ANTHROPIC THREATS

An area of approximately 3,593 km^2 of sandbanks has been mapped, which are potential nesting sites for the species *P. expansa, P. unifilis* and *P. sextuberculata* (Figure 5). This map of nesting sites can subsidize research and conservation actions for these species, and can direct inventories, beach monitoring, inspection activities and environmental awareness.

In the region of Negro River, the images were collected between December and February, differently from the rest of the other regions, where the images were collected between May and November. This fact may have an influence on the amount of sandbanks mapped. Furthermore, in some regions, such as the north and northeast of the state of Pará, the images had a large amount of clouds, since there is rainfall throughout the year, which can affect the results.

The anthropic threats were mapped to the study area in order to visualize areas with higher anthropic pressure (Figure 4). The variable human communities presented a high concentration in the state of Maranhão. A high concentration of mining activities was also observed in the Amazon River region, in the state of Amapá and in the Tocantins-Araguaia Basin. Some rivers also showed high values of this variable, such as the Madeira and Tapajós Rivers. The hydroelectric enterprises are more restricted, and this variable has high values along the entire Tocantins River. Deforestation is greater in the eastern region of the study area, especially in the Tocantins-Araguaia Basin, the state of Maranhão and along the Guaporé River, in the state of Rondônia.

The vulnerability analyses of the mapped sandbanks indicate that the areas with the most potential for nesting sites and with the most anthropic pressure are located mainly near the rivers: Araguaia and Tocantins (states of Tocantins –TO/ Mato-Grosso – MT/Pará – PA); Branco, Tacutu (state of Roraima

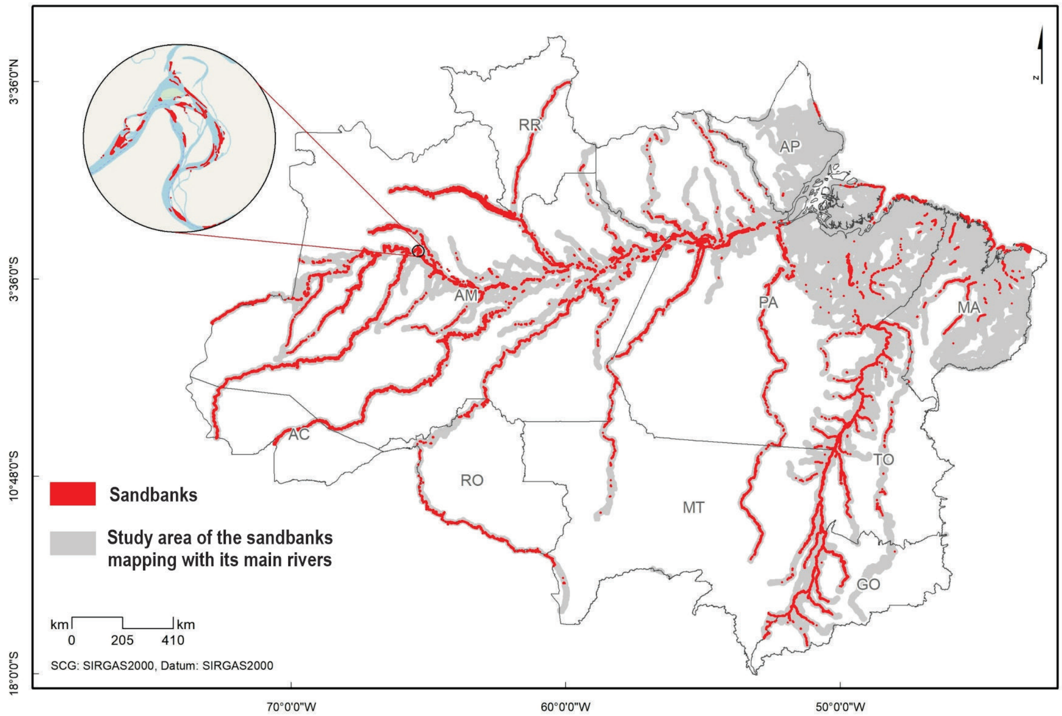

Figure 5 – Identification of the sandbanks mapped over the study area. The sandbanks are very small to the scale of the map. In the enlargement it is possible to better detail the pattern mapped.

– RR); Pindaré, Grajaú, Mearim, Itapecuru (state of Maranhão – MA); Guaporé (state of Rondônia – RO); Amazonas, Solimões, Madeira (States of Amazonas – AM/Pará – PA); Tapajós and Xingu (state of Pará – PA) (Figures 2 and 6).

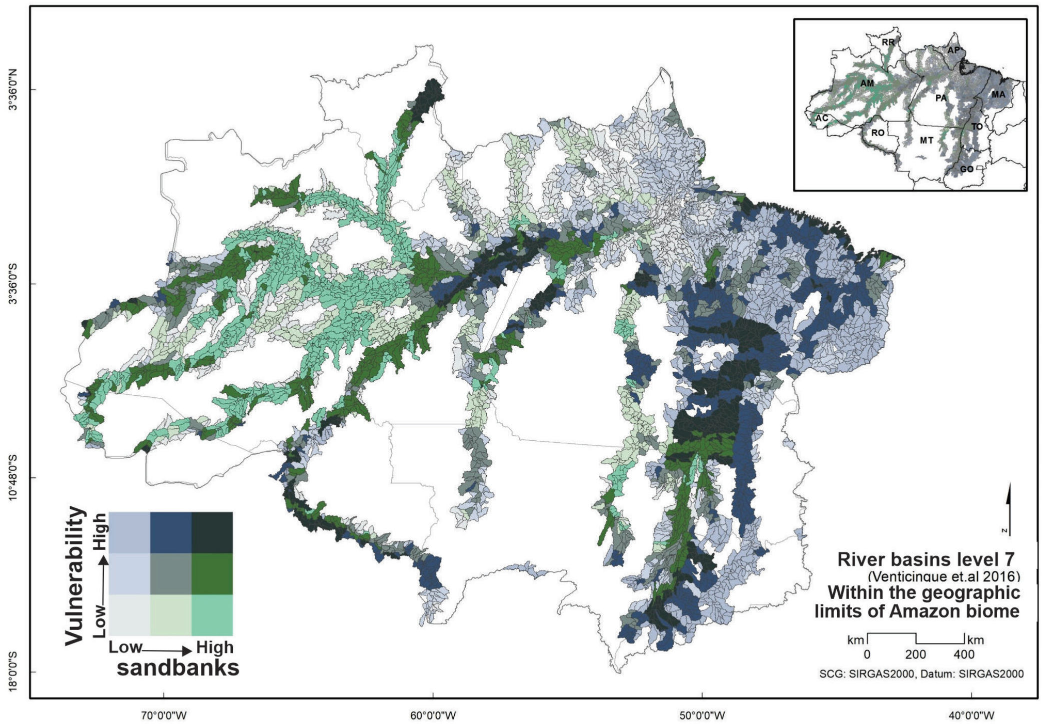

Figure 6 – Bivariate map relating the amount of sandbanks to the level of vulnerability per river basin. The regions in darker color, which correspond to the color located in the upper right corner of the legend, indicate regions with large number of sandbanks and high vulnerability.

The number of basins where sandbanks were mapped in the study area is 1,800 and the area of sandbanks mapped corresponds to 3,589 km^2. It was found that in 273 basins there are activities of the Brazilian Action Plan for the Amazon freshwater turtles, which are focused on monitoring reproductive sites (15.17%), which total 755.47 km^2 of sandbanks (21.05%). Considering only the state of Amazonas, for which the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) were created, 730 basins were mapped in the study area, which have 1,970.86 km^2 of sandbanks. Of these areas, in 105 basins of the state of Amazonas, actions of the Brazilian Action Plan are carried out directed to the monitoring of reproductive sites (14.38%) and 78 (10.68%) are contemplated in the Resolution Nº 25/2017, totaling an area of sandbanks of 444.29 km^2 (22.54%) and 373.98 km^2 (18.97%), respectively (Table 6).

The reproductive monitoring actions of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtle are not concentrated in the basins with greater availability of mapped sandbanks ($R^2 = 0.07$; $p > 0.05$).

The basins that cover the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) and/or the actions of the Brazilian Action Plan and the lagoon basins, that is, without the coverage of the Brazilian Action Plan and ZPTQs, as well as the sandbank areas mapped in each basin, are shown in Figure 7.

Table 6 – Number of basins and sandbanks mapped in the study area, basins and sandbanks with the action of the Brazilian Action Plan for the Conservation of the Amazon Freshwater Turtles and contemplated by the Temporary Protection Zones of Chelonians (ZPTQs), of the CEMAAN Resolution Nº 25/2017, and percentage of coverage of these public policies on the total of basins and sandbanks mapped in the study area and in the state of Amazonas.

	Number of hydrographic basins with sandbanks mapped	Area of sandbanks mapped (km^2)
STUDY AREA	1,800	3,589
The National Action Plan operation areas	273	755.47
Percent coverage of the National Action Plan (%)	15.17	21.05
AMAZONAS STATE	730	1,970.86
Area of actions of the National Action Plan	105	444.29
Areas of coverage of ZPTQs	78	373.98
Percent coverage by the National Action Plan (%)	14.38	22.54
Percentage of ZPTQs coverage (%)	10.68	18.97

The zones presented on Figure 7 are classified in relation to the protection and conservation level, according to CEMAAN Resolution Nº 25/2017. The figure also shows the lagoon basins, where there is no reproductive monitoring of the National Action Plan and no protection of the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians).

Currently, considering the study area of sandbank mapping, the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtle has 43% of its monitoring actions of reproductive

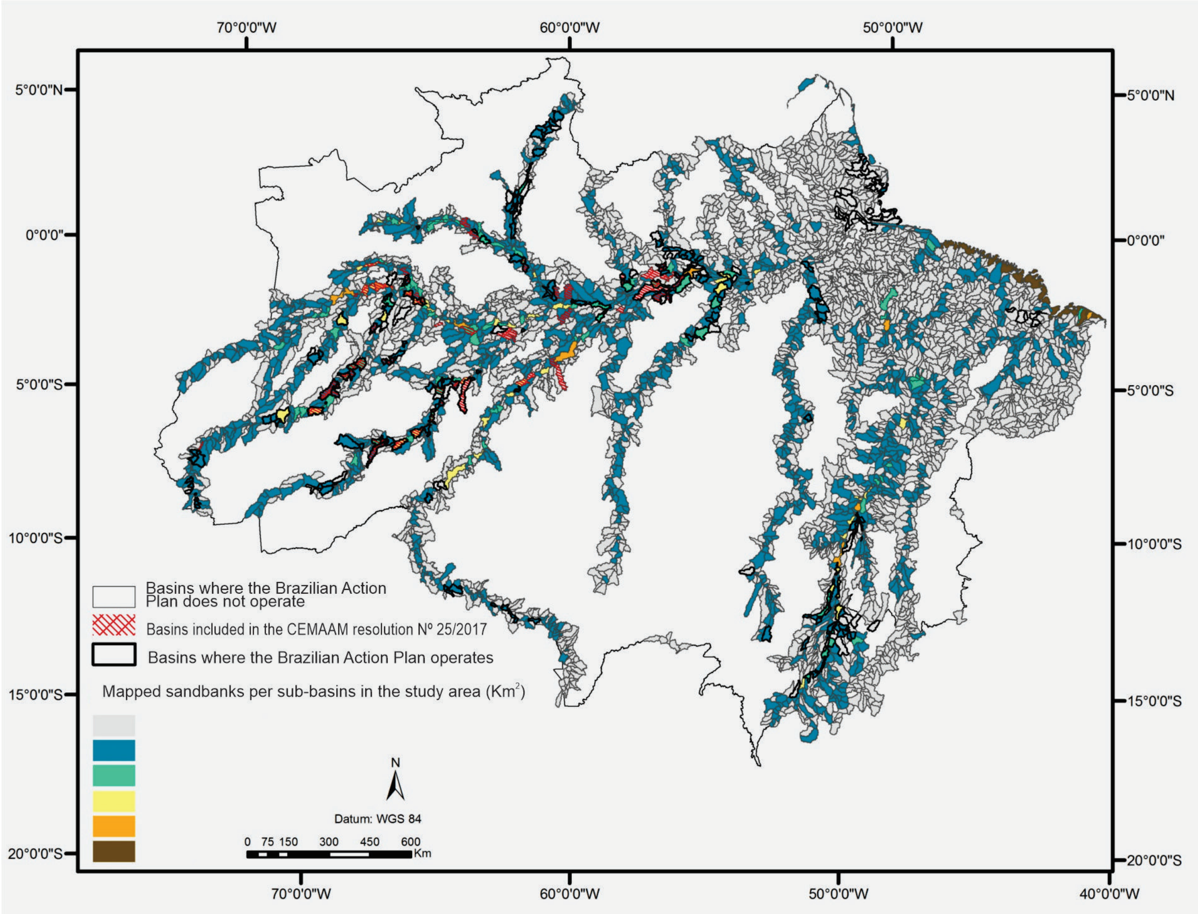

Figure 7 – Area of sandbanks mapped in the study area, basins with the intervention of the Brazilian Action Plan for the Conservation of Amazon freshwater turtles, aimed at monitoring nesting sites and considered by the Temporary Protection Zones of Chelonians (ZPTQs).

sites in basins identified as most vulnerable (upper tercile of sandbank and middle and lower terciles of vulnerability) as, for example, basins of the upper Araguaia River, upper Branco River and upper Amazon River. In relation to the total of the most vulnerable basins identified in this study (1,019 hydrographic basis), only 117 have reproductive monitoring actions of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles, that is, 11%. The regions monitored by the Brazilian Action Plan are concentrated in the upper Branco River/ state of Roraima – RR, lower Negro River/state of Amazonas – AM, Amazon River/ states of Amazonas – AM and Pará – PA, Purus and Juruá Rivers/ state of Amazonas – AM and Acre – AC, Tapajós River/states of Pará – PA, Guaporé River/ state of Rondônia – RO and middle Araguaia (Figure 8). The lower Araguaia and the Madeira and Solimões Rivers stand out as major gaps in conservation action (Figure 8).

Of the most vulnerable basins in the state of Amazonas (373 basins), only 9.4% are represented in the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) (Figure 9). The most vulnerable river basins and with ZPTQs occur in the Amazon, Madeira, Juruá, Purus and Solimões Rivers. However, in these same rivers there are extensive stretches with protection gaps, mainly along the Madeira and Solimões Rivers (Figure 9). It was found that, considering the sandbanks mapping study area, 45% (35) of the established ZPTQs are in basins identified as more vulnerable.

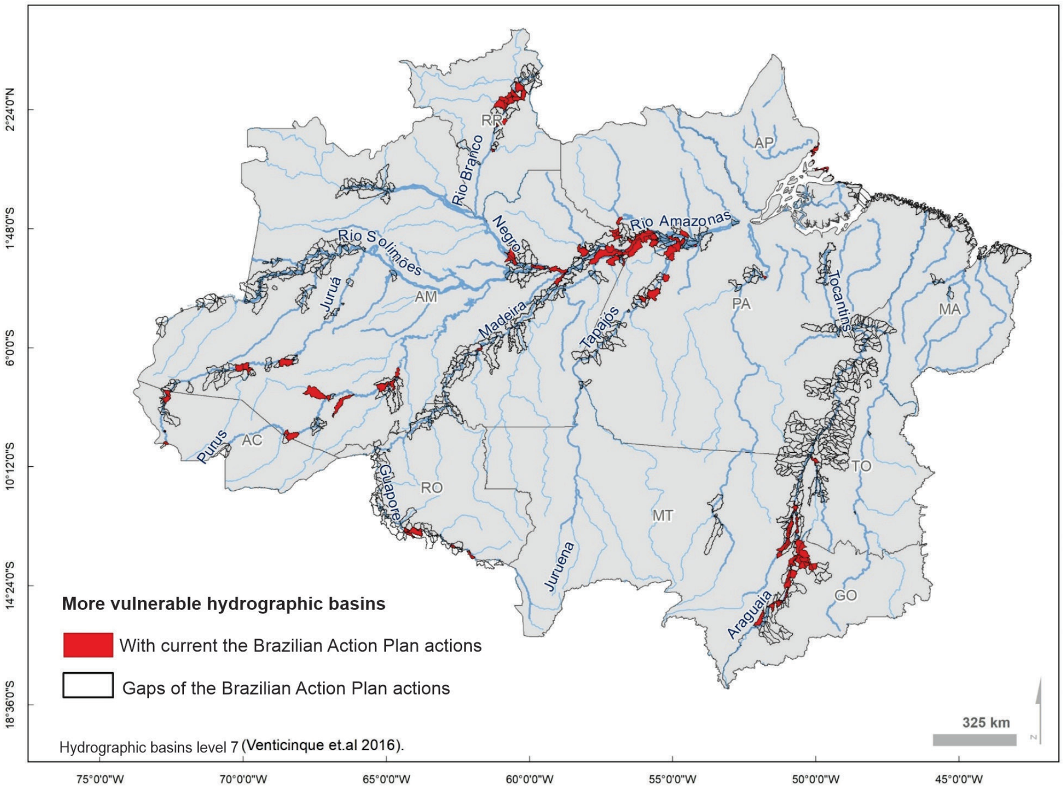

Figure 8 – Scope and gaps of the actions of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles aimed at monitoring reproductive sites, in relation to the river basins identified as most vulnerable. The most vulnerable basins present a high concentration of sandbanks (upper tercile) and medium or high vulnerability to anthropic threats (middle and upper terciles).

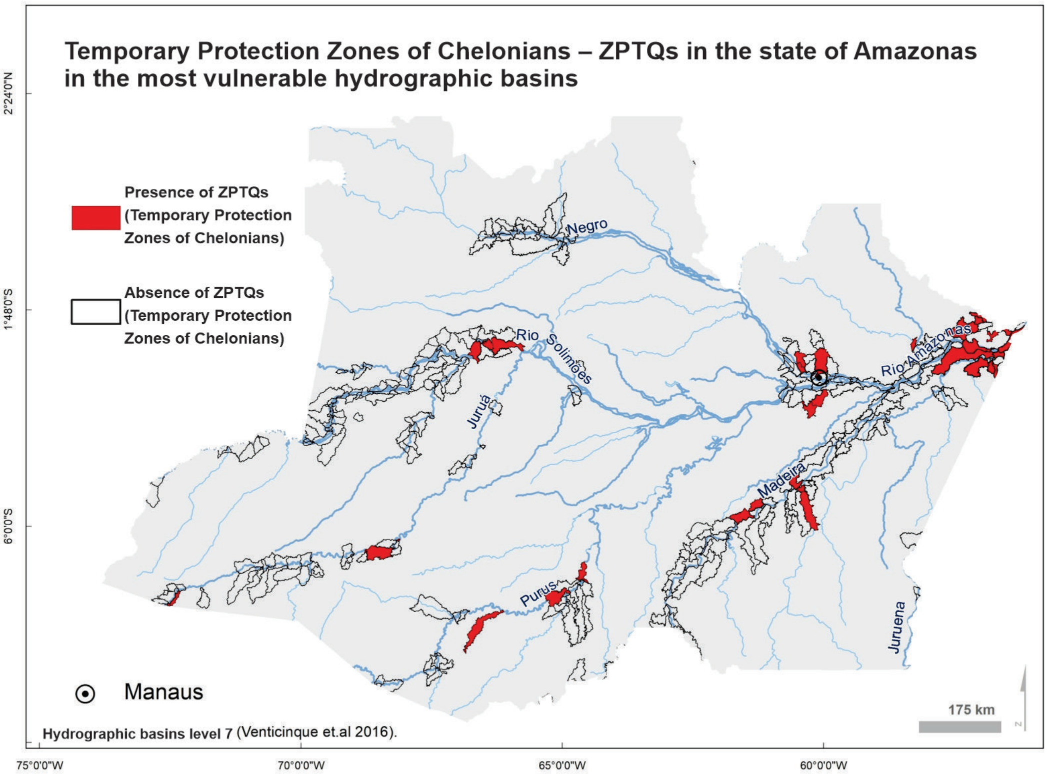

Figure 9 – The most vulnerable river basins, with the presence of the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians), which are the nesting areas and other reproductive sites for turtles (*Podocnemis expansa*, *Podocnemis unifilis, Podocnemis sextuberculata, Podocnemis erythrocephala* and *Peltocephalus dumerilianus*). It is also presented are the gaps of ZPTQs. These zones are classified considering the level of protection and conservation, according to the CEMAAM Resolution Nº 25/2017. Most vulnerable areas present high concentration of sandbanks (upper tercile) and medium or high vulnerability to anthropic threats (middle and upper terciles).

Discussion

The target species of turtles of the Brazilian Action Plan are vulnerable in the region of the "arch of deforestation", located in the northeast of the Brazilian Amazon, from the state of Maranhão to the southwest region of the state of Rondônia. However, there is also anthropic pressure outside this region, in the areas of the Trans-amazon highways and Cuiabá-Santarém (VIEIRA et al., 2008; INPE, 2014), located in the Xingu and Tapajós Basins, and in the Basins of the Branco, Amazonas, Solimões and Madeira Rivers.

Deforestation generates great impacts on aquatic ecosystems, which can cause erosion of the margins of water bodies, decrease the productivity of plants, as well as reduce water quality and increase water temperature (NEILL et al., 2001). Many of these impacts threaten the populations of several species of turtles (WALSER; BART, 1999; DECATANZARO et al., 2009; QUESNELLE et al., 2013). The loss of vegetation can alter the regional hydrological cycle. In the Tocantins-Araguaia Basin, one of the most vulnerable sites to sandbanks, deforestation has increased annual flow by 25%, changing the flood pulse (COSTA, 2004; COE et al., 2009). In addition, siltation of the riverbeds has been reported (ANDRADE, 2018, personal communication). In these basins, as in the other basins identified as vulnerable, the removal of vegetation cover can have a great impact on the target populations of the turtle Brazilian Action Plan, since they are organisms that consume plant material, depend on sandbanks and ravines for nesting, have the sex of the hatchlings determined by the temperature of the substrate and need the nests to remain non-flooded throughout the incubation period, so that the hatchlings do not die (VOGT, 2008); ANDRADE, 2008, 2012; FELIX-SILVA, 2009; FERRARA et al. , 2017).

Large hydroelectric projects commonly induce deforestation and flood extensive areas, including protected areas (FEARNSIDE, 2015), and may impact areas recognized as being of high importance for the conservation of turtles. Such disturbances occur at the landscape scale (COOPER et al., 2017), with basins such as the Tapajós and Madeira being the most vulnerable due to existing hydroelectric dams under construction and planning, and the Xingu, Trombetas and Uatumã Rivers are threatened by planned dams (LATRUBESSE et al., 2017). Besides the fragmentation of the rivers, the construction of hydroelectric dams reduces the downstream water pulse (POFF; HART 2002), threatening both the longitudinal movement of turtles and the lateral movement to feeding areas. In the state of Tocantins, reduction and fragmentation of the habitat of *P. expansa* and *P. unifilis* species were observed, due to the implementation of hydroelectric exploitation (FELIX-SILVA, 2009). In the upper Madeira River, hydroelectric dams may be responsible for affecting the connectivity of populations of the *Podocnemis* genus (KELLER et al., 2016).

The loss of habitat caused by dams may also affect the reproductive cycle of turtles, since the nesting period is related to the flood pulse of the water bodies where they occur (ALHO; PÁDUA, 1982). Artificial flooding can destroy reproductive sites of turtles and change the dynamics of beach formation in a region, as verified for nesting beaches of *P. unifilis* in the state of Amapá (NORRIS et al., 2018). In this case, females have to look for new areas to nest, which increases energy expenditure and modifies the nest density pattern, which may lead to increased predation (MARCHAND et al., 2002). Félix-Silva (2009) found that *P. expansa* disappears from the areas of influence of hydroelectric dams, where beaches remain submerged, while *P. unifilis* seeks new environments for nesting, but presents reduced reproductive success and altered sex ratio. At the HPP Balbina, an artificial beach for nesting *Podocnemis* was built downstream of the dam. The animals that remained upstream of the dam began to nest on small, narrow, low beaches with excess humidity and organic matter in areas located in smaller tributaries. The need to change the reproductive area led to overlapping nesting and the construction of very shallow nests, leading to the destruction of large numbers of eggs and a drastic reduction in the hatching rate (ANDRADE, 2008; ANDRADE et al., unpublished data). It is important to note that, in some populations, the search for new nesting sites, in previously unused areas, may generate greater nest dispersion and, consequently, a lower concentration of predators (VOGT, 2018, personal communication).

The high concentration of mining activities in the Amazon River region, state of Amapá and the Tocantins-Araguaia Basin, as well as in the Madeira and Tapajós Rivers, is another source of risk for turtle populations both directly and indirectly, due to alterations in soil cover. The organic form of mercury

– methylmercury – can be absorbed by organisms and accumulate in the food chain (MERGLER et al., 2007). Some studies show that the genus *Podocnemis* accumulates low levels of mercury, mainly because it is predominantly herbivorous (SCHNEIDER et al., 2010; SOUZA-ARAÚJO et al., 2015). On the other hand, Carvalho (2012) concluded that the amount of mercury in the yolk of *P. expansa* eggs is related to the weight of females and that animals with a higher rate of this element nest closer to the riverbank, which contributes to the loss of litters due to flooding. Either way, mercury contamination of turtles is still a concern, since it is a potential risk to human health.

Energy production and mining projects are often interrelated in the Brazilian Amazon, producing cumulative chain impacts. In the Xingu region, for example, the construction of the Belo Monte hydroelectric plant led to the implementation of Belo Sun, which will be the largest gold mining operation in Brazil, causing high social and environmental risks (TÓFOLI et al., 2017). This association, especially with the extraction of aluminum in the Amazon, demonstrates that part of the implementation of hydroelectric projects favors the mining companies themselves (FEARNSIDE, 2016), however, the synergistic environmental impacts are disregarded in the licensing processes. Thus, it is suggested that greater focus be given to wind projects in the country, because they are cheaper than hydroelectric plants when transmission costs and socio-environmental externalities are considered (DA SILVA et al., 2016). The generation of solar energy should be stimulated as an option of low environmental impact.

If the threats described above were not enough, the *Podocnemis* species have an intense history of exploitation in the Amazon Basin (BATES, 1892; SMITH, 1974), both in rural and urban areas (PANTOJA-LIMA et al., 2014). In the upper Amazon region and the Solimões and Madeira Rivers, between 1848 and 1859, 48 million eggs were taken from nature annually (BATES, 1982; SMITH, 1979). Currently, egg and adult consumption is still very high and has led to the depletion of many populations (KLEMENS; THORBJARNARSON, 1995; THORBJARNARSON et al., 2000; CANTARELLI et al., 2014). A conservative analysis suggests that in the years 1980 and 1990, between 38 – 95 thousand individuals of *P. unifilis* and 59 – 145 thousand individuals of *P. expansa* were consumed, annually, by rural populations of the Amazon (PERES, 2000). In the municipality of Tapauá/state of Amazonas – AM alone, it is estimated that more than 20 thousand individuals, mainly *P. sextuberculata*, were acquired for consumption annually (PANTOJA-LIMA et al., 2014).

Despite evidence that the pressure of turtle consumption increases with the proximity of human communities (CONWAY-GÓMEZ, 2007; ALCÂNTARA et al., 2013), the level of exploitation and preference for species vary according to each region of the Brazilian Amazon (FACHÍN-TERÁN et al, 2000; VOGT, 2001; SILVA, 2004), the season (PEZZUTI et al., 2010) and availability (FACHÍN-TERÁN, 2000), being a very strong historical and cultural factor. For this reason, human density, that is, the density of rural and urban communities, in itself, may not reflect the hunting pressure on the group on a large scale. In this study, the greatest exploitation pressure would be concentrated in northeastern of the Amazon, however, it is known that the exploitation of the group is very expressive in the states of Pará and Amazonas, for example (FACHÍNTERÁN et al., 2000; PEZZUTI et al., 2008; PEZZUTI et al., 2010; ALCÂNTARA et al., 2013). Furthermore, Bolivian, Peruvian and Colombian human populations near basins that are in international border areas (Guaporé River and northern Acre, for example) also exert pressure of use on Amazon freshwater turtles (PÁEZ et al., 2012) and such populations were not included in the analyses in this chapter. Thus, it becomes important to articulate the Brazilian Action Plan with government agencies of neighboring countries or foreign NGOs for the conservation of target species in these regions.

The Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles has been a fundamental public policy to understand, reduce and avoid the threats faced by target species. However, mainly due to the size of the occurrence of species in the Brazilian Amazon and the lack of financial resources, it can be seen that the number of basins in which the Brazilian Action Plan conducts monitoring of reproductive sites is still low in relation to the total number of basins where the sandbanks were mapped. Only 15.17% of the hydrographic basins with sandbanks mapped are covered by the plan. There are large gaps in conservation actions in the state of Maranhão; the lower Araguaia; Guaporé; Xingu and the upper and middle Tapajós. These regions should be prioritized in research to assess the status of turtle populations.

As needed, conservation and management programs should be developed in these areas, in addition to evaluating a possible expansion of the Brazilian Action Plan. In addition, these regions should be considered in licensing processes for infrastructure projects and other activities that impact the group. Although Maranhão has been a suitable area for the occurrence of species nesting areas in the models, the Amazonian part in the west of the state is the limit of species distribution, containing few individuals (VOGT, 2008; FERRARA et al., 2017). In the Guaporé River there is an estimated nesting of more than 30 thousand females of *P. expansa* (FORERO-MEDINA et al., 2019). The Tapajós River is important for the conservation of the three species and the Xingu, Araguaia and Tapajós Rivers for *P. expansa* and *P. unifilis* (VOGT, 2008; FERRARA et al., 2017).

The monitoring of reproductive areas of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles is not concentrated in the basins with greater availability of sandbanks. Perhaps this result is associated with the fact that the main strategy of the Brazilian Action Plan, with respect to the monitoring of nesting sites was, like the PQA, to prioritize regions of great abundance of nesting of *P. expansa* and regions of high exploitation of this species (there are 1,943 nesting beaches of *P. expansa* with the action of the Brazilian Action Plan, 1,033 of *P. unifilis* and 550 of *P. sextuberculata*. In some of these beaches more than one species nest). The species nests in groups on a few sandy beaches of a certain region, usually in high beaches and with coarse sand (VOGT, 2008; FERRARA et al., 2017) and, consequently, their nests are distributed in high densities in the areas where they occur. However, depending on the region, the other species may be even more impacted by human traffic and consumption.

In the state of Amazonas, *P. sextuberculata* is the most seized species when considering turtle trafficking (NASCIMENTO, 2009). In this state, only 14.38% of the hydrographic basins with sandbanks mapped are contemplated by Brazilian Action Plan and 10.68% by CEMAAN Resolution N° 25/2017. The spatial pattern of coverage by both public policies is similar. Some *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) can be priority areas for actions of the Brazilian Action Plan for the Amazon freshwater turtles, since they are in regions that are lacking actions, such as the Solimões and Madeira Rivers, which should be prioritized for the expansion of conservation actions in the state of Amazonas. About 88% of the turtle conservation areas in the Amazonas are protected by community actions, outside conservation units. The participatory system guarantees the expansion of the number of protected breeding sites and the coverage of a greater diversity of environments and river channels, covering 15 different rivers (ANDRADE, 2015, 2017). For greater coverage of programs aimed at the conservation of turtle, it is possible to invest in the sum of efforts employed in different government spheres and in community co-management.

It is important that the actions of government programs, non-governmental organizations, universities and research institutes are prioritized and carried out and/or expanded to areas where the target species are more vulnerable to anthropic threats (Figures 8 and 9). Currently, the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles has 43% of its monitoring actions of reproductive sites in the most vulnerable basins, such as the Upper Araguaia River, Upper Branco River and Upper Amazon River Basins. However, only 11% of the most vulnerable basins identified in this study have reproductive monitoring actions of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles, demonstrating that there is a need to expand this type of action. Large gaps in the Brazilian Action Plan were found in vulnerable areas, such as those located in the lower Araguaia, the Solimões River and the Madeira River. Long stretches of these mentioned rivers are also not covered by the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians). Human impacts in this region are related to deforestation, mining, and construction of hydroelectric plants, and so these regions should be considered in future Brazilian Action Plan action planning and other conservation and management programs. We also recommend greater articulation among the environmental institutions of these regions, so that the environmental impacts from these anthropic activities are adequately evaluated, mitigated, compensated or avoided. The same is recommended for the state of Amazonas, where only 9.4% of the most vulnerable basins are represented by the ZPTQs, although 45% of the existing ZPTQs are in areas of greater vulnerability.

For the vulnerability analysis, this study considered both current hydroelectric and mining projects as well as those that will be implemented in the near future, however, there are other long-term plans that were not included in the analysis, as well as other types of anthropic pressure that were not analyzed. It is also worth noting that illegal mining, frequent in the Brazilian Amazon, was not included in this study. The Government also intends to build 277 hydroelectric plants in the Amazon (CASTELLO et al., 2013). Thus, the target species of turtles of the Brazilian Action Plan may now and/or in the future be vulnerable in other locations that have not been identified in this study.

Conclusion

Due to the threats suffered by the species of the Brazilian Action Plan, its extensive distribution area in the Brazilian Amazon and the lack of financial and human resources for the environmental area, it is necessary that places where species are more vulnerable to anthropic actions be prioritized. This work indicates important rivers and basins for the target species of the Brazilian Action Plan, which are not contemplated by the monitoring actions of nesting sites of this plan and by the *Zona de Proteção Temporária de Quelônios* – ZPTQs (Temporary Protection Zones of Chelonians) of the CEMAAN Resolution Nº 25/2017, they are: low Araguaia, Solimões, Madeira and Tapajós Rivers. The possibility of expanding the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles to these lagoon areas should be evaluated, as well as joining efforts of the Brazilian Action Plan to conservation and management actions, from other governmental spheres, and include community participation. Community involvement is an important strategy to increase the protection coverage of Amazon freshwater turtles, as observed in participatory work (CAPUTO et al., 2005; MIORANDO et al., 2013). The location of research from universities, institutes and non-governmental organizations can also be guided by the results presented here. In addition, it is necessary that activities aimed at the conservation of turtles are carried out not only in nesting areas, but also in feeding areas such as floodplains and *igapós*[16].

Some strategies to mitigate the impacts of hydroelectric dams on turtles have been suggested, such as the restoration of nesting sites (NORRIS et al., 2018) and the creation of artificial beaches for nesting, such as the Balbina HPP. However, there are no studies that analyze the effectiveness of these actions and quantify, systematically and in the long term, the impact of these beaches on the sex ratio of the hatchlings. Nor are there studies in the Brazilian Amazon that quantify the impact of deforestation and mining areas on turtle populations. The environmental licensing process for the installation and execution of impact activities should always provide for research before and after their establishment. Only with this type of information, on a local scale and with long-term studies, will it be possible to propose effective solutions for the turtle conservation as well as the mitigation and environmental compensation. Unfortunately, recent proposals for laws, constitutional amendments and provisional measures may weaken Brazilian environmental legislation even further (AZEVEDO-SANTOS et al., 2017).

The creation of protected areas has been a widely used environmental compensation tool (PECHACEK et al., 2013). However, due to government socioeconomic interests, often there are no studies to assess which area is most effective for the establishment of conservation units. The compensation process should also integrate environmental issues and human well-being in the region, minimizing confrontations (PECHACEK et al., 2013). Actions to mitigate or compensate for the impacts of turtle populations are fundamental not only for the ecological balance, but also for the human population, since they have great significance in the culture and feeding of the Amazonian peoples.

16 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

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Annex 1 – Variables used to predict the appropriate area for the nesting of the target species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles .

Variables (unit)	Code	Description
Mean Annual temperature (°C) [1]	Bio 01	Calculated from minimum and maximum temperature
Variation of daily mean temperature (°C) [1]	Bio 02	Calculated from minimum and maximum temperature: (Monthly mean (temp max t - temp min)
Isothermality [1]	Bio 03	Calculated from minimum and maximum temperature: (Bio02/Bio07)
Temperature Seasonality (CV) [1]	Bio 04	Calculated from the minimum and maximum temperature: (Standard deviation *100)
Maximum temperature of the warmest month (°C) [1]	Bio 05	The maximum temperature of the warmest month
Minimum temperature of the coldest month (°C) [1]	Bio 06	The minimum temperature of the coldest month
Annual temperature variation (°C)[1]	Bio 07	Calculated from the minimum and maximum temperature: (Bio5-Bio6)
Mean temperature of the wettest trimester (°C) [1]	Bio 08	Calculated from the minimum and maximum temperature and precipitation (mm $month^{-1}$)
Mean Temperature in the driest trimester (°C) [1]	Bio 09	Calculated from the minimum and maximum temperature and precipitation (mm $month^{-1}$)
Mean Temperature of the warmest trimester trimes-ter (°C) [1]	Bio 10	Calculated from the minimum and maximum temperature
Mean Temperature in the coldest trimester (°C) [1]	Bio 11	Calculated from the minimum and maximum temperature
Annual precipitation (mm) [1]	Bio 12	Calculated from the precipitation (mm $month^{-1}$)
Precipitation of the wettest month (mm) [1]	Bio 13	Calculated from the precipitation (mm $month^{-1}$)
Precipitation of the driest month (mm) [1]	Bio 14	Calculated from the precipitation (mm $month^{-1}$)
Seasonality of precipitation (mm) [1]	Bio 15	Calculated from the precipitation (mm $month^{-1}$)
Precipitation of the wettest trimester (mm) [1]	Bio 16	Calculated from the precipitation (mm $month^{-1}$)
Precipitation of the driest trimester (mm) [1]	Bio 17	Calculated from the precipitation (mm $month^{-1}$)
Precipitation of the warmest trimester (mm) [1]	Bio 18	Calculated from the minimum and maximum temperature and precipitation (mm $month^{-1}$)
Precipitation of the coldest trimester (mm) [1]	Bio 19	Calculated from minimum and maximum temperature and precipitation (mm $month^{-1}$)
Mean annual radiation (W m-^{2}) [2]	Bio 20	Calculated from the radiation (W $m^{-2}d^{-1}$)
Highest weekly radiation (W m^{-2}) [2]	Bio 21	Calculated from the radiation (W $m^{-2}d^{-1}$)
Lowest weekly radiation (W m^{-2}) [2]	Bio 22	Calculated from the radiation (W $m^{-2}d^{-1}$)
Seasonality of radiation (CV) [2]	Bio 23	Calculated from the radiation (W $m^{-2}d^{-1}$)
Radiation of the wettest trimester (W m^{-2}) [2]	Bio 24	Calculated from the precipitation (mm month-1) and radiation (W $m^{-2}d^{-1}$)

Annex 1 – Variables used to predict the appropriate area for the nesting of the target species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles

Variables (unit)	Code	Description
Radiation of the driest trimester ($W\ m^{-2}$) [2]	Bio 25	Calculated from the precipitation (mm month-1) and radiation ($W\ m^{-2}d^{-1}$)
Radiation in the hottest trimester ($W\ m^{-2}$) [2]	Bio 26	Calculated from minimum and maximum temperature and radiation ($W\ m^{-2}d^{-1}$)
Radiation in the coldest trimester (W m-^{2}) [2]	Bio 27	Calculated from minimum and maximum temperature and radiation ($W\ m^{-2}d^{-1}$)
Index of mean annual humidity[2]	Bio 28	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Index of highest weekly humidity[2]	Bio 29	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Index of lowest weekly humidity[2]	Bio 30	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Seasonality of humidity index (CV) [2]	Bio 31	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1}))
Mean index of the humidity in the most humid tri-mester [2]	Bio 32	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Mean index of the humidity in the driest trimester [2]	Bio 33	Calculated from the precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Mean index of the humidity in the hottest trimester [2]	Bio 34	Calculated from the minimum, maximum temperature; precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Mean index of the humidity in the coldest trimester [2]	Bio 35	Calculated from the minimum, maximum temperature; precipitation (mm $month^{-1}$) and total evaporation (mm d^{-1})
Flow accumulation (number of cells) [3]	FACC	Defines the amount of drainage area upstream of each cell Flow direction (number of cells)
Flow direction (number of cells) [3]	FDIR	Defines the flow direction of each cell at the conditioned elevation to the steepest neighboring cell
Shuttle Radar Topography Mission (m) [4]	SRTM	Digital elevation data (SRTM)
Declivity (°) [5]	SLP	Maximum level of elevation within each cell and their eight neighboring cells
Composite Topographic Index[5]	CTI	Reflects the function of the upstream contribution area and the slope of the landscape
Evapotranspiration annual effective (mm) 6	AAE	Effective amount of water that is removed from the soil due to evaporation and transpiration processes, indicates alternative energy availability
Annual water balance (mm) [6]	AWB	Defines the fraction of water content available for evapotranspiration.

The references variables and site to download: [1] Hutchinson et al. (2009), available at http://www.worldclim.org/download; [2] Hutchinson et al. (2009), available in https://www.climond.org/Download.aspx; [3]Lehner et al. (2006), available in http://hydrosheds.cr.usgs.gov/index.php; [4] Farr et al. (2007), available in https://lta.cr.usgs.gov/SRTM2; [5] Moore et al. (1991), available in https://lta.cr.usgs.gov/HYDRO1K; [6] Ahn e Tateishi (1994), available in http://edit.csic.es/Climate.html

Annex 2 – Orbits and delimiting points for the study region, used for the acquisition of satellite images.

Orbit	Point	Orbit	Point
1	60, 61, 62, 63, 64, 65	**224**	60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72
2	60, 61, 62, 63, 64, 65	**225**	58, 62, 63, 64, 65, 66, 67, 68, 69. 70
3	62, 63, 64, 65, 66, 67	**226**	58, 60, 61, 62, 63, 64
4	62, 63, 64, 65, 66, 67	**227**	60, 61, 62, 63
5	63, 64, 65, 66	**228**	59, 61, 62, 63, 64, 67
6	63, 64	**229**	59, 61, 62, 63, 64, 65, 66, 67,70
220	62, 63	**230**	60, 61, 62, 63, 64, 69
221	61, 62, 63, 64, 69,	**231**	58, 59, 60, 61, 62, 63, 64, 69
222	61, 62, 63, 64, 65, 66, 67, 68, 70, 71	**232**	57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69
223	60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72	**233**	60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70

Chapter 5

Evaluation of the influence of seasonal environmental factors on the reproduction of the giant South American river turtle (Podocnemis expansa): a case study in the state of Tocantins

Melina S. Simoncini, Thiago Costa Gonçalves Portelinha, Kennedy Mota Montelo, Guth Berger Falcon, Erich Collicchio, Rafael Antônio Machado Balestra, Vera Luz Ferreira Luz, Adriana Malvasio

In Tocantins, the *Programa Quelônios da Amazônia* – PQA (Amazon Turtle Program) has been developing its activities on the Javaés River since 1985, around the Araguaia National Park (Bananal Island, between latitudes 9° 50'S and 11° 10'S, and longitudes 49° 56'O and 50° 30'O, Figure 1). Bananal Island is the largest river island in the world, with about 20,000 km^2 of extension, surrounded by the Araguaia and Javaés Rivers, being mostly covered by savannas and natural pastures, occurring seasonal floods (BORMA et al., 2009).

This Park is considered one of the most important ecological sanctuaries in the country, because it is in the *Cerrado*-Amazonian Forest transition belt (SEPLAN, 2001; MMA, 2001) and in a floodable area classified as ecotone (REZENDE et al., 2001). According to the climatic regionalization of the state of Tocantins, the climate of the region of Bananal Island is classified, predominantly, as B1wA'a', which is characterized by a humid climate with moderate hydric deficiency (SEPLAN, 2012). The regional climate is hot and seasonally humid, with two well-defined seasons: the rainy season (October to April) and the dry season (May to September). Associated with this climatic condition, the region suffers from seasonal flooding whose average annual flooding period occurs from January to June, partially overlapping the beginning of the dry season (COSTA, 2015). The total annual precipitation varies between 1,200 mm and 1,900 mm (COSTA, 2015). However, the mean rainfall corresponds to 1,466 mm per year, with 90% of the total accumulated rainfall normally occurring from October to April (BORMA et al., 2009).

The average air temperature ranged from 22 °C to 31 °C, with the regional average annual temperature equivalent to 26.5 °C (COSTA, 2015). In the rainy season, the average air temperature ranges between 18 ºC and 34 ºC, with maximum and minimum daily average temperatures of 30º C and 22.9 ºC, respectively. In the dry season, the average maximum and minimum temperatures reach 32ºC and 22ºC, respectively (OLIVEIRA, 2006).

The target species in this study is *Podocnemis expansa* (SCHWEIGGER, 1812), the largest freshwater turtle in South America. This species inhabits large rivers and tributaries of the Amazon and Orinoco Basins, it has a strong aquatic habit and very complex reproductive behavior (MALVASIO et al., 2003; VOGT, 2008). This case study has as objectives:

- Evaluate the influence of environmental variables on the beginning and duration of the nesting period of *P. expansa*; and
- Verify the influence of environmental variables on the number of reproductive females.

Influence of environmental variables on the beginning and duration of the *P. expansa* nesting period.

Reproductive data of females collected by PQA in eight beaches of Araguaia National Park – Canguçu, Comprida, Coco, Murici, Bonita, Jaburu, Marreca and Guava – were used (Figure 1), during four reproductive seasons (2005 to 2009, except 2007), in 1,715 nests (Figure 2). A database of environmental variables (minimum, average and maximum) of air temperatures, precipitation and river levels (local and in the headwater), obtained by the Brazilian Water Agency (www.hidroweb.ana.gov.br) and by the Federal University of Tocantins (UFT)/LBA–Tocantins

Figure 2 – Nesting beach of the Javaés River.

Program (Large Scale Biosphere–Atmosphere Experiment in Amazonia; LBA-TO, 2015), was then constructed.

The beginning and the duration of the nesting period varied among the analyzed years and the beaches. The first registered nesting was August 16, 2006 (Canguçu beach) and the later first nesting was registered on September 16, 2005 and 2006 (Jaburu beach), comprising a range of four weeks between

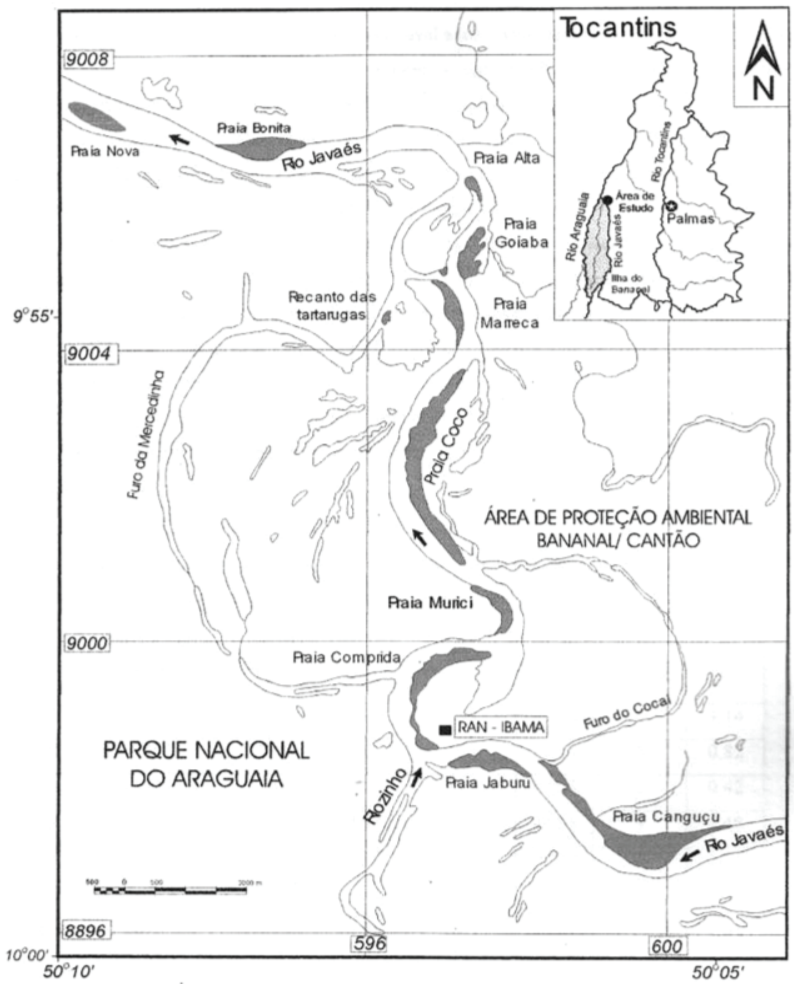

Figure 1 – Distribution of the study sites on the beaches of the Araguaia National Park (SALERA JÚNIOR et al., 2009).

the years and the beaches. Considering the four years of study, the total nesting period (from the first to the last recorded) comprised 10 weeks (August 16 to October 25). The average nesting period is approximately six weeks (Figure 3). Most females nested between September 13 and October 10.

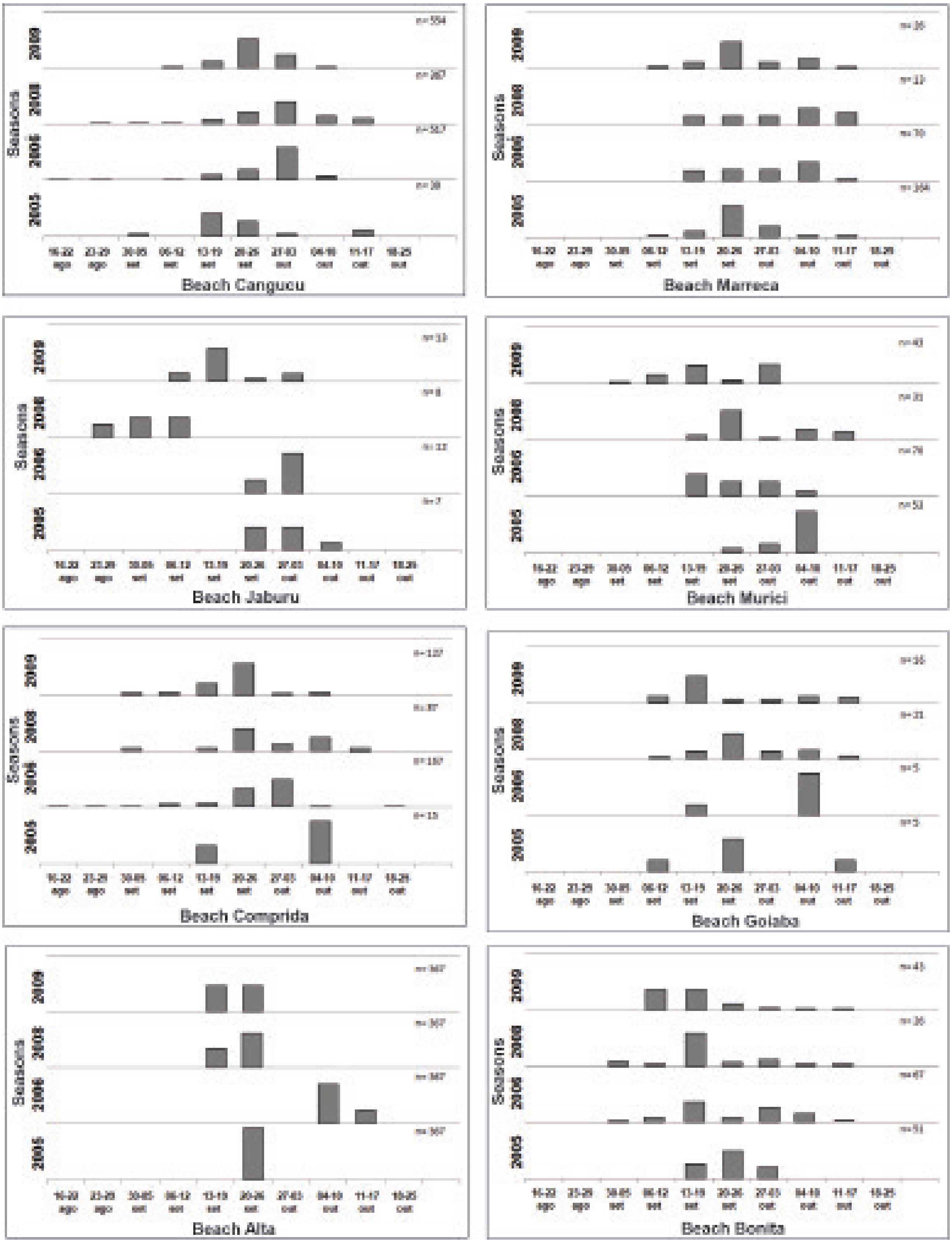

Figure 3 – Distribution of *Podocnemis expansa* nesting on the eight beaches studied.

The height of the bar shown in Figure 3 is proportional to the number of nests registered each week during the reproductive period. The x-axis represents the weeks (7 days), and the first week is represented by the days 16 to 22 of August and so on.

According to Soares (2000), the females of *P. expansa* possibly perceive small modifications in the environmental conditions, which would be the stimuli to start or stop nesting. The reproduction of the podocnemididae family depends on the annual seasonal cycle (flood and ebb), occurring oviposition and incubation in the ebbing season, and the hatchlings emergence coincide with the beginning of the river flood (ALHO; PÁDUA, 1982a; FACHÍN-TERRÁN, 1992; THORBJARNARSON et al., 1993). The beginning of the reduction in water levels seems to stimulate the migration of *P. expansa* females to nesting sites, since adults stay in the lagoons during the flood season and are concentrated in the rivers during the dry or ebbing season (ALHO; PÁDUA, 1982b; ALHO et al., 1984).

In this study, it is possible to observe that higher the temperature, slower is the beginning of nesting and when river level increases, the nesting is anticipated. These results indicate that the nesting period of *P. expansa* is related to the months of greater drought (MITTERMEIER, 1978; PRITCHARD; TREBBAU, 1984). During this period, the factor that would stimulate nesting would be small initial increments at the river level, allowing females to lay their eggs and they would be incubated until the moment of hatching, just before the river flood and, consequently, the beach flooding (PRITCHARD; TREBBAU, 1984; SOUZA; VOGT, 1994; VOGT, 2008).

However, it is not only the river level that determines the beginning of nesting, but the reduction of the air temperature, which is directly related to the incubation temperature of the nests. It is important to emphasize that high temperatures can reduce the viability of eggs (EWERT, 1985; MALVASIO, 2001; VALENZUELA, 2001; FERREIRA JÚNIOR; CASTRO, 2005). Mazaris et al. (2009) propose that female leatherback turtles (*Dermochelys coriacea*) begin their migration by observing temperature signals at foraging sites, moving to nesting sites and waiting there until the local temperature is ideal for egg deposition (ECKERT; ECKERT, 1988; PIKE, 2009). This species, in Costa Rica, shows similar behavior to that of *P. expansa* in this study, considering that an increase in air temperature causes nesting to delay (NEEMAN et al., 2015). Vogt (2008) comments that female of giant South American river turtle (*P. expansa*) stay two to three weeks on the beaches in the sun until they start nesting. Cold water sea turtles begin to nest only with increasing temperatures (WEISHAMPEL et al., 2004; 2010; HAWKES et al., 2007; MAZARIS et al., 2008; 2009; PIKE, 2009).

The results of this study suggest the influence of environmental variables (river levels and temperature) on the reproductive dynamics of *P. expansa*, but it should be considered that each nesting beach has different characteristics. Besides the influence of environmental variables, other factors such as the geomorphology of beaches (height, length, width, among others) influence the choice of nesting area (FERREIRA JÚNIOR, 2003), they prefer flat, high and sandy beaches and avoid clayey, humid and with much vegetation (PÁEZ et al., 2012).

The duration of the nesting period is closely related to the time of the beginning of the oviposition. In years when nesting starts earlier, females' nest for a longer period, but if the beginning of nesting delays (for example, due to high temperatures), females restrict the nesting period to a few weeks.

Synchronization of nesting time within a population (collective nesting) (PÁEZ et al., 2012) is related to the hatching time of the eggs. In the case of *P. expansa*, the hatchlings emerge before the beach flooding (FERREIRA JÚNIOR; CASTRO, 2010), when the environmental conditions are more favorable for survival (greater availability of shelter and food), in order to optimize growth and recruitment of individuals (RUTBERG, 1987; OGUTU et al., 2010).

Climate variables and hormonal factors were suggested as determinants in the collective nesting for the sea turtle *Lepidochelys olivacea*, (PLOTKIN, 2007). From these variables, precipitation stands out, since it determines the synchronization of the "*arribadas*" of females, i.e., the aggregations on beaches to nest in a very limited time (PLOTKIN et al., 1997). Just as temperatures at low latitudes can be restrictive for ectotherm reproduction (MEDINA; IBARGÜENGOYTÍA, 2010; SIMONCINI et al., 2013), very high temperatures restrict the nesting of the giant South American river turtle (*P. expansa*). Therefore, it is logical to think that the complex reproductive biology of the target species of this study, as well as other species of turtles (BOWEN; KARL, 2007), would be influenced by climate change (REECE et al., 2005).

Influence of environmental variables on the number of breeding females

In the second part of this study, the objective is to determine which environmental variables can influence the amount of *P. expansa* females for each reproductive season. For this purpose, a database with the number of nests identified by the PQA was organized, for the period 1985 to 2009 (except 1988, 1989, 1991, 1998 and 2001, due to difference in sample effort). The sand beaches of the Araguaia National Park in the state of Tocantins – TO included in this stage are: Canguçu, Coco, Comprida, Goiaba and Jaburu. Besides the number of nests (more than 6,400), the database included the number of eggs and hatching success (number of hatchlings born/ number of eggs*100). The environmental variables that could influence the reproductive effort of *P. expansa* were added to this database, such as the amount of precipitation (monthly millimeters) and the river level both in the nesting sites and in the headwater of the Araguaia River (upper Araguaia region). During the 20 years of study and for the five monitored beaches (Figure 4), 659,870 eggs were found, with an average clutch size of 102.6 ± 9.0 eggs (range 87.4-117.5 eggs). These values are similar to the 110 ± 19.4 eggs per nest reported by Malvasio et al. (2005), for the same region. The average hatching success was high (90.7 ± 5.0 %, and 80-97.5 % amplitude), reflecting the intervention of the PQA. These high values are related to the work of management and conservation of the PQA, since the nests are protected and the hatchlings are removed, to avoid the action of natural predators of the beaches and the river, in addition to human predation (SALERA JÚNIOR et al., 2009).

Regarding the climatic variables, it can be seen that the greater the precipitation at the river headwater, in May, the greater the number of females that nested on the beaches studied. Consequently, the greater the amount of precipitation in May, the more eggs and hatchlings are produced during the reproductive season (August-October). The influence of these variables on the river headwater is an important tool to estimate the nest production on the sand beaches.

Figure 4 – Footprints of *Podocnemis expansa* females, during the nesting period.

The influence of the climate on reptiles is recognized, as well as the role of rain in reproduction (CLERKE; ALFORD, 1993). The rains affect the availability of prey (DE CASTRO; SILVA, 2005) and influence the growth rate and energy invested in reproduction (SEIGEL; FITCH, 1985; CAMPOS; MAGNUSSON, 1995; CRUZ et al., 1999). Therefore, with the results of this study, it can be assumed that there is an indirect relationship between rainfall and food availability that would be affecting the reproductive investment of turtles. The increase in rainfall at the river headwater, before the reproductive period of some reptiles, may bring benefits by increasing the availability of food and enabling better body condition (food = energy accumulation), to invest in the next reproductive season (CAMPOS, 1991; HARSHMAN; ZERA, 2006; SIMONCINI et al., 2011).

In addition, the rains can help the movement or displacement of females from the flooding forests or lagoons to the river, and from the river to the nesting beaches (PLUTO; BELLIS, 1988; FACHÍN-TERÁN et al., 2006; DE LA OSSA; VOGT, 2011). Variations in river level were pointed out by Vanzolini and Gomes (1979) as responsible for the alteration of migratory habits and of the nesting sites of the giant South American river turtle and yellow-spotted river turtle and six-tubercled Amazon river turtle *(P. sextuberculata*), along the Japurá River, state of Amazonas. According to Vogt (2008), the adults of the giant South American river turtle, during the flood season, enter the lagoons, meanders and flooded forests to feed themselves. During the dry season, they return to the rivers. The increase in rainfall in the month of May delays the start of the dry season, allowing more females to migrate from the flooding forests or lagoons to the rivers, increasing the number of nests on the beaches.

For other reptiles, such as crocodilians, a relationship was observed between the rains and the number of females and nests produced. In years with little rain, the number of nests with eggs is very low due to the poor body condition of females, even resulting in low success in hatching (JOANEN; MCNEASE, 1989; LANCE et al., 2009). For the loggerhead turtle (*Caretta caretta*), the years with excessive rainfall after nesting negatively influence the successful hatching of the nests (KRAEMER; BELL, 1980). In this study, it is found that an increase in precipitation in November, after nesting and at nesting sites, reduces the hatching success of *P. expansa* eggs.

Final considerations: importance of environmental variables in the reproductive studies of turtles

Reptile activities are closely related to climate (HILL, 1980; SINERVO et al., 2010; PINCHEIRA-DONOSO; MEIRI, 2013; NORI et al., 2015; TUBERVILLE et al., 2015). Functions such as thermoregulation, reproductive frequency, length of reproductive period and clutch size are strongly related to environmental characteristics (JOANEN; MCNEASE, 1989; CLERKE; ALFORD, 1993; SEEBACHER et al., 2003; MAZARIS et al., 2008; SIMONCINI et al., 2009, 2011; DEL MONTE LUNA; LLUCH-COSTA, 2013; ROITBERG et al., 2013). To effectively design conservation plans it is necessary to understand how climate influences the natural history of these animals (STENSETH; MYSTERUD, 2002; WINKLER et al., 2002). A very important aspect is reproduction, used as a tool for planning and management decisions (GREENE, 2005; BURY, 2006).

- In this study, the relationships of climate and hydrological dynamics of rivers with the reproductive characteristics preferred by P. *expansa* are exposed and detailed below:
- The beginning of nesting delays when temperatures are high or when the level of the (local) river does not increase;
- The longer the beginning of nesting delays, the shorter the nesting period;
- The amount of nesting produced by the giant South American river turtle populations in the state of Tocantins, in each breeding season, is related to the rains at the river headwater ;
- Hatching success decreases with increasing local rains during egg incubation.
- From the information obtained and the precedents, under aspects of giant South American river turtle life history, it was possible to construct the following model (Figure 5).

Studies on the reproductive biology of the giant South American river turtle provide fundamental information for the planning, management and conservation of this species (VOGT, 1994). In addition, they can show how data generated by a conservation program are converted into useful tools for the improvement of the program itself, as well as for the planning of future projects. For example, knowing the effect of environmental variables in years with poor nest production, the PQA could reinforce the inspections of the nesting beaches and optimize the work of search and identification of nests, since the dates in which most of the nesting occurs are known. The evidence suggests that the reproductive investment of females is related to the physiology, health and size of the individuals, as well as to climatic factors, local and regional rains and river levels (JARVINEN, 1994; OLSSON; SHINE, 1997).

It is important to understand the potential impacts arising from man-made changes, including not only the construction of a dam (local/regional level), as already reported by previous studies (ALFINITO, 1975; SMITH, 1975; MITTERMEIER, 1978; ALHO, 2011), deforestation of riverheads (RUEDA-ALMONACID et al., 2007), but also climate variations, foreseen by global warming.

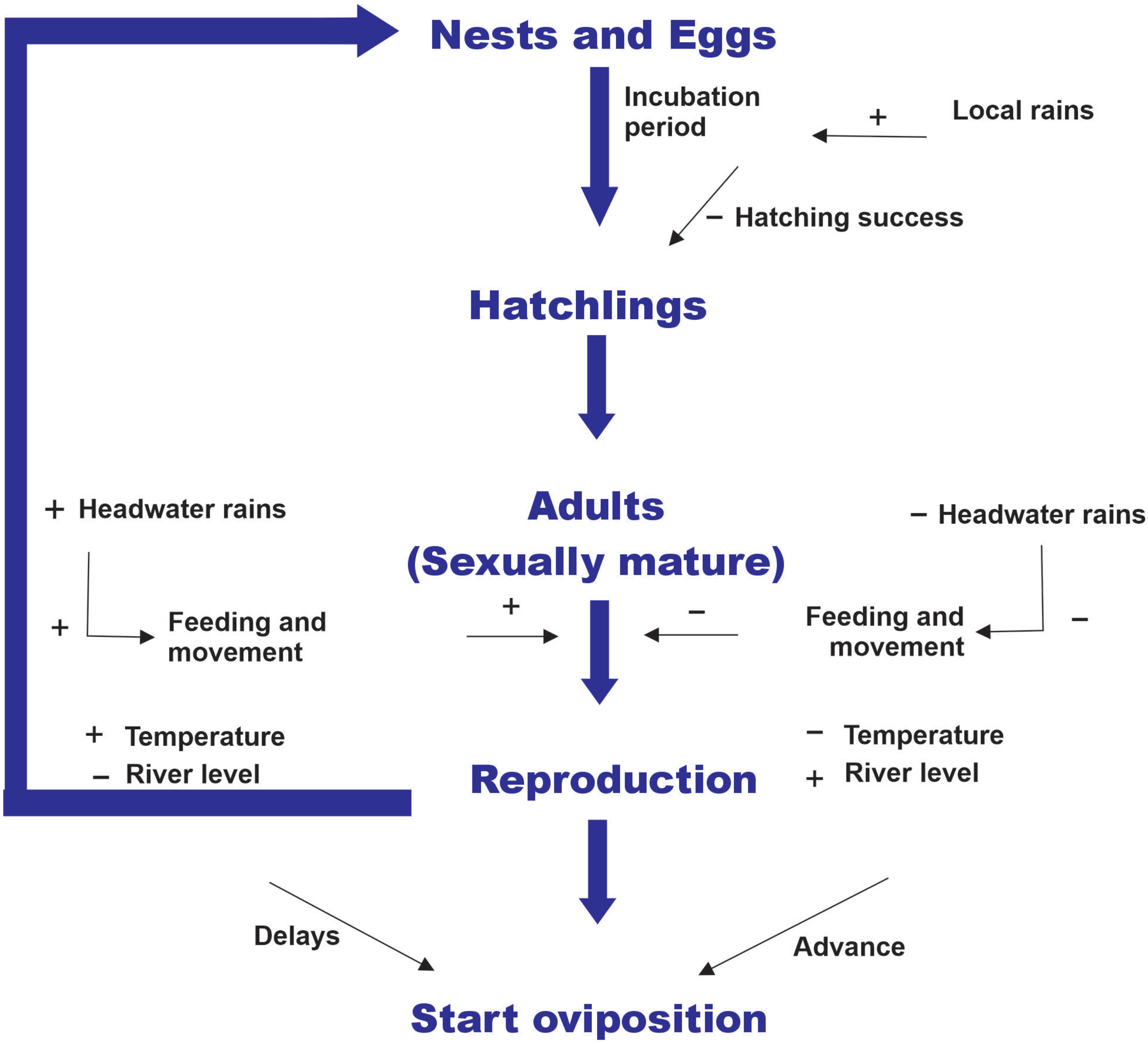

Figure 5 – Model obtained from the results of this study and previous data (from other studies conducted with this species in the region), as well as from the relationships with climatic variables and aspects of the life history of *Podocnemis expansa.*

However, other information about the species in the region is required, such as: 1) movement and use of space through telemetry studies; 2) how and when they move from the flooding forestslagoons to the rivers; and 3) data related to follicular and hormonal development, to know more deeply the reproductive aspects, fecundity and survival. All this information can help and substantiate adjustments in the current management plans for the giant South American river turtle. However, one should not forget the environmental education programs, which are extremely important for the protection and conservation not only of *P. expansa*, but also of all the species that inhabit the transition region Cerrado-Amazônia.

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Chapter 6

Ecological basis for the sustainable management of Amazon freshwater turtles: sustainability and alternatives to management practices

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Introduction

Several riverine communities are involved, in some way, in the protection of reproductive sites of Amazon freshwater turtles. Faced with the enormous work and effort they make to protect the nesting area and the enormous pressure of the turtle traffickers, these communities question when it will be possible to economically exploit this resource, or what kind of compensation they can receive for the important environmental service they provide. Despite being exploited in a predatory manner, because there are no techniques for extracting it in a sustainable manner, the giant South American river turtle (*Podocnemis expansa*), the yellow-spotted river turtle (*P. unifilis*) and the Six-tubercled Amazon River Turtle (*P. sextuberculata*) are widely dispersed and have reproductive potential, being a real alternative of protein in the diet of the inhabitants of the Amazon. However, the use of this resource requires the development of monitoring and management programs to avoid overexploitation (IBAMA, 2003; VOGT, 2003), i.e., it is necessary to establish ecological bases for the sustainable management of turtles. The rates of exploitation of the population, its survival, recruitment and size can be estimated by studies of population structure and dynamics (BATAUS, 1998; VOGT, 2003; MOURÃO et al., 2006; ANDRADE, 2015).

The management of threatened species is based on information on population structure and dynamics, with knowledge of their main demographic levels (CULLEN JUNIOR. et al., 2003; MOURÃO et al., 2006; GERMANO; RATHBURN, 2008; ZIMMER-SHAFFER et al., 2014). However, in the case of turtles, which are considered to have a great longevity, there are almost always gaps in the data (FRAZER et al., 1990; CROUSE, 1999; FACHÍN-TÉRAN, 2000; BJORNDAL et al., 2000).

For the implementation of effective management plans to reverse the population decline of turtles, demographic parameters should be quantified and the potential density-dependent effects on these parameters should be assessed in order to have an understanding of the recovery of aquatic resource stocks in general and to estimate the extent to which natural populations can be captured on a sustainable basis (BJORNDAL et al., 2000; ZIMMER-SHAFFER et al., 2014).

Long-term monitoring of animal populations must be an integral part of effective conservation measures guided by research and management (THOMAS, 1996). Apart from the parameters such as hatching rate, survival rate and mortality rate, it is necessary to calculate growth rates of juvenile turtles and the existing allometry between the straight carapace length, body mass and egg quantity in females (DODD JR., 1997; CONGDON et al., 1999; BJORNDAL et al., 2000; CANTARELLI, 2006). Long-term studies of natural populations are difficult due to extensive migrations and human predation, which can extirpate several individuals from a population in a short period of time (BJORNDAL et al., 2000; SOARES, 2000).

Although the majority of turtle populations remain within the protected area, the impacts of hunting and egg collection on the livelihoods of river dwellers, which in many places may be greater than those of illegal trafficking, should also be recorded and analyzed (ANDRADE, 2015).

Monitoring studies of marked hatchlings and adults of freshwater turtles can improve prediction models, as well as to obtain more data on the different stages of recruitment until the animals reach adult life. This will make it possible to generate more robust models to accompany the participatory management of turtles in the Amazon (ANDRADE, 2015).

The programs for the conservation of turtles that have been conducted by the Government (Brazilian Institute of Environment and Renewable Natural Resources - IBAMA, Chico Mendes Institute for Biodiversity Conservation - ICMBIO) or by community management (*Pé-de-pincha* Program) have shown that if the protection effort is maintained, there is a tendency to increase the number of females nesting and hatchlings produced on each beach (IBAMA, 1989; ANDRADE, 2008; 2012; 2015; PORTAL; BEZERRA, 2013; CANTARELLI et al., 2014). However, it is necessary to know whether the work of egg and hatchlings protection in managed areas effectively contributes to increase the number of young females and ensures a higher success/ survival rate of nests and hatchlings in both state and community protected areas (ANDRADE, 2015).

The systematization of data on the protection of turtle nests and hatchlings in areas protected by the Federal Government and by community programs for the conservation of turtles, associated with the parameters of structure and population dynamics of these stocks, makes it possible to estimate population models for giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtles, which will make it possible to evaluate the efficiency of these programs and the prediction of the possible impacts of these types of management on the conservation of these species.

To propose and test models of management of Amazon freshwater turtles in wildlife populations is not enough just have information about the trends of reproductive success (nests and hatchlings). Managers need ecological basis and a series of seasons of long-term monitoring of the population of each species that they intend to manage (ANDRADE, 2015).

To carry out conservation and management of the nesting beaches of turtles in the Amazon, the *Programa Quelônios da Amazônia* – PQA (Amazon Turtle Program) , initially, developed actions based on knowledge and techniques developed by the former "beach captains" who, before 1967, were the local responsible for watching and guarding the nests (ALFINITO, 1978; ANDRADE 1988; ANDRADE, 2015). These protocols were improved over time by the managers of the PQA and the extinct *Centro Nacional de Quelônios da Amazônia* – CENAQUA (National Center of Chelonians of the Amazon) and served as a basis for monitoring nests and hatchlings of the turtles nesting beaches since 1979 (IBAMA, 1989; PORTAL; BEZERRA, 2013), until reaching current protocols, with more scientific basis (BALESTRA et al., 2016).

In 2011, the *Centro Nacional de Pesquisa e Conservação de Répteis e Anfíbios* –RAN (National Center for Research and Conservation of Reptiles and Amphibians) part of the ICMBIO began a series of meetings and workshops to improve the basic protocol for conservationist management of turtles' nesting sites. Since then, it has incorporated to this protocol actions of population survey and monitoring, of the turtle stocks, in each protected area or conservation unit. In 2014, during the construction of the Brazilian Action Plan for the Conservation of Freshwater Turtles, PQA/IBAMA and RAN/ICMBIO defined the guidelines of the basic protocol for conservationist management and the reproductive and population monitoring of Amazon turtles, which were later published and disseminated (BALESTRA et al., 2016).

Actions for conservation and sustainable management of natural resources also require integrated initiatives through participatory monitoring and management, in which information collected by resource users helps guide local decision-makers on conservation management (KENNET et al., 2015).

The idea of decentralization in the management of natural resources and the involvement of local populations have gained ground in the formulation of public policies and in the preparation of regional development projects (OSTROM, 1990), escaping the classic options of privatizing resources or exclusive control by the State (OSTROM, 1990; IPEA, 2010). These changes have been taking place around the world and have a strong emphasis on communities and local impacts of community-based policies and co-management (FREITAS et al., 2009; BERKES, 2009).

Protecting turtles in order to later earn income from the sale of the surplus generated does not appear to have been an important component in communities' decision to conserve these animals. However, as local stocks of turtles have increased and, as a result, pressure from groups outside the community to illegally capture and sell these animals has increased, so have also increased the community complaints about lack of inspection. The illegal capture and sale of turtles continues to be a reality in most community areas of turtles' conservation, even in conservation units. With this in mind, the communities began to question the possibility of obtaining income from the protection of the turtles through a community turtle farm (*ex situ* management) of extraction quotas (eggs and animals) from *in situ* management (ANDRADE, 2017).

What is conservation and what are the management systems?

Management for the conservation of fauna consists in the adequate use of techniques with ecological basis and capable of modifying the characteristics of habitats and populations, considering all interrelations, so that the resource can multiply and be self-sustaining, making its use sustainable (BAILEY, 1984; ELTRINGHAM, 1984; PEEK, 1986). The sustainable and rational exploitation of native fauna is not well developed in South America (MAGNUSSON; MARIANO, 1986; ROBSON; REDFORD, 1991).

Most of the fauna management programs in Brazil are aimed at increasing the positive values of the resource, usually seen in terms of protection and maintaining populations and habitat for its survival (CULLEN JR. et al., 2003). However, an animal population can be managed to increase, decrease, be kept stable or be exploited in a sustainable way, but always with monitoring. Such a decision involves biological, political, social, economic and technical aspects (MOURÃO et al., 2006).

The exploitation of fauna must be based on natural productivity and ecological principles, and management is considered an art and a science, which are directly related to the biology of populations and, above all, to the interdependence of populations and their habitats (ELTRINGHAM, 1984; PEEK, 1986).

The exploitation systems of turtles used in the Amazon were intensified in public areas where the concession of use was made by authorizations (for families and soldiers, in the Colonial Period, and for "beach captains", in the Imperial and in the Republic period) in a mixed system of control (government and local community), or in private areas, such as the nesting areas in the rubber plantations, until, after the prohibition of hunting, in 1967, protection activities began to be executed exclusively by the Federal Government. Only in the 1990s, with the more open system of IBAMA, the riverine communities return to protecting the reproductive sites of turtles, in community systems of conservationist management, in the co-management of this resource (ANDRADE, 2017). In all these management systems, however, the objective is to protect the nests and hatchlings on the nesting beaches, which represents an important part of the system, but not the whole. Monitoring the other phases of the life cycle of these species is important to follow these populations (ANDRADE, 2015).

However, we must keep in mind that, historically, all large-scale exploitation of faunistic resources results in over-exploitation, exterminating species. It must be considered that slaughter (direct hunting) is not the only way to exploit wildlife. It is important, however, to be differentiated from harvesting or collection, which is the removal of animals from natural populations, for economic purposes, so the number removed (quota) does not exceed what the population can produce indefinitely (ELTRINGHAM, 1984).

The species of turtles that are faithful to the nesting area are vulnerable to overexploitation, especially species whose females' nest in only one area. Nesting is seasonal and attracts local residents who know where the females bury their eggs. Many of these eggs serve as food and, even when the clutch is not removed, the young suffer high mortality rate, during their journey across the sand or when they are swimming. With low percentage of recruitment, all care should be taken with the capture of adults (ELTRINGHAM, 1984; ZIMMER-SHAFFER et al., 2014).

There are three levels of fauna management: a) direct hunting: it is possible to extract predefined quotas directly from nature; b) extensive management in semi-natural areas: it is possible to increase the production of some fauna resource, with small changes in habitat or the adoption of restrictive rules/agreements of fishing control/fishing limits in delimited and controlled natural areas; c) intensive management: It allows for the raising of a species of fauna, with all the phases of the productive cycle in captivity (farming) or with one of the phases of the cycle in nature (ranching) (MAGNUSSON; MARIANO, 1986, IBAMA, 2003).

How to evaluate the sustainability of these systems? In general, comparative study plans are used between areas with much and little hunting or changes are evaluated with a rigid long-term monitoring program. The models most commonly used to evaluate sustainable use are: 1) Abundance, densities or comparisons of biomass; 2) Stock model; 3) Age structure model; 4) Exploitation model; 5) Maximum production model, among others (BODMER; ROBINSON, 2003). To analyze the sustainability of extensive turtle management models, we first need to have defined structure and dynamics parameters of the population to be exploited.

Structure and dynamics parameters of populations and population models of turtles.

Animal populations have several characteristics that define their structure. These characteristics or population parameters are of three types: a) number of animals (abundance and density); b) population dynamics (birth, mortality, immigration, emigration and biotic potential rates); c) age distribution, sex ratio and spatial distribution (BAILEY, 1984; KREBS, 1986; ODUM, 1988; ROBINSON; BOLEN, 1989).

Animal populations are biological units that can grow, stabilize, or decline over time, depending on the combined effects of birth, mortality, immigration, and emigration rates. These rates make up what we call population dynamics parameters and are directly related to the estimation of the intrinsic growth rate or biotic potential (ELTRINGHAM, 1984; BAILEY, 1984; PEEK, 1986; ROBINSON; BOLEN, 1989; BROWER et al., 1989).

The structure of an animal population is basically a "snapshot", which allows the estimation of the number of animals (abundance and density), how many males and how many females (sex ratio), what are the sizes and ages (categories or age or size classes) and distribution in the areas where they live. The dynamics, on the other hand, would be like a "film", where we could see, over time, the changes that are occurring in the population, through births (birth rate), deaths (mortality rate), migrations (movement, living area and migration rate) and how this influences the number of individuals (N) of that population over time (rate of population increase).

The term population dynamics applies to the study of variations in the number of individuals and the factors that influence these variations. It also includes the investigation of the rates at which individuals are lost and replaced and any regulatory process that tends to keep the population size in equilibrium (BAILEY, 1984; ODUM, 1988; KREBS, 1998; GOTELLI, 2007).

Population models are mathematical simplifications based on the structure and dynamics parameters of a population and provide a means of estimating the likely response of that population to a particular disturbance. The models also allow assessing the importance of data gaps with respect to the predictive capacity of the model (TIPTON, 1987; CULLEN JR. et al., 2003; GOTELLI, 2007). The basic tools for making a population model are computer programs and several years of population data collection (ROBINSON; BOLEN, 1989).

The logistic model is the most widely accepted and used in the study of wild animal population dynamics. This model predicts changes in population productivity, reproduction and mortality rates, population quality, and habitat conditions that occur with population growth and stable support capacity. The model is used to analyze populations and to predict impacts of changes in population or habitat parameters (BAILEY, 1984).

In performance models obtained from the logistic curve, intrinsic population growth rates and calculations of exploitation quota, an initial phase of accelerated growth, an inflection of the curve (when resources such as food and space begin to be limiting and normally have maximum performance) and a deceleration (when normally the bearing capacity of the environment is reached) may occur (PEEK, 1986).

Most animals have seasonal reproductions, producing annual support of birth. If we analyze a long period (50 to 100 years), these birth pulses become less visible, allowing comparisons through logistic curves (ROBINSON; BOLEN, 1989; GOTELLI, 2007).

Turtles are long-lived animals and models that require demographic estimates of age, growth, fecundity and survival are fundamental for their management. Most studies estimating the age and growth of freshwater turtles use growth rings on the carapace scutes as an age index, without estimating the error, and in few studies that use growth models or include many juveniles, growth is generally large and variable (SPENCER, 2002). The relationship between age and size is important for the development of demographic models and the identification of life stages in which turtles are more susceptible (BERNHARD; VOGT, 2010; GOTELLI, 2007; KREBS, 1998).

Studying the growth of turtles can help make better management decisions. Many demographic factors in the natural history of these animals are measured at least in part by body size. For example, to know how fast a population of turtles can grow, one must keep in mind how fast they will reach sexual maturity (which is one of the most important demographic variables) (ABERCROMBIE; VERDADE, 2000), the recruitment phase, and the first posture.

The protection of eggs and nests alone was not enough to replenish depleted sea turtle stocks (CROUSE, 1999; BJORNDAL et al., 2000). The models show that small reductions in the annual survival of juveniles and adults can profoundly affect the population dynamics, reducing population growth by directly affecting the recruitment phase. Reducing mortality rates of juveniles and adults is essential for the recovery of sea turtle populations. The most comprehensive models constructed for sea turtle populations, as well as models for other species of turtle, point to the need to maintain high annual survival of all life stages to sustain declining populations (CROUSE, 1999).

Over-exploitation by human populations has resulted in the drastic fall or extinction of sea turtle populations (ZIMMER-SCHAFFER et al., 2014). Attempts to control the remaining populations in a sustainable manner are hampered by insufficient knowledge of demographic parameters (BJORNDAL et al., 2000).

For the giant South American river turtle there are few studies to estimate models of population growth and biomass (DINIZ; SANTOS, 1997, BATAUS, 1998, ANDRADE, 2015).

The simulation models projected around parameters such as late age of reproduction and low survival rate in the first year of life suggest that benthic juveniles, as well as adults, should have a high annual survival rate to keep the population in equilibrium. More research on the main demographic and development parameters, and application of more adequate models, are necessary to build more realistic models for turtle populations (CROUSE, 1999).

Prediction models on population growth should include all stages of life of the studied species of turtle. Normally, the juvenile pelagic phase of turtles is little studied (BJORNDAL et al., 2000). The juvenile phase is a challenge for the study of the demography and life history patterns of aquatic turtles, a period in which these individuals are difficult to capture, perhaps because they live in pelagic environments or are difficult to access, and important information from this immature life stage, such as growth rate and mortality, in general, is extrapolated from population models (BJORDAL et al., 2000).

The rate of immigration and emigration at each stage seems to affect considerably the adjustments of population growth models for turtles. Some Amazonian species, such as six-tubercled Amazon river turtle, have great migratory capacity and hunting pressure seems not to have affected their population structure yet. The genetic monitoring of these natural populations in the Amazon Region has therefore become of great relevance as support for specific management and conservation projects for each species of turtles (SILVA, 2002).

Fordham et al. (2007) also notice that these manifestations of the potential long-term resilience of certain vertebrates, under a properly managed capture regime, are important to convince natural resource agencies that conservation with long-term viability need not necessarily exclude some degree of subsistence use. These results are largely relevant to applied ecology, providing important implications for the management of wild species subject to competing ecological pressures, such as subsistence and commercial hunting.

Another way of modeling the structure data and population dynamics is through the table of life, which summarizes important information such as survival, fecundity and age of maturity of a population, allowing, from an age structure, to infer about the dynamics and evolution of a population. Tables of life can also help in the construction of hypothetical models on population growth and survival (ROBINSON; BOLEN, 1984; PEEK, 1986). Among the attributes needed to compile a life table for turtles are: 1) Mean age at maturity; 2) Per capita fertility of females, which incorporates clutch size and frequency and adjustment for inter-seasonal reproductive frequency or mean proportion of adult females that do not nest each year; 3) Survival in all age classes, from egg to adult (FRAZER et al., 1980).

Another way to evaluate population growth is using the Leslie Matrix, which involves age structure and reproductive capacity. Leslie's projection matrix provides an average of the manipulation of age-specific fertility rates and age structure to determine the rates of increase and production. The basis of the matrix multiplies age-specific fertility and survival rates by population structure (PEEK, 1986).

Diniz and Santos (1997) proposed a first model for assessing the population growth of the giant South American river turtle, using Leslie's matrix as a mathematical model. Adopting some values such as average eggs, sex ratio, survival rate of the hatchlings until one year and age of sexual maturity, it was concluded that the populations of the giant South American river turtle in the sampled region were heading towards extinction. However, if the hatchlings were protected and at least 20% of them completed the first year of life and, of these, another 20% reached reproductive age, the value of – would rise to 1.05 (i.e., greater than 1), which would lead the population to be preserved.

Most of the giant South American river turtle and yellow-spotted river turtle protection programs aim to protect breeding females, nests, and hatchlings, which seems to have contributed significantly to these species' exit from the risk of extinction (IBAMA, 1989; CANTARELLI et al., 2014).

Modeling nest and hatchlings production: a preliminary approach

In most of the areas where the protection work of giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtle nesting sites is carried out, the main data recorded are the number of nests, the estimate of the total number of eggs and the production of hatchlings. In some of these beaches there are long historical series of this information annually collected and standardized by protocols established by the PQA. This series of data, which may reach more than 40 years of records (as in some nesting areas of Juruá River beaches), if well analyzed, may provide a reasonable idea of the trends of population growth of aquatic turtles' stocks in these regions (ANDRADE, 2012; 2015).

We propose to environmental managers a simplified approach that allows them to adjust the historical series of nest and hatchlings annual production data in each beach to a logistic model of population growth.

Nest and hatchlings production data must be annually recorded in each nesting area. This data, when related to the protection time of each area, generates a time series that can present a tendency of growth, stability or decline (Figure 1).

A regression analysis of the series is carried out and, in case it is significant, it should be verified by the estimation of the curve which model best describes the relationship for the construction of the population growth curve, being used in the evaluation, the logistic curves (GOTELLI, 2007; BARRY, 1995)

(Figure 2). The curve estimates can be made by several statistical programs (Past, Minitab, Statistica, R) being, later, defined as a general analysis model, the following logistic curve:

$$\text{- Logistic: } Nt = \frac{K}{1 + [(K-No)/No].e^{-rt}},$$

where Nt = total number of nests/females nesting or hatchlings produced in time t; No = number of nests, females nesting, or hatchlings produced in the first year of protection work; r = intrinsic population growth rate; e = Neperian constant = 2.717; K = capacity/environment support (GOTELLI, 2007).

With the curve models being established for each breeding site/species (Figure 2), we can obtain the values of the coefficients r (intrinsic growth rate) and K (capacity/support) of the nest and hatchlings growth models. The K values can also be determined by the maximum density of a population. The r and K values can be obtained directly from the curve models estimated by the statistical program (KREBS, 1986; BROWER et al., 1989).

If the intrinsic growth rate (r) is greater than zero it means that the population shows a tendency to grow; if it is equal to zero it means that it has stabilized; and if it is less than zero it shows a tendency to decline (KREBS, 1986).

The tabulation of the historical series of data of giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtles protection works, performed in each nesting area, allows the analysis of the variation in the number of females nesting in each nesting area and the number of hatchlings produced over the years. Although it does not necessarily represent the total number of females, this could be the only consistent indicator of the population variation of reproductive sites.

It should be taken into account that in very few turtle protection sites, wider and longer-term surveys were conducted, with animal capture, marking and biometrics, which made it possible to record basic information on population structure (sex ratio, size classes, abundance). The same can be considered in relation to the number of hatchlings produced, directly related to the number of nests on each beach (ANDRADE, 2015).

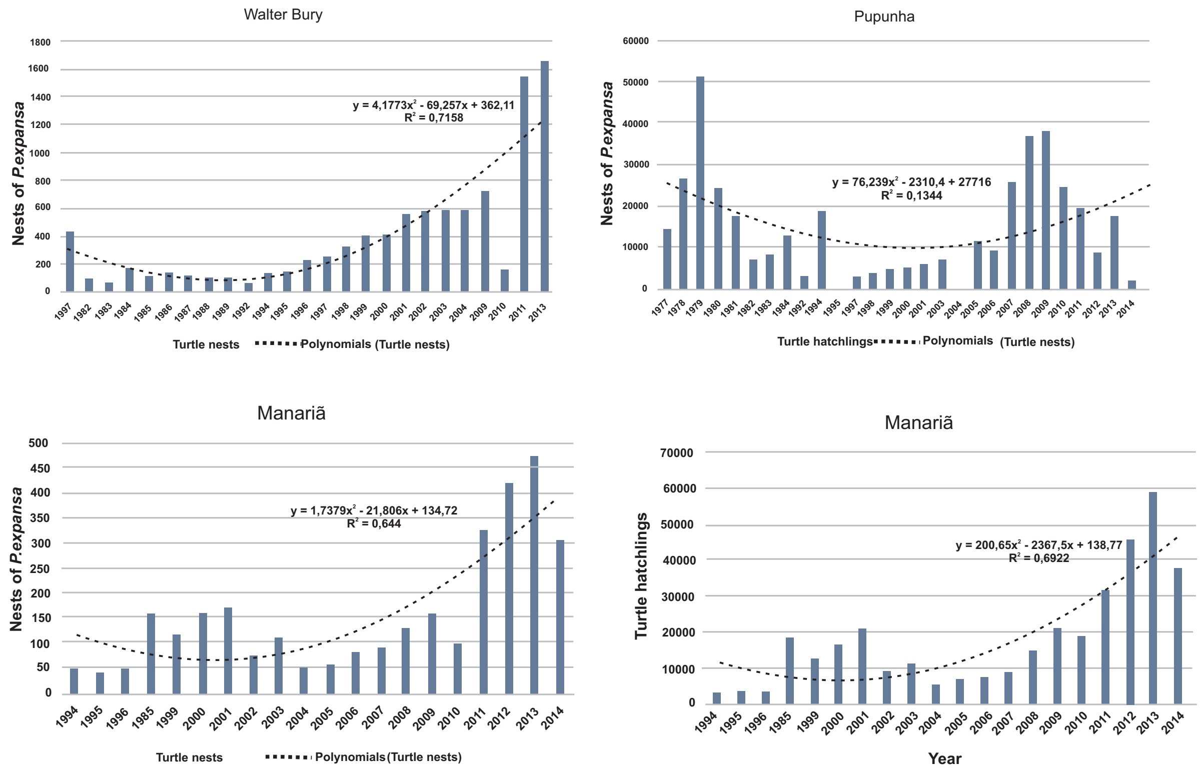

Figure 1 – Histograms of nest production and number of giant South American river turtle (Podocnemis expansa) in breeding sites of the Juruá River: A) Nests in the Walter Bury; B) Hatchlings in the Pupunha; C) Nests in the Manariã; D) Hatchlings in the Manariã (ANDRADE, 2015).

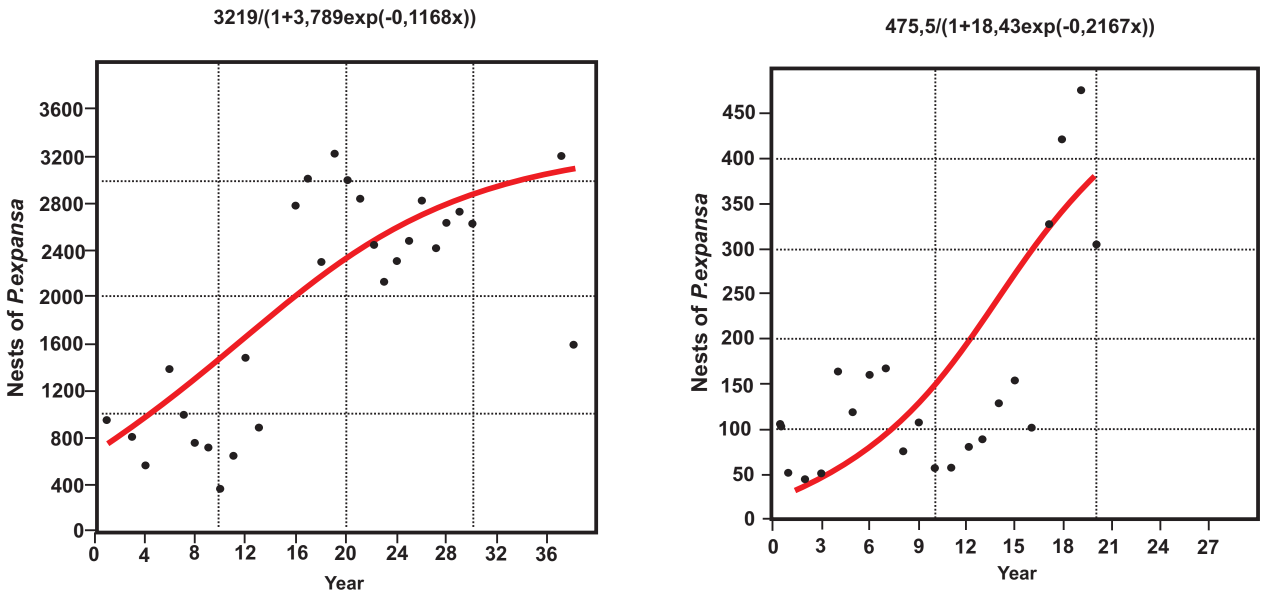

Figure 2 – Logistic curves of giant South American river turtle nests (Podocndemis expansa) at different nesting sites: A) Abufari, Purus River; B) Manariã, Juruá River (ANDRADE, 2015).

Thus, we decide to use a simpler population growth model, to verify if the nest and hatchlings data fit the growth curve models tested (logistic, as suggested by Hailey and Lambert, 2002).

As giant South American river turtle are long-lived animals, there is a great delay between the birth period and the beginning of the adult life of this animal, when the females would arrive at the beach to nest for the first time (recruitment). It is estimated that this time for the giant South American river turtle is 10 to 12 years and for yellow-spotted river turtle and, for six-tubercled Amazon river turtles, 6 to 7 years (GARCEZ, 2009; ANDRADE, 2012; 2015). In this case, recruitment "waves" would occur at 10-year intervals, with the population curve remaining in jumps or steps (discrete model). It was considered a model of continuous growth, instead of discrete, and with delay in the dense-dependent response, because when the intrinsic growth rates (r) are below 1.0 (as shown to be the case of podocnemidids turtle species), the behavior of the discrete model is similar to the continuous (GOTELLI, 2007; ANDRADE, 2015). It is also necessary to take into account that, as in the protected nesting areas, annually there are new "waves" of recruitment, which end up overlapping, giving a characteristic of continuity to the model.

The growth rate of the number of reproductive nests/females per unit of time (r t) is specific for each species in the analyzed nesting site, in a certain period of protection of the area, therefore it makes no sense to obtain the average values of r for each protection system used.

The same reasoning is valid for the support capacity (K) of each nesting beach or nesting site, as for the number of females of a certain species, which continues nesting in its area. The competition for space, for the nests in the sand of the nesting site, can reach a level in which there will be superposition of nests and the females will eventually dig up and roll over the eggs of others, which alters the number of hatchlings generated. Some females end up looking for other nesting sites, that is, each breeding site has its support capacity (K) for nests and hatchlings produced, being limited mainly by the space factor, therefore, this constant is also specific for each species and laying site, making no sense to use the average value of K, to generate a unique model of population growth curve (ANDRADE, 2015).

However, the population parameters r and K are those that allow one conservation area to be compared to another. The r units mean individual per individual and time unit (GOTELLI, 2007). Thus, it is possible to compare the instantaneous growth rates between the different protection systems used over time in the Amazon turtle breeding areas (ANDRADE, 2015).

With the curves selected for each area, simulations of up to 50 years of conservation can be made, and the values generated can be used to estimate the growth curve of the number of reproductive nests/females, of each species, according to the protection system. After the estimation of the logistic growth model curves per species and per protection system, we can validate the proposed models by comparing the estimated values to the real values (obtained by monitoring and data recording by managers or communities), by Spearman's correlation, and it is expected, for most curves, significant correlation. Figures 3, 4 and 5 present the logistic curve models for the giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtle, respectively.

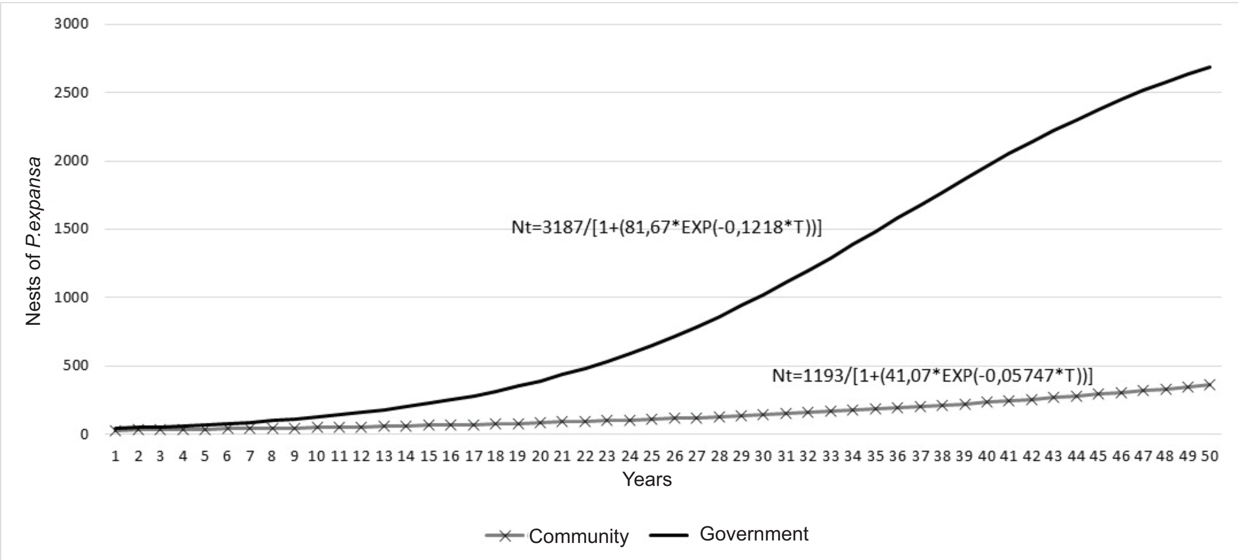

Figure 3 – Logistic growth curves of the number of reproductive nests/females of Podocnemis expansa in the state of Amazonas (ANDRADE, 2015).

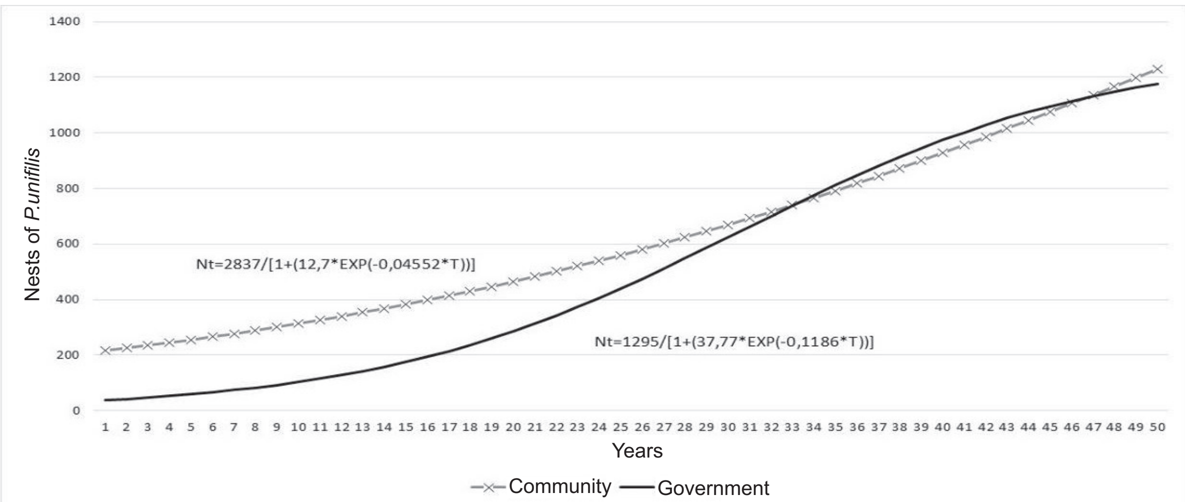

Figure 4 – Logistic growth curves of the number of reproductive nests/females of Podocnemis unifilis in the state of Amazonas (ANDRADE, 2015).

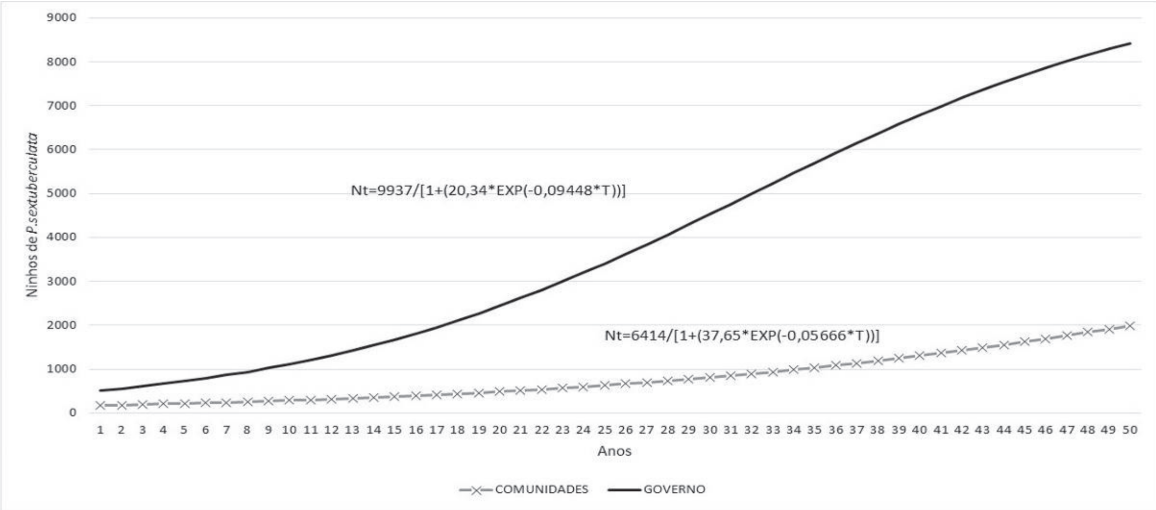

Figure 5 – Logistic growth curves of the number of reproductive Podocnemis sextuberculata nests/females in the state of Amazonas (ANDRADE, 2015).

Methodological proposals to study the structure parameters (abundance, density, sex ratio and age distribution) and population dynamics (growth, survival, mortality, life tables and movement/migration) of giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtle.

To estimate the size and structure of the turtle populations of monitored areas and the average growth rates of their individuals, the CMR (capture, mark-and recapture) methodology should be used. This method allows obtaining not only an estimate of the density, but also the survival and mortality rates of the populations studied (KREBS, 1986; GOTELLI, 2007).

In order to perform the population monitoring, the capture of adults, sub-adults, youngsters and hatchlings of giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtle in the areas of protection and management must be carried out. It is recommended that survey and monitoring excursions be made at different times of the year (at least during the ebb, drought and flood), with capture stations being set up in different environments (rivers, lakes, flooded forests, beach margins). The techniques of capture and marking are differentiated according to the category or class of age and the place and period of capture, aiming to mark as many individuals as possible (LOVICH et al., 2012; ANDRADE, 2015; BALESTRA et al., 2016). These actions can and should be carried out together with the beach monitors of the communities in order to enable them to monitor the participatory population and co-manage this resource (KENNET et al., 2015).

Estimates of population size (Nt), probability of survival (Φt) and finite rate of change (λt) can be generated by the Mark program. It is necessary to observe if there is a variation in the number of individuals captured between the different capture periods (flood – drought), as this affects the catchability (model assumption). To solve this problem, which normally occurs in the case of Amazon podocnemidids, one can use the design proposed by Fernandez (1995), who considers the captures, within the same year, as secondary periods, and the years as primary periods, allowing the estimate of abundance by the Jolly-Seber model.

The CMR is a direct and absolute fauna survey method that allows quantifying the studied population, being important in fauna management, kinesthetic planning, evaluation of environmental impacts or conservation of a certain species (CULLEN JR et al., 2003). It is also the only way to obtain data of each specimen such as biometrics, weight, sex and age, to estimate growth rates, sex ratio and distribution in size classes (Figure 6) or age, and also to record and map the habitats they occupy, their distribution and estimation of living area.

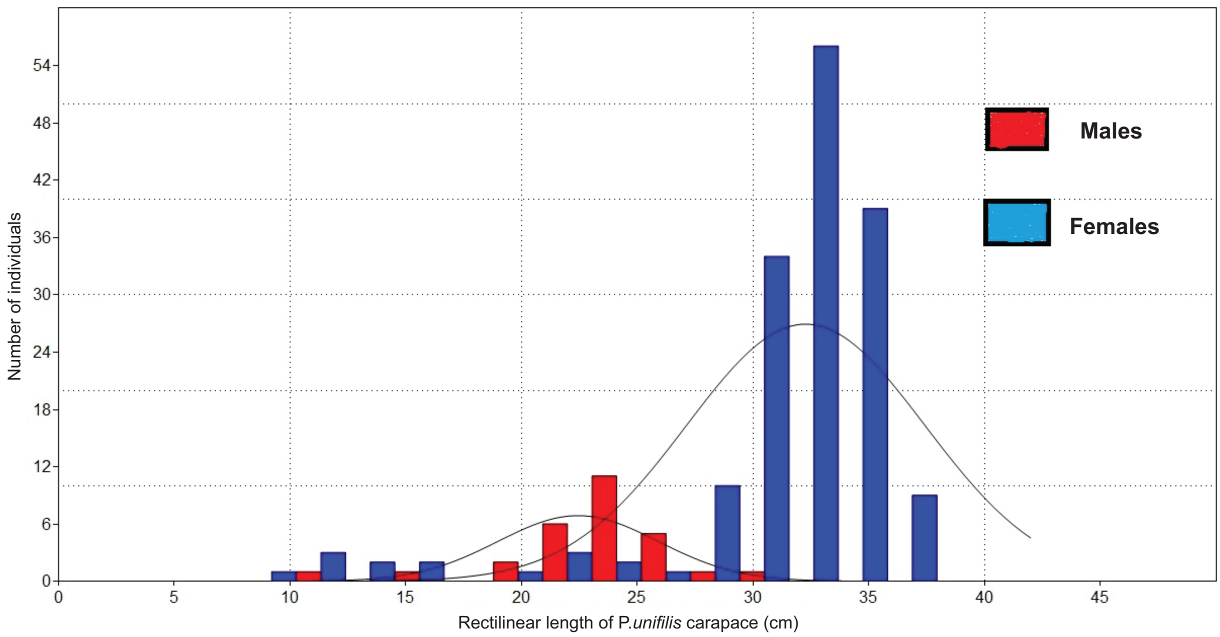

Figure 6 – Example of size classes: frequency distribution of yellow-spotted river turtle (Podocnemis unifilis) carapace length (cm) captured in Aliança, Piraruacá Lake, between 2010-2012 (ANDRADE, 2015).

Through the capture, marking, biometrics and weighing of turtles, their growth rates can be estimated, analyzing, for example, the best relationship between carapace length or weight, with the estimated age of the captured animals, and then growth curves in length or weight can be elaborated, according to Figure 7.

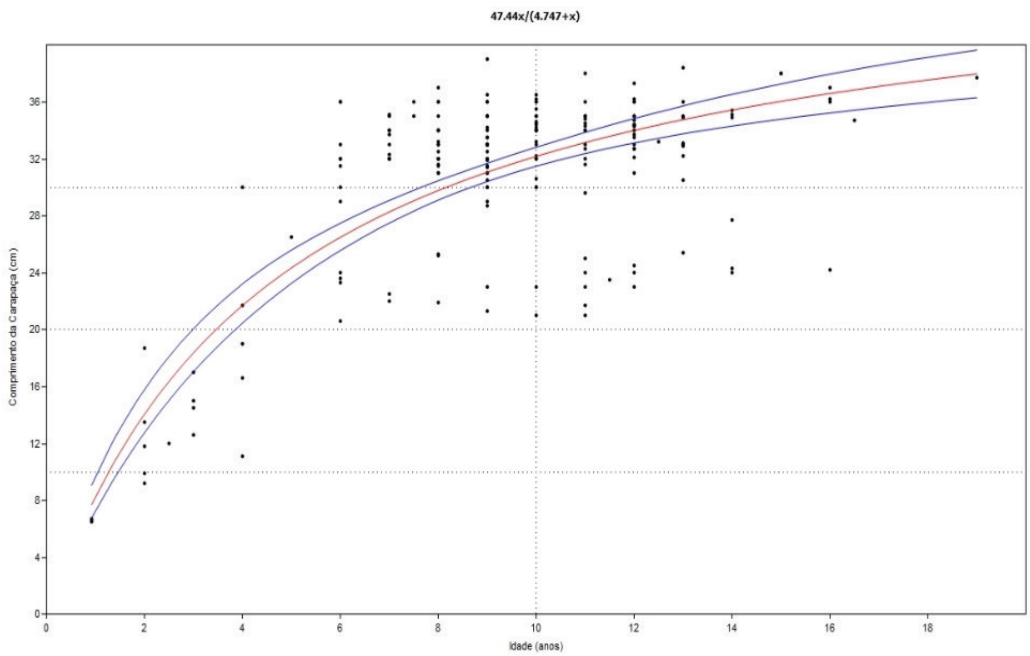

Figure 7 – Growth curve in carapace length (cm) of yellow-spotted river turtle (*Podocnemis unifilis*) of Lake Piraruacá, Terra Santa (ANDRADE, 2015).

From studies on the abundance, structure and dynamics of Amazonian podocnemidids populations, some of those conducted with the giant South American river turtle in the Crixás-Açu River (BATAUS, 1998), in the Araguaia River (LUSTOSA, 2017), in the Purus River (PEZZUTI et al., 2008) and in the Juruá River (ANDRADE, 2012; 2015), in Brazil, as well as in Venezuela (HERNANDEZ; SPIN, 2006) can be mentioned. For six-tubercled Amazon river turtle studies were made in Mamiraruá/Solimões-Japurá River (FACHIN-TERAN, 2000; FACHIN-TERAN et al., 2004; ARAÚJO, 2017), in Abufari/Purus River (PEZUTTI et al., 2008) and in the Juruá River (ANDRADE, 2012). For the yellow-spotted river turtle, the studies were conducted in the Purus River (PEZUTTI et al., 2008), in the Juruá, Andirá Rivers and Piraruacá Lake (ANDRADE, 2012; 2015), as well as in Tucuruí (SILVA, 2009). For the red-headed Amazon river turtle (*Podocnemis erythrocephala*) turtle, on the Negro River, the studies were made by Bernardes et al. (2014) and Bernhard (2010).

Table 1 – Number of animals sampled, carapace length (cm), weight (g), estimated age (years), and sex ratio (%) of turtles of the genus *Podocnemis*, in the middle Juruá.

Species	N	Straight line carapace length (cm)	Mass (g)	Age (years)	Sex ratio (%)
P. sextuberculata	2728	Mean=17.7±3.0	674.7±378.9	6.2±2.6	M=54.4
		Maximum = 29.9	2380	16	F=45.6
		Minimum = 4	55	1	
P. expansa	128	Mean=31.1±15.5	5878.6±9710.3	6.6±5.8	M=10.2
		Maximum = 77	44000	30	F=89.1
		Minimum = 7.5	69	0.6	I=0.7
P. unifilis	88	Mean=24.8±8.7	2507.0±2522.9	6.3±4.1	M=47.7
		Maximum = 45	11500	24	F=52.3
		Minimum = 6.7	60.5	1	

Source: Andrade (2012).

Table 1 shows an example of how the structure parameters of a population with size classes, age classes, and sex ratio can be briefly quantified, presenting the mean carapace length (cm), weight (g), estimated age (years), and sex ratio of 3,952 turtles captured, marked, and measured between 2004 and 2012, in the Extractive Reserve of the Middle Juruá and Substantiable Development Reserve Uacari.

With long-term population monitoring data on captured, measured and weighed turtles and their distribution in size/age classes and sex, we can elaborate the life tables of each species, associating them with reproductive monitoring data. The life tables summarize this information (survival, fecundity, age of maturation, generation time and life expectancy), allowing, from an age structure, to infer the population dynamics and evolution (FRAZER et al., 1990).

Survival in the first year of life can be estimated by comparing the total number of eggs and hatchlings born, with the one-year-old hatchlings captured. The number of newly hatched eggs or hatchlings can be estimated by counting 30 nests per species on the nesting area (ANDRADE, 2015; BALESTRA et al., 2016). Eggs and hatchlings are vulnerable to predators and abiotic factors, suggesting that high mortality may occur. Most studies focus on determining the success of nests or hatchlings (e.g., total number of hatchlings produced divided by the total number of eggs) (FRAZER et al., 1990).

All turtle populations, in which life tables have been made, are in decline due to drainage of their environments (freshwater turtles), predation or human interference (sea turtles) (FRAZER et al., 1990). Andrade (2012; 2015) has developed life tables for six-tubercled Amazon river turtle, yellow-spotted river turtles and giant South American river turtle in the middle Juruá and Andirá Rivers, in populations with an intrinsic growth rate (r) higher than zero, i.e., growing.

For studies of movement patterns, migration and use of turtle environments and living areas, radiotelemetry using radio transmitters can provide faster responses than the traditional capture-marking method and more accurate than participatory mapping.

To analyze the movement patterns of giant South American river turtle and yellow-spotted river turtle and to estimate the area of life in the managed areas, satellite radio transmitters (e.g., sir track, Figures 8 and 9) or VHF radio transmitters (e.g., AVM) can be installed. In the case of VHF transmitters, after installation the animals must be monitored daily by field technicians equipped with VHF receiver antennas (Figure 10) and GPS devices, to georeference the animals' location points as well as record environmental data such as depth, transparency, water temperature and type of vegetation close to the water body in which the turtle is located. Through satellite systems of PTT transmitters (Platform Transmitter terminals), with signals via the Argos system. It is possible to estimate the Schoener Index and the area of life of the turtles with radio transmitters, from the data analysis (CULLEN JUNIOR. et al., 2003).

Figure 8 – Giant South American river turtle (*Podocnemis expansa)* with satellite transmitter in the Resex middle Juruá River.

Figure 9 – Yellow-spotted river turtle (*Podocnemis unifilis)* with satellite transmitter in Lake Piraruacá (Photos: Paulo Andrade).

Figure 10 – Tracking of turtles with VHF receptors in the Juruá River (Photos: Paulo Andrade).

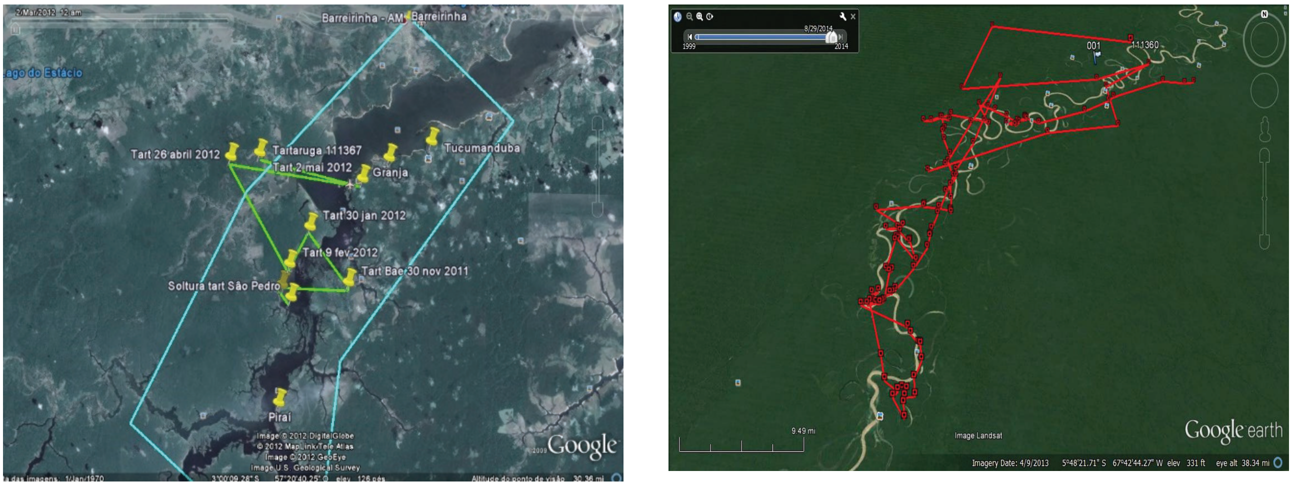

Figure 11 – Movement of giant South American river turtle (*Podocnemis expansa)* on the Andirá and Juruá Rivers (ANDRADE, 2012; 2015).

To analyze the movement pattern of the giant South American river turtle and yellow-spotted river turtle hatchlings marked and released, georeferencing data of the release, capture and recapture sites can be used. The coordinates of these points can be plotted to record successive linear movements, the maximum distance traveled (linear home range), to define the Minimum Polygon Convex (MPC) and to estimate the area of use, using the 95% Fixed Kernel method (SOUZA, 2012).

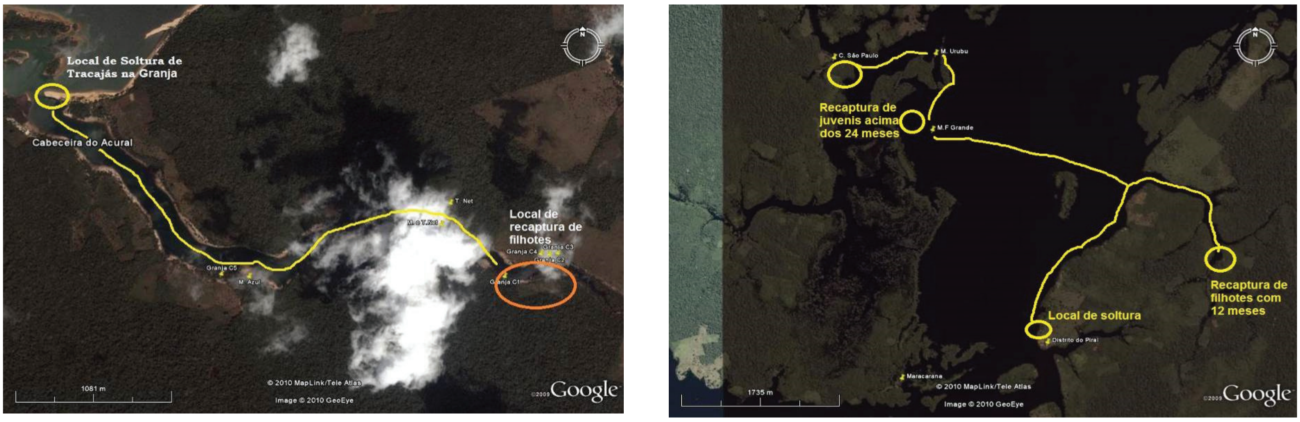

Figure 12 – Movement of yellow-spotted river turtle (Podocnemis *unifilis*) hatchlings microchipped and recaptured at 12 months and 36 months, on the Andirá River (ANDRADE, 2015).

In floodplain areas of rivers such as Purus, Juruá and the middle Amazon, with very low recapture of hatchlings, another option is active acoustic tracking (VR100 Vemco acoustic receiver) since the conventional VHF and satellite radio transmitters are very heavy for the hatchlings (because of the battery).

Life tables and sustainability analysis for six-tubercled Amazon river turtles (*Podocnemis sextuberculata*), yellow-spotted river turtles (*P. unifilis)* and giant South American river turtle (*P. expansa*) in middle Juruá: a case study

The nesting areas of the middle Juruá River have been protected by the riverine and rubber tapper communities for 40 years, with a good historical series of data on nests and hatchlings. Moreover, since 2004, through the *Pé-de-pincha* Project, a program of population monitoring of giant South American river turtle, yellow-spotted river turtles and six-tubercled Amazon river turtles based on CMR, radiotelemetry, participatory mapping and subsistence consumption recording has been initiated. This program consolidates ecological information to estimate the sustainability of management for use (ANDRADE, 2015).

Analysis of the time series of giant South American river turtle, yellow-spotted river turtles and six-tubercled Amazon river turtle nest production shows that the number of reproductive females/ giant South American river turtles' nests has increased in the region (Figure 13). However, community members have observed that as the number of giant South American river turtle nesting increases, the number of females of yellow-spotted river turtles on protected beaches decreases. The reduction in the number of yellow-spotted river turtles on beaches may be related to competition for space, on beaches, with giant South American river turtle, or capture for consumption or illegal sale. Analysis of the time series of yellow-spotted river turtle nests, however, shows stability, while that of six-tubercled Amazon river turtles presents a decline (Figure 13).

Between 2004 and 2012, the most captured species for subsistence consumption by community members was six-tubercled Amazon river turtle (59% to 89%), more than yellow-spotted river turtles (7% to 31%) and giant South American river turtle (4% to 10%). six-tubercled Amazon river turtle is captured all year round, and the number of carapaces found in the communities was much higher than that of other turtles. In the experimental captures of the monitoring, 91.7% of six-tubercled Amazon river turtles, 4.9% of yellow-spotted river turtles and 3.2% of giant South American river turtle were captured. In the middle Juruá, 98% of the community members interviewed confirmed that the practice of capture for illegal trade occurs (47% sold in the city, 35% in the community itself and 8% for the river traders) (ANDRADE, 2008; 2012).

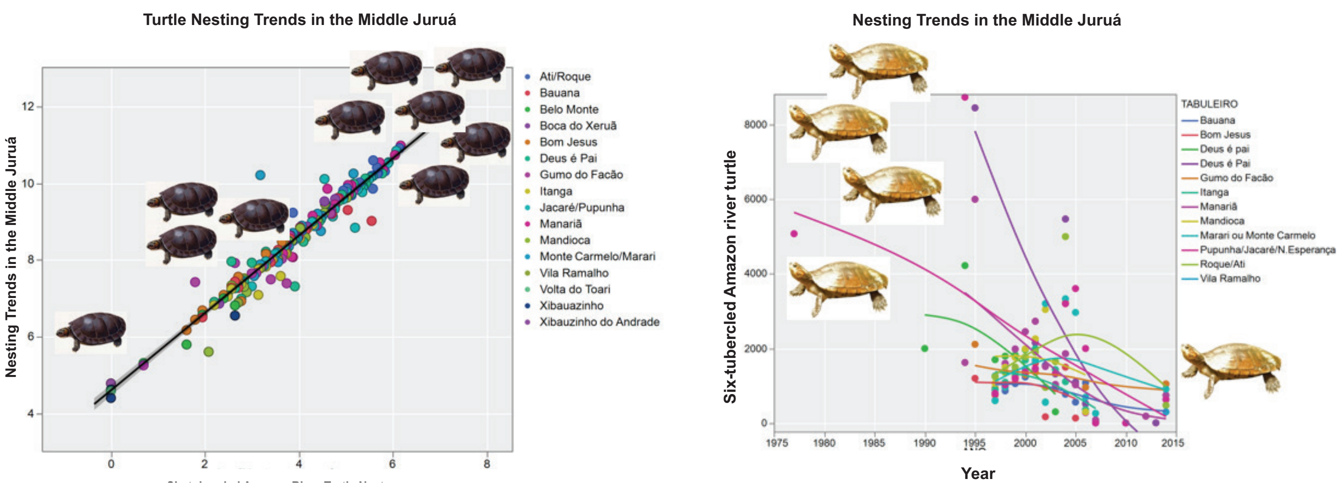

Figure 13 – Analysis of the trend in the production of nests of *Podocnemis expansa* and *P. sextuberculata*, in the middle Juruá River.

Based on the data of capture, marking and recapture of turtles in the middle Juruá, an attempt was made to estimate a table of life for the species of the genus *Podocnemis* (Table 2). For the six-tubercled Amazon river turtles with the highest number of marked and recaptured animals, the population abundance in the RESEX of the middle Juruá and RDS of the Uacari was estimated between 138,764 and 143,455 animals (ANDRADE, 2012).

Until the first year, the mortality rate estimated for six-tubercled Amazon river turtles was very high in the first year, reducing in the 2nd and 3rd years and gradually growing again in the following years. Ninety nine percent of the animals hatched die until they reach 13 years old. The survival curve of this species shows a high reduction of the population in the first years, followed by a constant gradual reduction (Type III) (Figure 14) (ANDRADE, 2012).

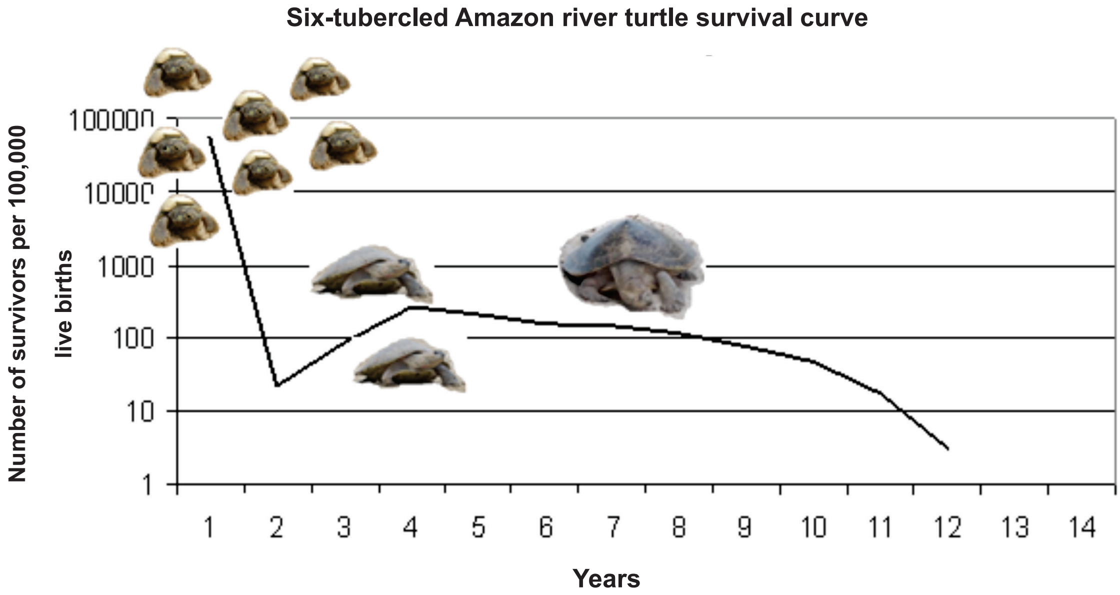

Figure 14 – Six-tubercled Amazon river turtles (*Podocnemis sextuberculata*) survival curve, in the middle Juruá.

The average life expectancy for six-tubercled Amazon river turtles was estimated at 6.3 ± 3.9 years, a relatively low value compared to the maximum estimated age (16 to 22 years). Probably, the reduced average life expectancy value was influenced by hunting pressure that occurs on the population stocks of this species, in the middle Juruá River. As females reach reproductive age around 7 years, most at recruitment age may not nest at all (ANDRADE, 2015).

The mean reproductive rate (Ro) was found among the age classes of the reproductive phase (from 6 years, in six-tubercled Amazon river turtles), being obtained an average value of 1.8 hatchlings/female in reproductive age. If the ratio is balanced, it is deduced that the population is replaced more or less during one generation (ANDRADE, 2015).

For yellow-spotted river turtles, the estimated average life expectancy was very low (3.8 ± 1.7 years). The mortality rate was high in the first year, being reduced in the second. For yellow-spotted river turtles, the average annual survival rate in the first years was estimated at 0.031%. Considering the reproductive age around 7 years, the net reproductive rate (Ro) was estimated at 0.024 hatchling/female in reproductive age. The value of Ro was very low, indicating that some factor contributed negatively to the gradual reduction of the population (ANDRADE, 2015).

Table 2 – Table of life for six-tubercled Amazon river turtles (*Podocnemis sextuberculata*) in the Extractive Reserve of the middle Juruá River/state of Amazonas – AM.

X	Nx	lx	Dx	Qx	Lx	Tx	Ex
0	54133	1.0000	54111	0.99	27077.5	28203.5	0.52
1	22	0.0004	64	0.91	54	1126	51.18
2	86	0.0016	177	0.06	174.5	1072	12.46
3	263	0.0049	57	0.22	234.5	897.5	3.41
4	206	0.0038	51	0.25	180.5	663	3.22
5	155	0.0029	9	0.06	150.5	482.5	3.11
6	146	0.0027	32	0.22	130	332	2.27
7	114	0.0021	36	0.32	96	202	1.77
8	78	0.0014	32	0.41	62	106	1.36
9	46	0.0008	29	0.63	31.5	44	0.96
10	17	0.0003	14	0.82	10	12.5	0.73
11	3	0.0001	3	1.00	1.5	2.5	0.83
12	0	0.0000	1	0.00	0.5	1	0
13	1	0.0001	1	1.00	0.5	0	-
Mean life expectancy = 6.3±3.9 years – Maximum= 16 to 22 years							

Note: X = Age Interval; nx = observed number of animals in different age classes; lx = proportion of surviving animals each year (survival rate); dx = number of deaths within the age range; Qx = Mortality rate; Lx = average number of living individuals in the age range; Tx = Individuals per unit of time; Ex = life expectancy per age class (ANDRADE, 2012).

The average life expectancy of giant South American river turtle was estimated at 10.0 ± 16.5 years. The mortality rate of the turtles seems to be high until the first year, reducing in the second and increasing in the third year, until the 5 years, when it reduces again to 6 years and, finally, remains high after 7 years. In this species, 47%, on average, of animals will die by the age of seven (ANDRADE, 2015).

Analyzing the movement of the animals, it can be seen that 42.9% of the six-tubercled Amazon river turtles had migrated to other areas, leaving the area of origin. Of the females of giant South American river turtle monitored, only 71% remained faithful to the nesting site, where they were captured, returning to nest for 3 consecutive years, moving, on average, 11.3±3.5 km of their nesting area. However, 29% of the turtles went to other nesting areas, between 48.8 km and 289.7 km away from their place of origin. The yellow-spotted river turtles monitored remained faithful not only to the nesting beach, but to the feeding lake, where they move during the flooded season, on average 3.9±2.9 km away from the beach of origin, which may facilitate their capture by the riparian people (ANDRADE, 2012; 2015).

Considering the annual increase in hatchling production, an intrinsic annual growth rate (r) equal to 0.83 was estimated. However, when Ro and r were calculated, by survival rates and life tables, a lower value was found, equal to 0.41, which indicates that that turtle population was growing (r>0). But considering the values of k (population balance constant, maximum population value) = 207,889 animals/river and annual growth rate r = 0.83, it can be observed that each year there are, on average, 172,818 hatchlings in the system, however, if we consider that the survival rates are relatively small (1% to 5%), the estimated annual recruitment drops to 2,475 six-tubercled Amazon river turtles, 1,185 yellow-spotted river turtles and 520 turtles in the nesting areas of the middle Juruá River (ANDRADE, 2015).

The average annual estimate of the capture of turtles for subsistence consumption by the communities is 69 six-tubercled Amazon river turtles (18.8%), 195 yellow-spotted river turtles (53.2%) and 102 giant South American river turtle (28%), the majority being juvenile females (PROBUC data, 2009-2012). These figures indicate a reduction in the percentage of six-tubercled Amazon river turtles captured by community members, compared to the 2004 – 2008 estimates (ANDRADE, 2008). With regard to the illegal trade, it is estimated that turtle traffickers in the region remove 698 turtles, 128 yellow-spotted river turtles and 6,818 six-tubercled Amazon river turtles per year, totaling 7,644 turtles caught for the illegal trade per year, and between 19,800 and 23,100 eggs, of the three species, per year (personal information, PROBUC and PMJ data, 2014-2015). Between June 2017 and October 2018, 523 Six-tubercled Amazon River Turtles, 191 turtles and 41 yellow-spotted river turtles (personal information of the manager of RESEX Médio Juruá) were seized by the inspectors.

Thus, it is estimated that between 3,500 and 4,180 turtles are recruited annually, which begin the reproductive phase in 14 nesting beaches protected by the communities in the middle Juruá River, however, the capture for subsistence and illegal trade remove, on average, from 7,500 to 8,208 animals. These natural recruitment values would make it impossible to extract turtles, in a rational way, in free living populations, considering only the current number of managed beaches. Increasing this number would possibly increase the recruitment rate and, therefore, the number of adult animals would reach the nesting age.

The sustainability analysis of turtle capture by the maximum production and stock model presents the same result, indicating that the extraction of animals by this management probably leads to the reduction of stocks, with high risk of local extinction (Figure 15).

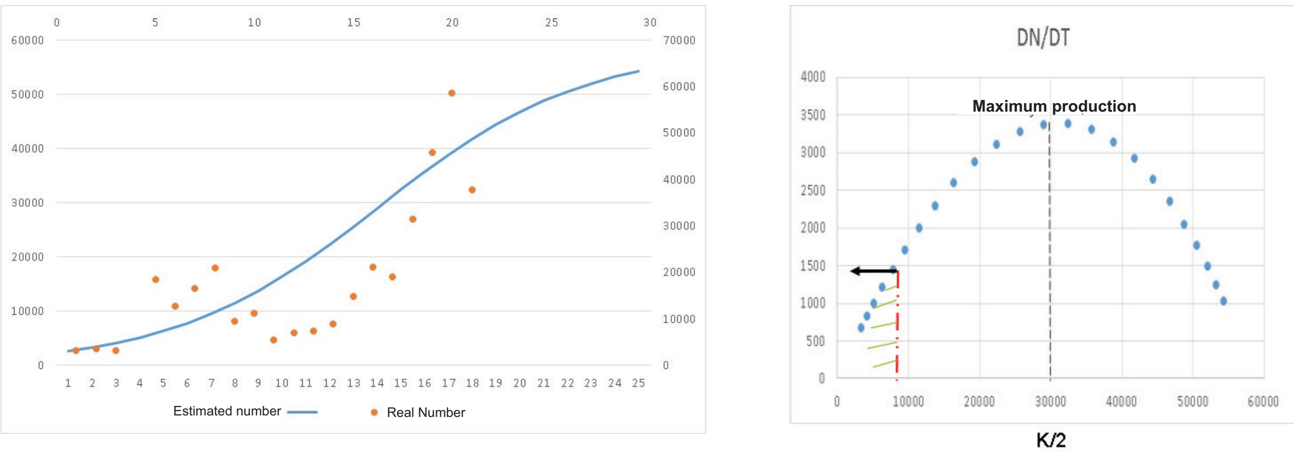

Figure 15 – Analysis of the sustainability of the capture of turtles in the middle Juruá River.

The capture of turtles for illegal trade is not being reduced by frequent inspection actions, so there is a situation that makes it impossible to implement management systems *in situ*, with extraction of adult quotas. The collection of eggs in nesting areas, with high rates of overlap of giant South American river turtle nests (or in areas of the beach threatened by flooding), and the community breeding of a percentage of the hatchlings produced in the protected beaches may be an option for income generation for the monitors that protect the nesting areas.

In the middle-lower Amazon, where the *Pé-de-pincha* Program operates, the intrinsic population growth rate was estimated at r = 0.33±0.19, on average, in the protected yellow-spotted river turtle nesting sites, representing an average annual increase of 38% in females, of reproductive age, on protected beaches (ANDRADE, 2008; 2015). In this same region, the average survival rate found for yellow-spotted river turtle hatchlings, up to 24 months of age, varied from 5.9% to 13.6%, and the average life expectancy or hope estimated at 187.8 ± 76.2 months, that is 15.6 years, being much higher than that found in the Juruá River (ANDRADE, 2012). The average value found for the intrinsic growth rate (r) of the populations studied in Parintins and Barreirinha was 0.35 ± 0.13, which indicates growth in the populations studied ($r > 0$) (ANDRADE, 2012; 2015). The same occurs with yellow-spotted river turtle populations in Terra Santa/state of Pará – PA, where the probability of survival varied from 0.14 to

5.6, and the rate of population change from 0.19 to 5.6 (ANDRADE, 2012; 2015), showing an increase in local yellow-spotted river turtle populations, due to the community-based conservation actions. One of the factors that may contribute to this increased resilience of yellow-spotted river turtle populations, with their rapid recovery in response to community protection actions, would be a lower rate of migration of individuals and their fidelity to the reproductive site.

Another way to evaluate the sustainability of fauna populations, with possible future scenarios, is using stochastic (probabilistic) analysis models, such as the Population Viability Analysis (PVA), done by the Vortex Program (MILLER; LACY, 2005). Sustainability and PVA analysis evaluations need the information of population monitoring, with long-term CMR.

For yellow-spotted river turtle populations in areas protected by the *Pé-de-pincha* Program, in the middle Amazon River, more than 150 simulations were conducted involving scenarios with uncontrolled hunting and community conservation management (ANDRADE, 2015). PVA is one of the criteria used by IUCN to assess whether a certain taxon is threatened. Andrade (2015) observed that in the scenario with community-based protection, the populations of yellow-spotted river turtles had a probability of extinction equal to zero, over 50 years, with maintenance of genetic diversity at 98% for average size populations in approximately 1,239 reproductive females, with increasing stochastic growth rates (r = 0.072±0.069) whose simulated population grew at higher rates in relation to capacity/support. With information such as this, it was possible to establish criteria to define priority conservation areas of turtles in the state of Amazonas and define guidelines for implementing the use of percentages of the protected hatchlings in community breeding systems, as in Resolution Nº 26 of the Amazonas State Council on the Environment (CEMAAM, 2017).

Other cases and considerations about the management for the use of fauna

Law Nº 9,605 of February 12, 1998, which deals with environmental crimes, makes a distinction between hunting and fishing, so that fish, crustaceans and mollusks in Brazilian territory are not considered belonging to the Brazilian fauna in the face of the legislation and are treated as resources.

Perhaps, for this reason, it is very difficult in Brazil to follow the path of sustainable management of wildlife fauna. Hunting, even though it is widely carried out in Brazil, especially in the interior, is a taboo and considered a crime. Although management is conceptually different from hunting, because it involves several tools and techniques with ecological basis (as demonstrated) that aim to ensure that the population of the species is not in danger, in legislation there is no such distinction, so depending on who is interpreting the law, everything can be considered hunting.

In any case, both the fauna and the fishing resource and the forest resource can be managed in a sustainable way. An example of sustainable management that is working well in Brazil is the *pirarucu* (*Arapaima gigas*), in the state of Amazonas, where fishing is prohibited all year round, except in areas where sustainable management is authorized by IBAMA. The managed areas must be located in conservation units or have fishing agreements. The management is carried out directly by the riverside communities, which must estimate the population of these fish in their region. In 2011, only 14 areas were authorized for management, in 2014 there were 42, with permission for fishing of 43,000 fish. In the Juruá River, in the lakes where management is authorized, the population of *pirarucu* (*Arapaima gigas*) is 33 times larger than where management does not occur (CAMPOS-SILVA; PERES, 2016).

This fact occurs because the riverside community respects the established quota and protects the area from fishermen. In areas where pirarucu fishing is prohibited, the federal, state, or municipal government is not able to supervise the activity properly and there is no local community interested in protecting the area. In this way, they become nobody's areas, in which illegal fishing occurs in an unregulated and unsustainable way. The annual income from the *pirarucu* trade in areas authorized for management can reach US$ 10,601 per community and US$ 1,046 per family (CAMPOS-SILVA; PERES, 2016).

Today, in Brazil, two species of wild fauna are being managed for use in nature: the spectacled caiman (*Caiman crocodilus*) and the black caiman (*Melanosuchus niger*). Since 2009, the riverside communities that live in the Extractive Reserve of Cuniã are authorized to capture and slaughter these species, being able to commercialize the meat and leather. ICMBIO annually authorizes a quota and the minimum size for slaughter.

Despite the great demand of the population for the consumption of turtles in the North Region of Brazil, its use is not authorized, except when coming from regularized commercial breeders.

Costa Rica managed to implement the egg management of the olive Ridley sea turtle (*Lepidochelys olivácea*). In the Ostional Wildlife Refuge, there is a huge nesting of this species of sea turtle, classified as vulnerable by the International Union for Conservation of Nature. The number of females that go up to the beach to dig their nests and lay their eggs is estimated between 20 and 190 thousand. The limited space of the beach and the large number of turtles cause some females to dig up nests of each other, causing great loss of eggs, because the unearthed eggs do not generate hatchlings. In 1987, it was authorized for the first time, in the region, that the inhabitants collect a portion of the eggs deposited on the beach for commercialization (LAGUEUX, 1991; CAMPBELL, 1998). After more than two decades of the project in operation, it is estimated that the population of turtles nesting is increasing (BALLESTERO et al., 2000) and that the hatching rate has increased by 20% in some years (CAMPBELL et al., 2007). The community has formed a cooperative responsible for selling eggs and the Costa Rica government establishes the unit value of egg sales. The community perception of the project impact on the community economy is quite positive (CAMPBELL, 1998).

A project to use yellow-spotted river turtle eggs has also proved viable in Ecuador (CAPUTO et al., 2005). The study estimates that 63% of yellow-spotted river turtle nests in the region were lost to flooding. The community was allowed to remove the eggs from areas that had a high chance of flooding and committed to protect the nests in other areas. In addition, a value of 35 cents per person was offered for each yellow-spotted river turtle hatchling. It was observed that the number of eggs that the community was able to consume (28%) was much lower than the number of eggs that would be lost by flooding (63%) and the selection of nests for consumption was based on criteria that optimized the amount of hatchlings born. It is also evident that community management can include the marketing of part of the eggs that are naturally lost. Therefore, there is the possibility of expanding the use to obtain income, without any impact on natural populations, since the collection is directed to condemned nests.

These examples show that community fauna management has contributed to the conservation of some species. Whether or not authorized by the Public Power, the reality is that the consumption of wild fauna by communities in the Amazon already occurs, in a sustainable way or not. In the specific case of the turtles of the Amazon region, the riverside communities use this resource as an important source of protein and as a medicine. Some people also sell turtles on the illegal market, and this is perhaps one of the greatest threats to the species (PEZZUTI et al., 2010; PANTOJA-LIMA et al., 2014).

Some communities in the region do sustainable management, such as the floodplain communities of the lower Amazon River (MIORANDO et al., 2013; ANDRADE, 2015). In these locations fishing agreements have been implemented to regulate fishing activity, based on local knowledge of techniques and periods of the year in which the activity can cause more damage to fish populations. The objective is to delimit areas where fish and turtles can be extracted. In the lower Amazon region and in the middle Juruá River, there are communities with a history of elaborating additional rules, agreed upon in community meetings, focused on the preservation of important nesting areas for the turtle populations. These are the cases of the communities Ilha de São Miguel, Água Preta and Aracampina (MCGRATH et al., 2006; MIORANDO et al., 2013). In the exclusive case of the Água Preta community, a reserve area was created where fishing and the collection of turtles and birds' eggs on the beaches, as well as the animals themselves, are expressly prohibited. The area is supervised by the community that organizes itself to protect it.

In some turtle reproductive areas in the Amazon, besides the monitoring and protection of nests and hatchlings, there are long term population monitoring programs with CMR, estimating structure parameters and population dynamics in the Rivers Juruá, Purus, Solimões/ Japurá, Negro/ Unini, Uatumã, Andirá, Nhamundá, Trombetas, Tapajós, Iriri, Xingu and Araguaia. In these places, where information basis of applied ecology exist, to build population models and carry out sustainability analyses of hunting, medium and long-term *in situ* management experiments can be initiated.

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Chapter 7

Community involvement in the processes of conservation of the Amazon freshwater turtles

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Community management of turtles

The history of the economic use of turtles in the Amazon seems to be an exemplary case of the "tragedy of the commons", defended by Hardin (1968), in which the maximization of individual interests in the use of this faunistic resource resulted in its predatory use and exhaustion.

However, throughout the Amazon, riverine populations have (re)organized themselves to discipline the exploitation of wildlife, especially fish, in areas of collective use, since, although equally dependent on this natural resource, users have reached differentiated levels in the development of local management institutions. It is observed that, while some groups do not develop any form of collective resource management, others maintain formal agreements that include not only access rules, but also the prohibition of predatory capture techniques and explicit rules on the division of resource flow among authorized appropriators (MCGRATH et al., 1993; PINTO; PEREIRA, 2004; BERKES, 2009). The logic of collective action, demonstrated by Olson (1965), seems to subsidize, in part, these actions.

Several experiences have been developed by the Amazonian riverside populations, indicating the adoption of management systems in animal and vegetal extraction, and the management of these resources is guided by peculiar forms of social organization (CHAVES; LIRA, 2011). The participation of all users in the process of construction, implementation and monitoring of aquatic resource management strategies has been called co-management, community management or participatory management (FREITAS et al., 2009; BERKES, 2009).

In the 1960s and 1970s, riverine settlements with more than 13 houses began to be called communities, with the implementation of a formal political organization based on the Movimentos Eclesiais de Base – MEB (Basic Ecclesial Movements), which formed leaders and guided the riverine people on the responsibility of political decisions that affected their lives (LIMA; ALENCAR, 2006). Since 1980, this social reorganization has been consolidated and riverine communities in the lower Amazon begin to exert strong pressure to participate in decisions about the management of fishing resources (FREITAS et al., 2009). After the World Conference on the Environment in Rio de Janeiro in 1992, community participation ceases to be just a claim of riverside populations and becomes a model of sustainable development (ARAÚJO, 2012).

In addition to the community organization provided by the basic ecclesial communities, the Catholic Church had, since the Second Vatican Council (1962), established guidelines on respect for the "integrity of creation", which defends respect for animals and plants, and that the use of mineral, vegetable and animal resources could not be separated from respect for moral requirements, being destined for the common good in the present and future (Verses 2.415-2.418 of the Catechism of the Catholic Church 1999 - J. Paul II, 2006). Since that Council, the need to preserve the environment and natural resources has also been preached, and these ideals have been passed on to the riverside communities and expanded until reaching their peak with the publication of the encyclical *Laudato Si* in 2015, when it calls on everyone to defend our common home, nature (FRANCISCO, 2015).

In the 1990s, several initiatives of shared management of natural resources began to emerge in Brazil. It is during this period that IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) began training volunteer environmental agents (Figure 1), who would assist this agency in monitoring and controlling a lakes management program initially developed in Tefé, Amazonas (Community Lakes Management and Conservation Program) and in Santarém, Pará (Iara/IBAMA and Várzea/IPAM Project). The community lakes management system provided for preservation, maintenance or subsistence of lakes and commercial fishing, and was implemented in Tefé to resolve conflicts that occurred between communities and commercial fishermen, after a long process of organization and training of basic communities, with support from the Catholic Church in the late 1960s (BATISTA et al., 2004; FREITAS et al., 2009).

Figure 1 – Volunteer environmental agent performing nest transfer.

Parallel to the community organizing movement, changes have occurred in IBAMA's administrative structure, with the decentralization of decision making, linked to fishing, which delegates to regional management the competence to create local norms. Thus, the first ordinances of the state of Amazonas on community conservation of lakes were issued in 1995. In the state of Pará, unlike the state of Amazonas, fishing agreements have been regulated since 1999. In Amazonas, the logic of these initiatives was eminently preservationist, aimed at guaranteeing fishing resources for the subsistence of community members. In Pará, the agreements provided for maintaining stocks for commercial use (BATISTA et al., 2004).

Community fisheries agreements are participative forms of management of fishing resources and participatory planning or management that began to be discussed and encouraged by IBAMA in the 1990s in Tefé/state of Amazonas – AM (AQUINO, 2007; RASEIRA, 2007). The implementation of fishing agreements by riverine communities, with the objective of regulating fisheries and restricting catches, is one of the most interesting manifestations that have emerged from fishing conflicts in the floodplain lakes of the middle Amazon region and in Tefé (CERDEIRA; MELO, 1999). Between 1995 and 2005, through IBAMA ordinances and normative instructions, 34 fishing agreements were legalized in 20 municipalities of the region, with regulations created by the communities and users of fishing resources to organize and control fishing locally (BOCARDE; LIMA, 2008).

Community management as a conservation strategy in the Brazilian Amazon arose from an alliance of grassroots organizations (which aimed to protect their natural resources from invaders such as loggers, cattle breeders, and commercial fishermen), environmental agencies (interested in sharing decision-making and resource monitoring), and non-governmental organizations or environmental institutions, which considered traditional extractive systems as one of the foundations for conservation and development in the Amazon (MCGRATH et al., 2006).

Actions for the conservation and sustainable management of natural resources also require integrated initiatives through participatory monitoring and management, in which the information collected by resource users helps guide local decision-makers on conservation management (KENNET et al., 2015).

The idea of decentralization in the management of natural resources and the involvement of local populations have conquered space in the formulation of public policies and in the elaboration of regional development projects (OSTROM, 1990), escaping the classic options of privatization of resources or exclusive control by the State (OSTROM, 1990; IPEA, 2010). These changes have been taking place around the world and have a strong emphasis on communities and the local impacts of policies based on community management and co-management (FREITAS et al., 2009; BERKES, 2009).

In this period of change, in 1999, the Federal University of Amazonas was sought out by community members in the municipality of Terra Santa/state of Pará – PA (Figure 2), in the region of the middle Amazon River, who wanted to learn techniques to protect yellow-spotted river turtle (*Podocnemis unifilis*) nests and hatchlings and recover their natural stocks depleted by illegal capture (ANDRADE et al., 2001).

Figure 2 – Release of turtle hatchlings in Terra Santa/ state of Pará – PA.

In a partnership with IBAMA, they created a community turtle conservation project. The project was called *Pé-de-pincha*, because the footprints that the yellow-spotted river turtle (*Podocnemis unifilis)* leaves on the sand are similar to soda bottle-caps that the Amazonians call *pincha*. Thus, a program of extension and turtle community management was created, which would reach, in 16 years, 122 communities in 18 municipalities in the region. The areas of operation of this program are mostly outside of conservation units and, in general, their turtle populations are at very low levels. To recover these stocks, the community members translocate the nests to protected areas and then take care of the hatchlings for two months, until they are returned to nature. The work developed by the community members is voluntary (ANDRADE et al., 2001; 2004 and 2005; PINTO; PEREIRA, 2004; ANDRADE, 2008; 2012).

In the Extractive Reserve of the Middle Juruá River there is a community management system of 10 turtle nesting areas, with more than 30 years of protective work. Unlike the areas of the *Pé-de-pincha* program, these are areas still have large stocks of *Podocnemis expansa (*giant South American river turtle*)*, *P. unifilis* and *P. sextuberculata* (six-tubercled Amazon river turtle) (ANDRADE, 2008; FONSECA et al., 2011; ARAÚJO, 2012; AMAZONAS, 2014).

Other experiences of community conservation of turtles of the genus *Podocnemis* have been recorded in the following sites in the Brazilian Amazon: areas of the Mamirauá Sustainable Development Reserve on the Solimões River (PEZZUTI, 1997; FACHIN-TERÁN, 2000; OLIVEIRA, 2006); in the RDS of Uatumã, on the Uatumã River, and in the RDS of Uacari, in the middle Juruá River (FONSECA et al, 2011; AMAZONAS, 2014); in the Forest and Extractive Reserve Canutama (NUSEC, 2013), on the Purus River; on the Ituxi River, in Lábrea (ANDRADE et al., 2013); in the Extractive Reserve Jutaí, on the Jutaí River (ICMBIO, 2011); in the Piagaçu-Purus Sustainable Development Reserve (WALDEZ et al.., 2013), in Juruti, in the middle Amazon (IBAMA, 2012); in the Aritapera region, in the lower Amazon, in Santarém (MIORANDO et al., 2013); in Pracuúba and Afuá, (PORTAL et al., 2005); in the Guaporé River, among others.

In all other countries of the Amazon Basin and the Orinoco River community management of *P. expansa* and *P. unifilis* is also carried out – in Venezuela (HERNANDÉZ; SPIN, 2006; HERNANDÉZ et al., 2010); in Colombia (TCA, 1997; MARTINEZ; RODRIGUEZ, 1997), in Peru (SOINI, 1997; 1999) and in Ecuador (TOWSEND, 2008). Páez et al. (2015) report that in the 1980s, in response to the decline of the populations of podocnemidids, several conservation programs were created in the Amazon and Orinoco Basins (ten programs in Brazil, Bolivia, Colombia, Ecuador, and Venezuela), in which, among the most widely used conservation strategies, is the transfer of nests from threatened areas to sites protected by communities or environmental agencies.

The numbers of community conservation of turtles in the state of Amazonas – AM

Between 1974 and 2014, in Amazonas, 153,798 giant South American river turtle nests, 117,287 yellow-spotted river turtle, 53,1245 six-tubercled Amazon river turtle and 21,266 of red-headed Amazon river turtle *(P. erythrocephala),* which produced 14,522,286 hatchlings of *P. expansa*, 2,299,454 of *P. unifilis*, 5,161,016 of *P. sextuberculata* and 150,049 of *P. erythrocephala*, were officially protected by federal environmental agencies (Government: 11% of the areas), landowners/rubber tappers (beach guardians system, which occurred until 2004, accounted for 5% of the areas), environment municipal city halls/secretariats (3% of the areas), *Centro de Preservação e Pesquisa de Quelônios Aquáticos* – CPPQA (The Aquatic Chelonian Preservation and Research Center) of ELETRONORTE/ELETROBRAS (3%) and communities/community protection systems, which corresponds to 78% of the areas, since 1990 (ANDRADE, 2015).

The community protection system for turtles' breeding areas involves: the communities of each region in all phases, from perception to decision making; planning and organization of conservation activities; labor for monitoring the beach, recording production data (nests and hatchlings, Figure 3) and holding events/turtles release parties.

Figure 3 – Egg biometry performed in Canutama/state of Amazonas.

The resources for the execution of these activities are from the community itself and from partner institutions or entities that support the turtle conservation work. This system may have the involvement of federal environmental agencies (IBAMA, Chico Mendes Institute for Biodiversity Conservation - ICMBIO), state (CEUC) or municipal (municipal departments of environment), with the provision of logistical and material support, but the protection, monitoring and decision making are eminently community-based, since it is the participatory management of this resource (ANDRADE, 2015).

In the 1990's, there was an expansion of community protection systems, which, in addition to replacing the system of the owner or beach captain, made possible the exponential increase of areas for the protection of turtle (Figure 4). The increase in community production of giant South American river turtle (*P. expansa*) hatchlings in Amazonas between 1999 and 2014 was mainly due to the increase in the number of beaches protected through the *Pé-de-pinch* Project, which currently supports 93.9% of community protection of *P. expansa* hatchlings.

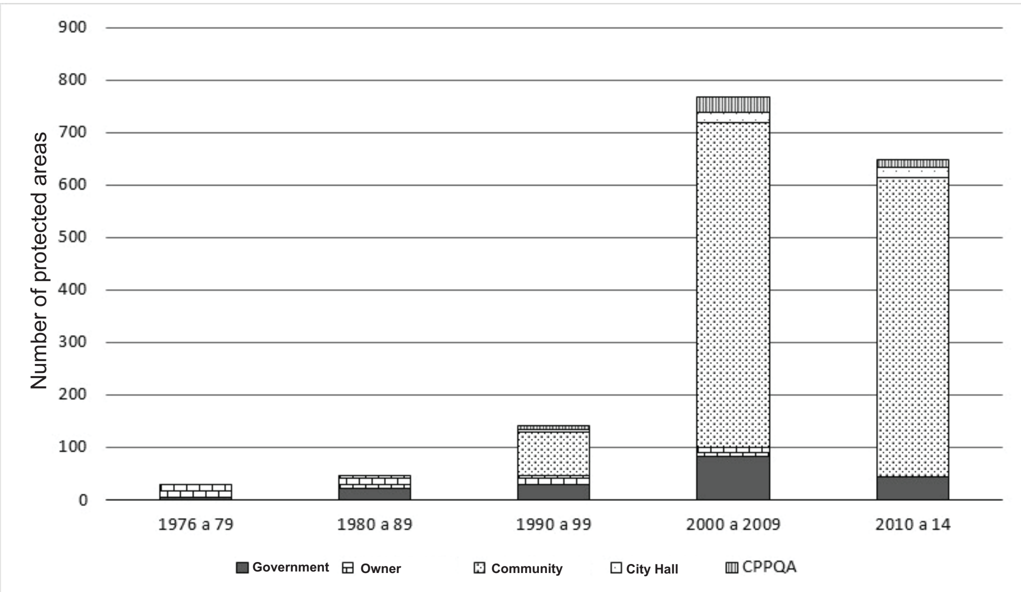

Figure 4 – Number of reproduction beaches served by different protection systems in the state of Amazonas between 1976 and 2014 (ANDRADE, 2015).

Although the turtle nesting area protected exclusively by the Federal Government correspond to only 11% of the areas, they accounted for the production of 10,263,208 *P. expansa* hatchlings, or 64.2% of the total produced. However, when analyzing the production of yellow-spotted river turtle hatchlings in the last 40 years in the state of Amazonas, it is possible to verify that the community conservation system is responsible for the protection of 1,421,749 hatchlings, or 60.7% of total production. The federal environmental agencies initially prioritized the protection of the most productive areas of giant South American river turtle, while the communities usually work in areas with smaller populations (as a result of intense human predation) or in environments where there is a higher occurrence of yellow-spotted river turtle, giving priority to this second species (ANDRADE, 2015). Figure 5 shows the participation of different protection systems in the conservation of yellow-spotted river turtle hatchlings in Amazonas between 1976 and 2014.

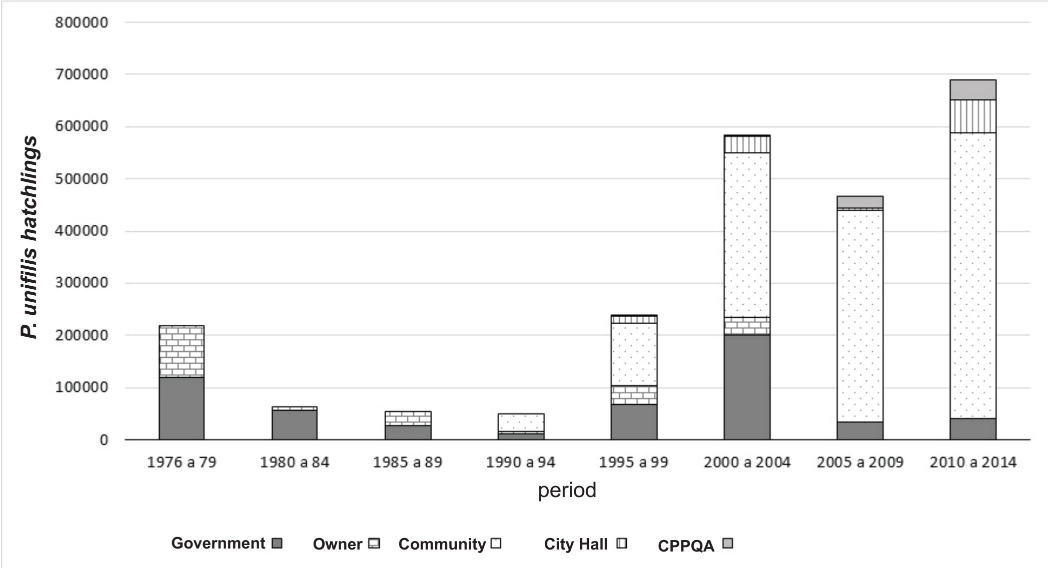

Figure 5 – Participation of different protection systems in the conservation of yellow-spotted river turtle (*Podocnemis unifilis*) hatchlings in the state of Amazonas between 1976 and 2014 (ANDRADE, 2015).

The increased participation of the community conservation system in the production of yellow-spotted river turtle hatchlings from 1999 was mainly due to the increase in the areas covered by the *Pé-de-pincha* project. Having the yellow-spotted river turtle as a flagship species, this project significantly expanded the number of protection areas in the Amazonas and western Pará. Initially, the project accounted for 15.9% of the community conservation of *P. unifilis*, but in 2014, it reached 96.2% of the community production of the hatchlings of this species.

For the smaller species of podocnemidids (*P. unifilis, P. sextuberculata* and *P. erythrocephala*), the community conservation system managed to cover more areas and produce more hatchlings for the restocking of the areas, while for the giant South American river turtle, the protection system, which involved only the government (federal environmental agencies), managed to protect more nests and hatchlings, in a few high-production nesting areas.

The overall analysis of the areas of turtle nesting, due to the protection system adopted, showed that in the 40 years analyzed 78.2% of the nesting sites were protected by the communities, clarifying that between 1976 and 1989, all the beaches were protected by the Government or by landowners/rubber tappers. Community turtle conservation began to gain strength between 1990 and 1999, when it protected 58.2% of the areas, increasing to 80.6% between 2000 and 2009, until it became the system responsible for protecting 88.1% of the turtle breeding areas in Amazonas.

This fact can be linked to several factors, such as the creation of IBAMA in 1989, when the Federal Government began the decentralization of fisheries management, involving states and communities, differently from what occurred in the extinct IBDF. These changes led to the publication of the ordinances for the creation of lakes under community management, in 1995, in the Solimões River/state of Amazonas – AM, and, in 1999, in fishing agreements, in the lower Amazon (BATISTA et al., 2004). Also, during this period (1990-1999), in order to comply with CONAMA Resolution Nº 3/1988, which created the Environmental Task Force, the first voluntary environmental agents were chosen and trained by local residents (AZEVEDO; APEL, 2004).

Community mobilization and organization to protect fishing resources in the Solimões/Amazonas floodplains ended up contributing to the emergence of community initiatives for the conservation of turtles, such as the *Pé-de-pincha* Project, in the middle Amazon (ANDRADE, 2008; 2012; ANDRADE et al., 2004), and community management areas in Santarém (MIORANDO et al., 2013). In the Juruá River, this community management originated with the organization of the rubber tappers' basic movements, after the death of Chico Mendes, when the extractive reserves and the National Center for Traditional Populations (CNPT) (MCGRATH et al., 2006) were created within the IBAMA's structure, which began to support community initiatives for the protection of the mid-Juruá River nesting areas in Amazonas, starting in 1994 (Figure 6).

Figure 6 – Release of hatchlings, by community members, in Carauari/state of Amazonas – AM.

This system of community protection of the turtle populations succeeded in expanding the turtle protection areas in Amazonas, which before was concentrated in the Purus, Juruá and Uatumã Rivers, to several river channels, protecting nests and hatchlings of *P. unifilis* (60.7%), *P. sextuberculata* (44%), *P. erythrocephala* (58.8%) and *P. expansa* (13.3%).

The *Pé-de-pincha* Project has worked with two systems for the protection of turtle nests and hatchlings: 1) In areas with large giant South American river Turtle populations (Juruá and Purus Rivers) the project assists environmental agencies in training/ logistical support for beach monitors and in recording the number of nests and hatchlings protected. These areas are mainly in the middle and low Juruá River (20) and in the middle Purus River (6); 2) In areas where populations have been drastically reduced and there is a great risk of predation of nests for human consumption. The nests are transferred to places protected by the communities (incubating areas). In these areas, the project is responsible not only for training and supporting the communities, but also for carrying out the protection actions and the equipment and resources made available for the work.

The traditional areas of operation of the *Pé-de-pincha* Project were, initially, in the physiographic zone of the middle Amazon and then in the Rivers Negro and Madeira, which corresponds to most of the project areas of operation (95 areas). Between 1999 and 2014, 57,855 nests of yellow-spotted river turtle, 1,003 of giant South American river turtle, 8,933 of six-tubercled Amazon river turtles and 15,267 of red-headed Amazon river turtle were transferred and protected. During the same period, 1,085,802 hatchlings from the transferred nests were released, 852,166 of which were yellow-spotted river turtle (78%), 92,410 of six-tubercled Amazon river turtle (9%), 52,752 of the giant South American river turtles (5%) and 88,474 of red-headed Amazon river turtle (8%). Figure 7 shows the evolution of the number of protected areas and hatchlings in the traditional areas of the *Pé-de-pincha* Project between 1999 and 2014 (ANDRADE, 2015).

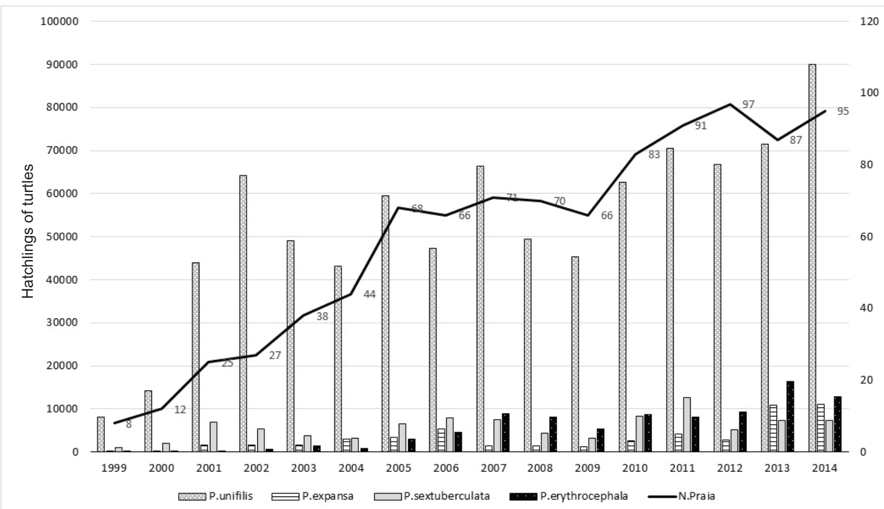

Figure 7 – Hatchlings of turtles (*P. unifilis, P. expansa, P. sextuberculata and P. erythrocephala*) protected in traditional management areas - *Pé-de-pincha* Project, 1999 and 2014 (ANDRADE, 2015).

The analysis of the increase in the production of turtle nests and hatchlings on beaches protected by the community system demonstrates that this form of participatory management and monitoring is not only productive but effective in increasing and protecting the turtle stocks in their regions, being an important component to help the government action for the administration and management of turtles in the Amazon.

The *Pé-de-pincha* Project reaches 122 communities in 18 municipalities of Amazonas (Nhamundá, Parintins, Barreirinha, Maués, Itacoatiara, Manaus, Novo Airão, Barcelos, Borba, Careiro, Tefé, Juruá, Carauari, Itamarati/Eirunepé, Canutama) and in west of the state of Pará (Terra Santa, Oriximiná and Juruti), in an area corresponding to 2.7% of the Amazon. In its 16 years of existence, it has trained 219 volunteer environmental agents and 148 environmental managers in turtle conservation and management techniques. It has sensitized, through lectures, more than 86,507 listeners, and trained 1,350 rural school teachers in environmental education. To encourage alternative income generation, courses in fish technology, chicken farming, medicinal plants, community gardens and community turtle farming were administered to 5,798 participants. The total number of people involved and mobilized was 28,379 and, indirectly, 314,845 people, constituting one of the largest volunteer programs in Brazil (ANDRADE, 2012; 2015).

Pinto and Pereira (2004) analyzed the effects of institutional incentives on communities participating in community turtle management through the *Pé-de-pincha* Project. Considering that individuals rationally choose their strategies for conservation and use of natural resources, according to the incentives offered, the authors analyzed three components of the system: the abundance of the managed resource (number of nests, eggs and females nesting), the economic alternatives of local users, and the search to reduce the number of appropriators of the resource by excluding external competitors.

The authors identified that in degraded areas, where there was a reduction in the turtle population, management was more efficient in communities with relative abundance of the resource; greater mobilization and social organization; more options for productive activity; greater purchasing power; greater consistency in collective agreements and effectiveness in controlling and monitoring the established rules. Thus, they showed that besides the ecological aspects of the managed fauna resource (abundance and density of *P. unifilis* nests and females), socioeconomic aspects of each community are directly related to the effective or non-success of conservation on a community basis.

Andrade et al. (2004) analyzed the effective costs for the production of 153,437 turtle hatchlings, through community management, between 1999 and 2002, in the middle Amazon, estimating an average value of R$ 1.74 or U$ 0.8/hatchling protected, and profitability of 120.1%, considering the estimated value of environmental services provided by the communities.

The *Pé-de-pincha* community turtle management program has its actions based on participatory methodologies and local actions. The project depends especially on the level of engagement and participation of local user groups, their organizational capacities and social capital. The project randomly encounters social groups with a considerable history of organization in the places where it operates, the result of educational and political actions of civil society organizations. With the transfer of scientific knowledge and management technologies, from the proposing agents to these local groups and betting on the longevity of the communities, it is believed that the *Pé-de-pincha* proposal finds a safe field for its perpetuation, after the direct actions and intervention of the proponents have ceased (PINTO; PEREIRA, 2004).

Studies promoted by *Pé-de-pincha* allow us to conclude that the economic sustainability of participatory management actions depends, mainly, on the investment made by the local user groups themselves, who sponsor the management actions. The communities that stood out the most in terms of the results obtained (monitored posture sites, transferred nests and released hatchlings) were exactly those with the highest organizational contribution rate. In addition, these communities are also the ones that have economic alternatives, less economic dependence and less exploitation of aquatic fauna resources, such as, for example, communities with agricultural production, cattle raising or rubber tappers.

Another example of a participatory turtle management program that has been in operation for a long time in Amazonas is the one created on the Uatumã River by the *Centro de Preservação e Pesquisas de Quelônios Aquáticos* – CPPQA (Center for the Preservation and Research of Aquatic Chelonians), at the HPP Balbina and Uatumã. Sustainable Development Reserve. The first turtle monitoring in the region began in 1986, by the Instituto Nacional de Pesquisas da Amaônia, upstream (Pitinga) and downstream (Uatumã and Abacate) of the dam, to assess the impacts of the construction of the hydroelectric plant on the reproduction of turtles. At that time, 370 turtles were registered near the dam, prevented from going upstream. For this reason, two artificial beaches were built for nesting (NASCIMENTO, 2006). In 1995, biologists José Pierre Armond and Roberto Myai, from ELETRONORTE's environmental projects, made a survey of areas with potential for natural turtle reproduction, to implement management measures based on the protection of nesting and hatching of the young (OLIVEIRA et al., 2011). From 1995, the monitoring expanded to the beaches downstream of the dam and began to involve the communities of Bela Vista/Complex of Calabar, Maracarana, Livramento, Manain, S. Benedito and Caioé Grande, totaling 49 protected areas. This community management was responsible for the protection of 6,764 turtle nests and the release of 118,671 hatchlings (50,706 of *P. expansa*; 63,918 of *P. unifilis*; 4,047 of *P. sextuberculata* and 1,349 of *P. erythrocephala*). The participation of communities and beach agents (environmental protection agents) in the Uatumã Turtle Project takes place in an organized way, with people interested in participating in the activities on a voluntary basis or not, and volunteers receive initial training that goes from the training of beach agents to the final phase of the project, which is the release of the hatchlings into nature.

The economic sustainability of the participatory management proposal depends on alternatives and economic opportunities available to users. With this in mind, the project has been developing demonstrative and educational actions to foster the diversification of farming activities in the localities involved (PINTO, 2002).

In socioecological terms, a fundamental argument by Pinto, (2002), is that management systems, in addition to being socially constructed, are also plural. However, it is possible to outline at least three foundations for what has been called decentralized management of natural resources, to make explicit a proposal that is distinct from the proposal of centralized management. In the first place, the theory of the Tragedy of the Commons is considered rejected or contested because it instills universality, truth and objectivity in a perspective that places itself above questioning, the superiority of private property and the incorrigible nature of (dis)incentives for collective action. The second component emphasizes social fluidity and indeterminism, which corresponds to questioning about balance, stability and orderly development, indicated by ecological succession and greater attention to instability, indeterminism and chaotic processes. Finally, it states that if multiple truths are important, then local perspectives and knowledge must be prioritized, as they maintain a political interface – local conflicts are sometimes the only means of resistance by which elites maintain control over sources of power (PINTO, 2002; PEREIRA; PINTO, 2011).

While seeking to understand which are the ecological and socio-economic factors that facilitate or hinder the spontaneous emergence of these local management institutions, in different localities, governments and other local public organizations have sought to implement actions to strengthen existing institutions and foster their emergence in areas where resource users are not sufficiently organized (MCGRATH et al., 1993; FANCHÍN-TERÁN, 2000).

Community management of natural resources is part of the recent public policies of co-management encouraged by federal environmental agencies (IBAMA and ICMBIO), through specific programs that have operated in the Amazon in the last 20 years, such as ProManejo, ProVárzea and the Program of Voluntary Environmental Agents, demonstrating the interest of the Federal Government in increasing the participation of Amazonian communities in the process of co-management of local resources (AZEVEDO; APEL, 2004; BATISTA et al., 2004; RUFINO, 2005; ANDRADE et al., 2013).

At the state level, the government of Amazonas, through the actions of the *Secretaria de Estado do Meio Ambiente e Desenvolvimento Sustentáve*l – SDS (State Secretariat of Environment and Sustainable Development), has invested heavily in recent years in the implementation of conservation units for direct use, with the participation of communities in the processes of implementing management plans. The *Pé-de-pincha* Project has been working with the *Centro Estadual de Unidades de Conservação* – CEUC/SDS (State Center of Conservation Units) team in training and capacity building of beach agents in middle Juruá River, as well as monitoring the turtle populations in the area (AMAZONAS, 2014).

As of December 8, 2011, the Federal Government transferred to the states the responsibility for managing wild fauna in captivity, through Article 8º of Complementary Law Nº 140, and by its item XVII should, in a supplementary manner to federal environmental agencies, encourage activities that conserve these species of wild fauna *in situ*, reinforcing the importance, for the state of Amazonas, of monitoring community activities of fauna conservation.

The SDS also created a Turtle Working Group (SDS Ordinance Nº 128, of August 5, 2011), whose goal was to formulate guidelines for the conservation of turtles throughout the state of Amazonas, which includes defining priority areas for protection and monitoring, as well as encouraging participatory systems of community management, with support for qualification programs for technicians and community members, including voluntary environmental agents (AMAZONAS, 2014). As a result of this WG, in 2017, the Amazonas State Council for the Environment (CEMAAN) published two resolutions (CEMAAN Nº 25 and Nº 26/2017), recognizing the main areas for the conservation of turtles in Amazonas and the efforts of the communities that protect them, and regulating the community breeding of turtles.

Cantarelli et al. (2014) recognized that initiatives involving local communities and institutions in Amazonas have resulted in an increase protection of the nesting habitat of podocnemidids.

Changes in community perceptions regarding turtles

The level of the relationship between the Amazonian riverside dwellers and the turtles seems to be directly linked to the importance that each species occupies as a possible source of food or income. The greater the use and consumption of a certain species of turtles, the greater the degree of knowledge about biological and ecological characteristics of this species (ANDRADE, 2015).

The community management of turtles represents a model of co-management that emerged from the relationships established between the Amazonian man and this important fauna resource over hundreds of years. In the search for the capture of giant South American river turtle, yellow-spotted river turtle and six-tubercled Amazon river turtle as a basic source of protein food in the floodplains and *igapós*[17], the indigenous people, and then the riverside dwellers, learned, through empirical observation, knowledge such as: identifying different species; knowing the places where they live; what they eat, where and when they lay their eggs; which are the best capture equipment; and which are the best techniques to protect their nesting environments, nests and hatchlings (ANDRADE, 2015).

In areas with large giant South American river turtle nesting areas (nesting beaches with many turtles), the communities organize themselves, watch and monitor the nests until the emergence of the hatchlings, with the purpose of preventing this resource from being plundered by invaders. In these places, the view of the turtle resource remains as a possible source of wealth, of income generation. Faced with the enormous work and effort they do to protect the nesting areas and the great pressure exerted by turtle traffickers (psychological and financial, such as attempts to buy animals and even death threats), these communities question when it will be possible to economically exploit this resource again and what kind of compensation they can have for the important environmental service they perform.

In areas that have been depredated, where turtles and their nests have been predatorily captured, up to almost the level of local extinction, the reason why some communities protect the last nests and specimens of turtles is another. The communities organize themselves to try to recover the populations of the animals that they have often helped to destroy. It is not just a matter of fighting the invader who comes from outside to take the turtle, but of making a personal and collective effort to conserve what little they have left, with the hope of ensuring that future generations (children and grandchildren) can see these animals.

17 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

Faced with the scarcity of nests and hatchlings, the attention becomes much more focused on the importance of each nest and each animal. The difference in the level of awareness between the two realities (abundance and scarcity) is quite large, because when there are few animals, the feeling of responsibility and belonging over each hatchling is amplified. Following the hatching of eggs and seeing the hatchlings seems to play an important role in raising awareness in the community, because many adults and children in the communities had never seen the emergence of hatchlings and therefore could not make the association between the eggs or animals they ate with the small and fragile hatchling. The level of empathy is undoubtedly much higher with the hatchlings than with adults or their eggs, by developing in humans/mammals a sense of responsibility, a kind of "parental" care over the hatchling (WALL, 2010; ALCOCK, 2011)

Performing turtle hatchlings release events has become the major tool for awareness and dissemination of the conservation and management work carried out by the communities (Figure 8). Making it possible for people from other communities or municipalities to see the care and release of thousands of turtles became an important environmental education tool, which ended up motivating other communities and municipalities to organize themselves to protect nests, adults and hatchlings. In addition to the *Pé-de-pincha* Project, other turtle community conservation projects hold the hatchling release parties (TCA, 1997; MARTINEZ; RODRIGUES, 1997; SOINI, 1999; PORTAL et al., 2005; OLIVEIRA, 2006; SPIN, 2006; TOWSEND, 2008; FONSECA et al., 2011; ICMBIO, 2011; PORTAL; BEZERRA, 2013; AMAZONAS, 2014; ANDRADE, 2015).

Figure 8 – Turtle hatchling release event held in Acapuzinho/ state of Amazonas – AM.

In schools where students participated in the nest protection stages, they accompanied the emergence of hatchlings, took care of them in nurseries and finally measured, weighed and marked the hatchlings for release, students were able to make the association with practical activities developed by teachers, there were significant improvements in the learning process and school performance (ANDRADE, 2012; SILVA; FACHIN-TERÁN, 2015).

In all areas of participatory turtle management in the Amazon, community members have complained about the lack of inspection and control by environmental agencies. The division of IBAMA in 2007 and, later, the dismantling of its physical structure by closing its offices in the interior from 2011, created a vacuum in the defense of natural resources that, until now, has not been efficiently occupied by the state environmental agencies of inspection and control or by the municipal environmental secretariats. This lack of institutional support, in the face of complaints about illegal capture of turtles made daily by environmental agents to environmental authorities, has been one of the main causes of discouragement for the work of community protection of yellow-spotted river turtle and giant South American river turtle.

Conclusion

The riverside communities of the Amazon see in the turtle an important food resource that has been managed and conserved by them, with participation in different systems of use and protection throughout history. This perception of turtles as food resources within the complex agro-extractivist systems of the floodplain and *igapós*[18] communities seems to be the initial propulsion mechanism of these community task

18 Translator's note: blackwater-flooded forests in the Amazon biome. These forests and similar swamp forests are seasonally inundated with freshwater. They typically occur along the lower reaches of rivers and around freshwater lakes.

forces for the turtle conservation. That is, by mobilizing its members, the community chooses to direct an annual productive effort to recover local stocks of yellow-spotted river turtle and giant South American river turtle for current and future generations.

The community system for the protection of turtles is responsible for the majority of the giant South American river turtle, yellow-spotted river turtles and six-tubercled Amazon river turtles conservation areas (88%), ensuring that a greater diversity of nesting environments are conserved in several rivers, protecting mainly nests and hatchlings of *P. unifilis* (60.7%), *P. sextuberculata* (44%) and *P. erythrocephala* (58.8%).

The community system of turtle conservation, based on voluntary work and the elaboration and execution of community agreements as a tool for participatory management of natural resources, is extremely important as a conservation strategy, and is complementary to the protection system made by the Government, which is also based on the creation of reserves, instruments/ordinances for restricting areas/ use and mechanisms for monitoring and control.

Furthermore, the community management of turtles demonstrates that, as a form of participatory management and monitoring, it is not only productive, but effective in increasing and protecting the stocks of turtles in their regions, and efficient in protecting the species at a lower operational cost, being an important component, which should be incorporated by the Government for the administration and management of turtles in the Amazon.

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Chapter 8

Threats to Amazon freshwater turtles

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Introduction

Anthropic disturbances have altered landscapes on a large scale, causing the loss of environments and consequently leading species to extinction (PRIMACK; RODRIGUES, 2001). Although direct human exploitation is the preponderant factor for the reduction of natural populations of turtles (THORBJARNARSON et al., 2000; MOLL; MOLL, 2004), the loss, degradation and modification of natural environments contribute to increase the vulnerability of these organisms in nature (FELIX-SILVA, 2009). The current model of economic development to which the Amazonian ecosystem is subjected has contributed not only to the destruction of environments, but also to the loss of Amazonian socio-biodiversity (FELIX-SILVA, 2009). Thus, the vulnerability of Amazon freshwater turtles increases with the damming of rivers for the construction of hydroelectric plants, the channeling of rivers, the establishment of waterways, mining, the expansion of the agricultural frontier, disorderly tourism, by-catches, the opening and paving of highways, the introduction of exotic species and pollution (MOLL, 1997; BURKE et al., 2000; MOLL; MOLL, 2004; FELIX-SILVA, 2009).

In the Amazon, the aquatic fauna of turtles is rich and varied, the podocnemididae family being the most widely distributed throughout the basin. Its main representatives are the giant South American river turtle (*Podocnemis expansa*), the yellow-spotted river turtle (*P. unifilis*), the six-tubercled Amazon river turtle (*P. sextuberculata*), the red-headed Amazon river turtle, (*P. erythrocephala*) and the big-headed sideneck turtle (*Peltocephalus dumerilianus*). Besides these, other families with not so wide distribution also play an important role in the Amazon ecosystem, such as Chelideos (*Chelus fimbriatus*; *Mesoclemmys raniceps*; *Platemys platycephala*; *Rhinemys rufipes*; *Phrynops geoffroanus*; *Mesoclemmys gibba*; *Mesoclemmys nasuta*), the kinosternidae (*Kinosternon scorpioides*) and the geoemididae (*Rhinoclemmys punctularia*). The podocnemidids, as well as other representatives of aquatic fauna, have their densities and abundances influenced by the annual variation of the hydrologic cycle in the various river systems where they occur. These cycles obey a natural regime of flooding and ebbing that alters the availability of environments used for feeding and reproduction (BURY, 1979; JUNK et al., 1989; JUNK; MELO, 1990).

Flood and ebb regimes may be altered due to environmental modifications, resulting from the establishment of development projects. In addition to this impact, changes can also occur in vegetation cover, water quality, sound disturbance levels, intensity of direct exploration, availability of environments used by organisms, among others. Thus, organisms that are closely related to aquatic environments and their flood pulse, such as aquatic turtles, will have not only their population dynamics modified, but also their nutritional status, access to partners and reproductive areas and, consequently, reproductive success or not.

The main threats to Amazon freshwater turtle populations are presented below, considering, above all, the most abundant species.

Direct exploitation: hunting/fishing pressure on populations of Amazon freshwater turtle

One of the main threats to turtles is direct exploitation. According to Klemens and Thorbjarnarson (1995), the use of turtles (adults and eggs) as a source of food for humans is the main factor for the population decline in 46% of taxa of these animals. The capture of turtles and their eggs occurs in several areas of the Brazilian Amazon, mainly during the low-water season, when the beaches used for nesting emerge on the banks of white, black or clear water rivers. It is a very old practice in the Amazon Region, occurring for thousands of years in subsistence livelihood and by indigenous populations (CARVAJAL, 1955) and later, as a commercial product exploited on a large scale (BATES, 1892; GOELDI, 1906; COINTE, 1922; PEREIRA, 1954; MITTERMEIER, 1975; SMITH, 1979; GILMORE, 1986; JOHNS, 1987; VERÍSSIMO, 1970; WALLACE, 1979; REBÊLO; LUGLI, 1996; MOLL;MOLL, 2004). Historically, these animals represent a significant food and economic resource for the riverside and indigenous populations of the region (REBÉLO; LUGLI 1996; REBÉLO; PEZZUTI, 2000; CONWAY, 2004; PEZZUTI et al., 2004; CAPUTO et al., 2005; REBÊLO et al., 2005; PEZZUTI et al., 2010a). The historical importance of these animals can be found in the literature contained in the chronicles of naturalist travelers and diaries of Jesuit priests on their trips to South America. These are reports that illustrate in detail the use and abundance of turtles in the 18th and 19th centuries.

The giant South American river turtle, for example, was known as "boi do rio" (river ox) (MOLL; MOLL, 2004) or "boi do Amazonas" (ox of the Amazonas) (VERÍSSIMO, 1970; GILMORE, 1986), due to its great local importance. This species is frequently cited as a source of animal protein in the diets of the riverside population (COINTE, 1922; DANIEL, 1976; WALLACE, 1979; DANTAS, 1987; HERNDON; GIBBON, 1991).

At that time, local communities stored turtles in corrals (GOELDI, 1906; VERÍSSIMO, 1970; MITTERMIER, 1975), to be consumed during the flood season, when aquatic animals are dispersed in the environment (SIOLI, 1991; Figure 1).

Figure 1 – Corral for clandestine storage of aquatic turtles. Abufari Biological Reserve/state of Amazonas – AM (Photo: Juarez Pezzuti)

In addition to the rich nutritional source, turtle eggs were for several years the main raw material used in the public lighting of the cities and in the cooking of food (WALLACE, 1979). Mixed with tar, or pitch, they were also used in the sealing of boats (COINTE, 1922; GILMORE, 1997). The eggs were collected on the beaches in amazing quantities, shipped in canoes, where they were broken and kneaded by foot, mixed with water, put to dry in the sun and then the oil (butter) was extracted (BATES, 1892; DANIEL, 1976; HERNDON; GIBBON, 1991). The reduction in turtle populations in the state of Amazonas has been attributed to the use of this butter, an intensely exploited product.

As time went by, the oil from the eggs of the giant South American river turtle was no longer exploited and a change in patterns occurred: eggs and meat of this species began to be considered delicacies, among the classes with greater purchasing power, and a source of income for the classes with low purchasing power (ALHO, 1985; REBÊLO, 1985; JOHNS, 1987). In general, the consumption of turtles still is a tradition in the Amazon (REBÊLO;

LUGLI, 1996; REBÊLO; PEZZUTI, 2000; CONWAY, 2004; FACHÍN-TERÁN et al., 2004; CAPUTO et al., 2005; Figure 2), being commonly sold in the region (REBÊLO; LUGLI, 1996; REBÊLO; PEZZUTI, 2000; CONWAY, 2004; FACHÍN-TERÁN et al., 2004; CAPUTO et al., 2005; Figure 2), representing a direct threat to turtle populations. The giant South American river turtle, specifically, continue to be one of the main sources of protein for Amazonian indigenous and riverine populations (KLEMENS; THORBJARNARSON, 1995; PEZZUTI, 2003; FACHÍN-TERÁN; VOGT, 2004), however there is a tendency to exploit smaller species of turtles such as yellow-spotted river turtle, six-tubercled Amazon river turtle (MITTERMEIER, 1975; SMITH, 1979; VOGT, 2004) and scorpion mud turtle (ALHO, 1985; PEZZUTI, 2003). The latter is quite appreciated in Belém (SILVA COUTINHO, 1868; JOHNS, 1987).

Figure 2 – Red-headed Amazon river turtle (*Podocnemis erythrocephala*) captured and being baked for human consumption in Jaú National Park /state of Amazonas (Photo: Juarez Pezzuti).

The rates of consumption of turtles in the Amazon vary according to location, and the number of studies that record this information is low (Table 1). Cultural changes, the abundance and availability of the resource in localities reflect the variations observed in the use (BARBOZA, 2012). In Bolivia, Conway (2004) relates the use of *Podocnemis* turtles to both cultural and historical preferences and the economic scarcity of riverine peoples. In the Brazilian Amazon, the use of turtles is configured by food restrictions and taboos[19], with applications in popular medicine (ALVES; SANTANA, 2008; PEZZUTI et al., 2010b), highlighting the giant South American river turtle, whose fat is widely sold in local markets and fairs (FIGUEIREDO, 1994; ALVES; SANTANA, 2008). Table 2 shows studies on the therapeutic use of turtles in the Amazon. Alves and Alves (2011) point out that, although the demand for these products is unknown, they may constitute an important issue for the conservation and management of turtles, and their inclusion in the debates on herpetofauna conservation and public health is important (ALVES; SANTANA, 2008).

The capture of turtles in the Amazon is permeated by a great diversity of techniques based on a set of local knowledge, whose selection occurs due to the seasonality of the environment, which determines temporal and spatial patterns of displacement of animals, especially in the reproductive period (Figures 3 and 4). Among the techniques employed we have: Beacon, camurim[20], reed fishing, cev[21], espinhel, itapuá or tapauá (harpoon), jaticá[22], lamparina, lance, lantern, long line[23], hand, diving, rapazinho[24], gill nets, bubuinha net[25], rifle, saca-de-malha[26], pitiú, sararaca (arrow), tarrafa[27], among others ((BATES, 1892); GOELDI, 1906; PEREIRA, 1954; VERÍSSIMO, 1970;

19 Some species are avoided because they are considered harmful. The term "reimoso" (harmful) is used locally for animals subject to food taboos, when they are avoided under certain circumstances, such as illness, menstruation, pregnancy, and postpartum.
20 TN Small cork buoy with lines and hook, for fishing turtles
21 TN "make the ceva", in hunter jargon - to attract the animals. They then set up nets or elevated structures to wait for the animals to arrive and shoot them from above. The animal is lured to a specific point by means of cevas (food in the traps).
22 Long-stemmed harpoon, used in turtle fishing.
23 A fishing instrument consisting of a line and a hook on one end.
24 A fishing gear consisting of a long line and hook attached to one end, while the other end is tied to trees or pieces of wood attached to the lakeshore.
25 A fishing net that drifts in the river, floating, with one end tied to objects (plastic containers) and the other end guided by the fisherman.
26 The mesh bag is a type of trap that is positioned in the water so that it floats and is attached by means of ropes to the trunks where the turtles usually show thermoregulation behavior. The fisherman initially sets up the mesh bag near the places frequented by the animals and, during the period of greater solar intensity, stays hidden and waits for the animal. When the animal climbs the trunk, it usually remains at rest, thermoregulating, at which time the fisherman appears, scaring it, making it fall into the water where the trap is set.
27 A fishing net composed of small lead balls at the tip that allow the weight of the net to increase, so that it can sink in the water when thrown over the animal.

Figure 3 – Artisanal fishing for the capture of big-headed sideneck turtle (*Peltocephalus dumerilianus*) in the Jaú National Park/state of Amazonas (Photo: Juarez Pezzuti).

Figure 4 – Artisanal fishing for the capture of giant South American river turtle (*Podocnemis expansa*) in the floodplain area of Santarém/state of Pará (Photo: Project PPG7 II/CNPQ).

OJASTI, 1971; ALHO et al. , 1979; SMITH, 1979; PRITCHARD; TREBBAU, 1984; FACHÍN-TERÁN, 1992; PEZZUTI, 2003; FACHÍN-TERÁN et al., 2003; 2004; REBÊLO et al., 2005; PEZZUTI et al., 2008a; 2008b; FÉLIX-SILVA, 2009; BARBOZA et al., 2013). Pezzuti et al. (2004) elucidate the importance of investigating native fishing strategies as a tool to better understand the ecology of turtles, as well as to support future research and implementation of management programs (Figure 5).

The uncontrolled exploitation of turtles may affect the observed abundance, population size structure, male and female proportions, spatial distribution and, consequently, change in the use of environments and recruitment of individuals. Studies of the population structure of podocnemidids (PEZZUTI; VOGT, 1999; FACHÍN-TERÁN; VOGT, 2004; FÉLIX-SILVA, 2009; MIORANDO et al, 2013; 2015), the most important gender in terms of use by human populations in the Amazon, shows deviations

Figure 5 – Extraction of aquatic turtle in the floodplain of Santarém/state of Pará (Photo: Project PPG7 II/CNPQ).

in sex ratio for males and often these authors point to differential capture as the cause of this deviation, since females are larger and therefore have more yield potential, and are more easily captured during the nesting period (REBÉLO; LUGLI, 1996; PEZZUTI; VOGT, 1999; FACHÍN-TERÁN et al, 2004; PEZZUTI et al., 2004; REBÊLO et al., 2006; FÉLIX-SILVA, 2009). These results are worrisome, since there is no knowledge of the reflection of this deviation in sex ratio, in the medium and long terms, for the recruitment of individuals in the population, for example.

Although turtles are common and widely distributed in the Amazon Region, their exploitation is illegal in Brazil, according to Law Nº 5,197 of January 3, 1967 (BRAZIL, 1967). Consent to exploitation is only permitted when the situation involves human populations "in a state of need, to satisfy the hunger of the agent or his family," as established by Law Nº 9605 of February 12, 1998 (BRAZIL, 1998). The right of these populations to natural resources and to exercise millennial practices, such as hunting and fishing, is also recognized by Convention Nº 169, of 1989, on Indigenous and Tribal Peoples in Independent Countries, of the International Labor Organization, of which Brazil has been a signatory since 2004 (BRAZIL, 2004), and by Decree Nº 6.040, of February 7, 2007, which institutes the National Policy for the Sustainable Development of Traditional Peoples and Communities (BRAZIL, 2007). However, this right is often not guaranteed to the inhabitants of the Amazon, which generates a situation of fear and distrust.

In this scenario of retaliation suffered historically, the riverside populations carry out consumption and trade in a clandestine manner (Figures 6, 7, 8, 9) and, many times, they are afraid to talk to researchers, avoiding revealing information about the use of these animals, which results in difficulty and complexity in data collection. Researchers are unaware of the real impact of the direct use of turtles on their natural populations (PANTOJA et al., 2014). Under this perspective, recognizing that, in fact, the consumption of turtles is a traditional and common activity in the Amazon, it is necessary to highlight the caveat of Conway-Gomes (2008) about the relevance in understanding the attitudes and cultural practices related to the use of turtles in the planning of its management.

Figure 6 – Turtles illegally captured in the Jaú National Park /state of Amazonas (Photo: Juarez Pezzuti).

Figure 7 – Seizure of aquatic turtles in the Abufari Biological Reserve/state of Amazonas (Photo: Juarez Pezzuti).

Figure 8 – Big-headed sideneck turtle (*Peltocephalus dumerilianus*) illegally captured in Carabinani River/state of Amazonas (Photo: Juarez Pezzuti).

Figure 9 – Big-headed sideneck turtle (*Peltocephalus dumerilianus*) illegally captured on the Negro River /state of Amazonas (Photo: Juarez Pezzuti).

Given the current scenario in which prohibition does not prevent clandestinity in the use of these resources, it is pertinent to discuss the community turtle management in the Amazon, guaranteeing their availability as a source of animal protein for Amazonian populations, ensuring sovereignty and food security. There are experiences of community management in the region, such as in the floodplain of Santarém/state of Pará, where Barboza (2012) analyzed the use, practices and knowledge involved in community management activities of aquatic turtles. In the above-mentioned study, it was verified that the fishermen present refined knowledge about the ecology of turtles, to the point of recognizing variations in their behavior, being this ecological knowledge associated with the characteristics of local management, the history of animal use, preferences, aversions, food taboos and availability of the resource, in determining the species used.

Miorando (2013) studied the effects of fisheries agreements on the relative abundance of *Podocnemis* turtles in the same area, noting that the lakes of communities that made fisheries agreements had a higher occurrence of turtles as opposed to lakes that did not. In a recent case study on the experience of community management of yellow-spotted river turtle in the Pacaya Samiria National Reserve, Peruvian Amazonia, Harju et al. (2018) elucidate that after the implementation of the management program, community members saw an increase in the yellow-spotted river turtle population and economic benefits. The program transformed illegal extractors into legalized yellow-spotted river turtle managers, through training in egg relocation and incubation on artificial beaches, as well as allowing for the consumption of eggs and the commercialization of eggs and hatchlings. In the face of all the discussion exposed, the great challenge today is the management of turtles in the Amazon and the legal recognition of their use.

Table 1 – Consumption and commercialization of turtles in the Amazon.

Locality	Species	Information about human consumption	Information about commercialization	Reference
Middle and lower Jaú River, Novo Airão and Manaus/state of Amazonas, Brazil	Turtles in general	Widespread taste for meat and eggs of turtles, with sporadic consumption		Rebêlo and Pezzuti (2000)
In the region near the cities of Novo Airão and Barcelos, on the Negro River/state of Amazonas, Brazil.	*Podocnemis. unifilis; P. erythrocephala* and *Peltocephala. dumerilianus*	They constitute the most abundant and consumed species		Rebêlo and Pezzuti (2000)
Jaú National Park/state of Amazonas, Brazil.	Turtles in general	Consumption of turtle eggs in 3.1% of the total recorded meals of riverside dwellers.	Turtles are sold per unit and one female of yellow-spotted river turtle (*Podocnemis unifilis)* is sold for R$20.00, or a little less than R$3.00 per kilo.	Pezzuti et al. (2004)
Barcelos/state of Amazonas, Brazil.	*P. expansa and P. unifilis;*		A large adult *P. expansa* female, weighing about 50 kg, sold by fishermen to recreational owners for R$40.00, and can be resold for more than R$200.00 in Manaus.	Pezzuti et al. (2004; 2010)
Abaetetuba/state of Pará, Brazil	*P. expansa; P. unifilis; P. dumerilianus* and *Kinosternon scorpioides*		There is a trade of turtles in free markets.	Sampaio (2003)
Purus River/state of Amazonas, Brazil	Turtles in general		IBAMA seized 3,978 turtles in regional vessels.	Kemenes and Pezzuti, (2007)
Floodplain in eastern Bolivia	Turtles in general	Present in 1 to 1.25 meal/weekly		Conway-Gomez (2008)
Xingu/state of Pará, Brazil	*P. expansa*	A total of 243 animals were captured by the riverine population during the monitoring carried out in this study. Of these, 26 turtles (10.7% of the animals caught) were marketed, the rest of which were consumed by the fishermen families		Pezzuti et al. (2008)
Floodplain of Santarém/state of Pará, Brazil	*P. expansa* and *P. unifilis* *P. sextuberculata*		In 2009, the community seized 1,000 meters of turtle gill nets (a specific net for the capture of six-tubercled Amazon river turtles from a group of fishermen from the community itself.	Miorando (2013)

Locality	Species	Information about human consumption	Information about commercialization	Reference
Floodplain of Santarém/ state of Pará, Brazil	*P. expansa; P. unifilis*	The estimated consumption of yellow-spotted river turtles (*Podocnemis unifilis)* per capita ranged from 1.23 to 1.64 individuals and 34.57 to 87.33 eggs per year; the consumption of` six-tubercled Amazon river turtle *(P. sextuberculata)* per capita/year ranged from 0.11 to 0.88 individuals and 0.21 to 16.98 eggs, while the estimated consumption for giant South American river turtle (*P. expansa)* ranged from 0.02 to 0.16 individual per person/year, with no record of egg consumption of this species.	The average price of a *P. unifilis or P. sextuberculata* in the studied communities is about R$ 5, while the market price at Santarem headquarters is R$ 25 for a *P. unifilis or* R$ 30.00 for a *P. sextuberculata* and R$ 100.00 for a *P. expansa* .	Barboza (2012)
Urban area of the Abufari Biological Reserve, municipality of Tapauá/state of Amazonas, Brazil	*P. expansa; P. unifilis* and *P. sextuberculata*	Consumption exceeds 20,000 turtles, representing about R$ 400,000.00.	In the dry season in Tapauá, there are between 45 and 100 fishermen who survive only from the capture and marketing of turtles.	Pantoja-Lima (2012)
Tapauá/state of Amazonas, Brazil	*P. expans; P. unifilis* and *P. sextuberculata*	The consumption of turtles occurred in 100% of the interviewed families (101), corresponding to a per capita consumption of 15.9 g/person/day.		Pantoja-Lima et al. (2014)
Caxiuanã/state of Pará, Brazil	*Chelonoidis. carbonarius; C. denticulatus; Platemys. platycephala; Peltocephalus. dumerilianus; Podocnemis. Unifilis* and *P. sextuberculata*	Tortoises are the most consumed throughout the year, with predominance in the summer.	Tortoises, the big-headed sideneck turtle (*Peltocephalus dumerilianus*) and the yellow--spotted river turtle (*Podocnemis unifilis)* are commercialized with greater frequency. The values vary from R$ 1,00 for the smaller species, with low weight and easy to obtain, such as tortoise and spot-legged turtle, to R$ 15,00 for the larger species, such as the big-headed sideneck turtle. The turtle is rarely captured and, in the same way, sold.	Félix-Silva et al. (2013)

Table 2 – Medicinal use of turtles in the Amazon

Species	Local	Information about medical use	Reference
Podocnemis expansa	Belém and Soure/state of Pará, Brazil; Negro River/state of Amazonas, Brazil; Xingu/state of Pará, Brazil; Floodplain of Santarém/ state of Pará, Brazil;	Treatment of various diseases (acnes, dislocation, bleeding, scarring, inflammations, pterygium, tumors, rheumatism, skin spots, earache, arthrosis, arthritis, swelling, wounds, paralysis and muscle aches).	Alves and Rosa (2007a; 2007b), Alves and Santana (2008), Barboza, (2012), Pezzuti et al. (2008a; 2010b)
	Negro River/state of Amazonas, Brazil	Applied as moisturizing cosmetic and sunscreen.	Silva (2008)
	Floodplain of Santarém/ state of Pará, Brazil	Fat is used in swellings in the body and cleansing of the skin, in addition to other applications (pimples on the face, hernia, black cloth, varicose veins, earache, toothache, stroke, boil).	Barboza (2012)
P. sextuberculata	Floodplain of Santarém/ state of Pará, Brazil	Fat used in swellings	Barboza (2012)
P. unifilis	Alter do Chão/state of Pará, Brazil	Fat is used in the treatment of rheumatism.	Branch and Silva (1983)
	Soure/state of Pará, Brazil	Used for curing tumors, erysipelas and rheumatism.	Alves and Rosa (2007a)
	Xingu/state of Pará, Brazil	Treatment of earache, spots and pink eye.	Pezzuti et al. (2008a)
	Barcelos/state of Amazonas,, Brazil	Dermatological diseases such as scabies, itching, versicolor pityriasis, dermatophytosis and skin lesions.	Lima-Santos et al. (2012).
	Floodplain of Santarém/ state of Pará, Brazil	Bone, penis, tail and fat are used in the preparation of teas, unguent and ointments in the treatment of muscle pain, urinary infection, swelling, stomach pain and babies with cramps.	Barboza (2012)
Chelonoidis carbonrius; C. denticulatus	Belém/state of Pará, Brazil.	Used in cases of thrombosis, pityriasis, epilepsy, 'liver diseases' (authors' quotation marks), rheumatism, asthma, arthrosis, arthritis, osteoporosis.	Alves and Rosa (2007b)
	Middle Negro River/state of Amazonas, Brazil.	Used to cure people bitten or stung by venomous snakes.	Silva (2008)
	Xingu/state of Pará, Brazil	Healing, stroke, digestion, toothache, wound, stingray sting, swelling, leishmaniosis, mumps, pneumonia, rheumatism.	Pezzuti et al. (2008a)
	Many places in Brazil.	Use in the treatment of phlegm, erysipelas, bronchitis, asthma, inflamed throat, hernia, worms, leishmaniosis and chickenpox.	Alves et al. (2009)
	Jaú River/state of Amazonas, Brazil.	Asthma treatment, healing of newborn navel, swelling, sore throat, leishmaniosis, hemorrhage, torsion, wounds, menstrual colic, intestinal colic, hernia, snake bite, diarrhea, paralysis, inflammation, and hemorrhoids.	Pezzuti et al. (2010b).
	Floodplain of Santarém/ state of Pará, Brazil	The carapace is crushed into a fine powder and used in the form of tea in cases of hemorrhage.	Barboza (2012)
Platemys platycephala	Soure/state of Pará, Brazil.	Application of fat in wounds, tumors, erysipelas and rheumatism.	Alves and Rosa (2007a)
Mesoclemmys nasuta	Jaú River/state of Amazonas, Brazil.	Interviewees were unable to prescribe the methods of use.	Pezzuti et al. (2010b)
Peltocephalus dumerilianus	Jaú River/state of Amazonas, Brazil.	Use of epidermal shields in cases of hemorrhage, hemorrhoid and asthma	
Chelus fimbriata	Middle Negro River/state of Amazonas, Brazil.	The carapace is crushed into a fine powder and used in the form of tea to cure respiratory problems and hemorrhage.	Silva (2008)
	Jaú River/state of Amazonas, Brazil.	Menstrual pains, poor digestion, hemorrhage, diarrhea and hemorrhoid.	Pezzuti et al. (2010b)
	Marajó Island state of Pará, Brazil.	It is recommended in cases of stomach pains, hemorrhoids, infectious diarrhea, constipation and intestinal worms.	Lima-Santos et al. (2012)

Waterways, reservoirs and hydroelectric plants

The construction of dams is increasingly common in large rivers, especially in the Amazon Basin (CARNEIRO FILHO; SOUZA, 2009). Currently, the main Amazonian rivers are regulated according to the construction of reservoirs (Figure 10). The few rivers that have not yet been dammed are at some stage of the feasibility study/environmental impact study/implementation process. Few are the rivers of the Amazon Basin that, until now, dams for energy production have not been built, such as, for example, the low Tapajós River (since its formers have countless small and medium dams) and the Negro River. Cumulative effects indicate a threat of fragmentation and functional impairment of the basin and its connectivity (ANDERSON et al., 2018). In the case of several dams built, under construction or designed for Andean tributaries, a recent study conducted by Forsberg et al. (2017) demonstrates that this set will compromise the contribution of sediments from these areas, affecting the hydrogeological dynamics of the Amazon floodplains, drastically impacting the maintenance of nesting areas in terms of nutrients brought to areas of post-production dispersion and feeding of aquatic turtles.

Figure 10 – Jirau Hydroelectric Power Plant, Madeira River/state of Rondônia (Photo: Daniely Félix-Silva).

In general, the construction of reservoirs compromises the mechanisms of water functioning associated to the impacted basins, with high socio-environmental and economic impacts. In addition, today, large reservoirs have multiple uses, going beyond the production of energy and water reserves, which enhances the complexity of impacts (TUNDISI, 1994).

The reservoirs of the Amazon Basin present low declivity and, consequently, flood large areas. This characteristic in addition to its dendritic form makes environmental impact analysis difficult, due to the high heterogeneity. However, some impacts are universally known and predicted such as: flooding of areas and consequent loss of environments; loss of services of terrestrial and aquatic ecosystems, and consequent interference in ecological processes; loss of terrestrial vegetation and fauna; impact on migratory species; change in the composition of aquatic fauna; interference in sediment transport; emission of greenhouse gases; changes in downstream hydrological dynamics, among others (JUNK; MELO, 1987; TUNDISI, 2007; CARNEIRO FILHO; SOUZA, 2009) (Figures 11 and 12). Even in reservoirs of the "run-of-river" type, that is, those where technically the amount of water entering the system is the same as that leaving, there are drastic changes in the ecosystem, with flooding and, consequently, the disappearance of large areas, naturally used by local organisms. Although this is an argument used by entrepreneurs and the Government, to propagate that this type of hydroelectric plant does not interfere in the downstream hydrological cycle, the operation can manipulate the discharges, generating the desired energy when necessary and retaining water afterwards, thus managing to maintain a balanced discharge average. This, however, differs totally from the natural pattern, with still unknown impacts on the aquatic fauna**.**

Figure 11 – Reservoir of Tucuruí Hydro-Power Complex, Tocantins River/state of Pará (Photo: Daniely Félix-Silva).

Figure 12 – Nesting area of *Podocnemis unifilis* at the Tucuruí Hydroelectric Power Plant, Tocantins River/state of Pará (Photo: Daniely Félix-Silva).

The impacts of cascading reservoirs, which produce cumulative effects such as those of the Tocantins and Madeira rivers, and what is proposed for the Tapajós River should also be considered. With the flow regulation, there is a modification of the hydrological regime and the consequent alteration of the flooding dynamics and flooded areas, alteration in the reproductive dynamics of the aquatic fauna and flora, in the flooding areas, water retention, interfering in the biogeochemical system, and of the water quality downstream.

Some reservoirs in the Amazon already show profound changes upstream and downstream, consequently compromising local and regional ecosystems, with direct and indirect effects on all organisms, such as in the Tucurí, Balbina and Curuá-Una HPP (JUNK; MELO, 1987; TUNDISI, 2007).

The construction and operation of dams transform lotic environments into lentic (JUNK; MELLO, 1987; MOLL, 2004) and these environmental modifications completely alter the reproduction, nursery and feeding areas of all aquatic fauna, especially aquatic turtles (PEZZUTI et al., 2008; FÉLIX-SILVA, 2009).

Despite the numerous hydroelectric projects in the Amazon, few studies show the real impacts on the populations of aquatic turtles. The monitoring conducted prioritized the post-filling phases (FELIX-SILVA, 2009) and only recently included the pre-filling phase in the environmental programs conducted by the construction companies, without the proper evaluation of the quality of the protocols applied.

Table 3 specifies some of the impacts diagnosed and predicted in reservoir areas in the Amazon.

Table 3 – Impacts of environmental modification, for hydroelectric use, on aquatic turtles.

Population Parameters	Reservoir	Downstream
Abundance density	• Decrease in population abundance. • Increased vulnerability of the turtle populations due to the increase in population density in the region of the hydroelectric project.	• Decrease in population abundance. • Increased vulnerability of turtle populations due to the increase in population density in the region of the hydroelectric project.
Distribution	• Modification in the spatial distribution of turtles in the area of occurrence due to the disappearance of traditionally used environments and the emergence of new environments steaming from the increase of the water mirror.	• Modification in the spatial distribution of turtles due to the interruption of the migratory route caused by the physical barrier of the enterprise
Migration	• Interruption of the migratory route and consequent confinement of organisms upstream of the dam. In the case of cascading reservoirs, e.g., HPP Santo Antônio, individuals upstream of the dam and downstream of the Jirau HPP dam are confined.	• Interruption of the migratory route and consequent confinement of organisms downstream of the dam.

Population Parameters	Reservoir	Downstream
Population structure	• Deviation in sex ratio due to differential capture. • Change, in the long term, in the average size and biomass of individuals due to differential capture and food availability.	• Deviation in sex ratio due to differential capture. • Change, in the long term, in the average size and biomass of individuals as a function of differential capture.
Feeding	• Change in the nutritional status of organisms due to the change in food availability for herbivore species.	• Change in hydrological cycle and access to seasonally floodable feeding areas.
Reproduction	• Modification in areas traditionally used for oviposition, with consequences for the low rate of hatching and sexual ratio. • Low hatching rate, especially *P. expansa* and *P. sextuberculata*, due to selectivity regarding the reproductive site. • Low recruitment of individuals due to the sex ratio diverted to males, in most investigated populations, high rates of egg collections, in reproductive areas, and low hatching rates. • High mortality rate of embryos (soil compaction, invasion of grass roots, ant predation, low nest depth) due to eggs deposited in altered environments.	• Modification in areas traditionally used for oviposition, due to sediment retention, with consequence for reduction in the number of nests, hatching rate and sex ratio. • Low recruitment of individuals due to the sex ratio diverted to males, in most investigated populations, high rates of egg collections, in reproductive areas, and low rates of hatching.
Health	• Contamination by heavy metals and toxic products due to pollution of water bodies from mineral exploration and agricultural frontier.	• Contamination by heavy metals and toxic products due to pollution of water bodies from the mineral exploration and agricultural frontier.
Genetics	• Loss of genetic variability due to the confinement of upstream populations, with interruption of the gene flow in the basin.	• Loss of genetic variability due to the confinement of upstream populations, with interruption of the gene flow in the basin.

Each species, depending on its life history and ecological requirements, responds differently to the changes that have occurred. For example, *Podocnemis expansa* is a species more sensitive to environmental changes when compared to *P. unifilis* and therefore can respond more quickly to variations in its natural environment, as observed in the Tucuruí HPP Reservoir, where the species disappeared after 20 years of construction of the enterprise (FÉLIXSILVA, 2009). The hydroelectric dam reservoirs are important emitters of carbon dioxide, which contributes to the increase in the planet temperature (FEARNSIDE, 2009; 2016). For turtles, that are organism dependent on the physical characteristics of the environment, climate change is perhaps the greatest threat on a global scale, since it can affect all aspects of the life history of ectothermic animals in general, especially amphibians and reptiles. In the case of turtles and crocodilians, the deviation of the sex ratio of the hatchlings is a critical aspect, since it is the incubation temperatures that determine the sex of embryos during their development.

The effects described above are interrelated and can affect several biological parameters at the same time, occurring in cascade effect and potentiated. The additional impacts of installing transmission lines (JUNK; MELO, 1987; FELIXSILVA et al., 2009) and infrastructure projects, which are directly associated with energy enterprises, should also be considered (Figure 13). Although smaller compared to the creation of an artificial reservoir, the installation of transmission lines fragments the landscape, suppresses riparian vegetation, increases noise pollution, capture pressure, soil erosion and silting up of water bodies. These impacts can have repercussions for aquatic, semi-aquatic and terrestrial turtle species, with changes in turtle population dynamics, loss of breeding environments, silting and even population decline (FELIX-SILVA et al., 2009).

Figure 13 – Transmission line of the Santo Antônio HPP, Jaciparaná River/state of Rondônia (Photo: Aderson Alcântara).

Considering the scenario of large hydroelectric projects in the Amazon Region, it is possible to suppose that, even if podocnemidids turtle populations remain in the affected areas, uncontrolled direct exploitation and socio-environmental aggravating factors may, in the medium and long term, reduce these populations to very low quantities if no conservation measures are taken (ALCÂNTARA et al., 2013).

Agricultural activity, deforestation, logging, burnings

Current and historical causes for deforestation in the Amazon are several and often interrelated, ranging from incentives for occupation of the Amazon and fiscal incentives in the past to the current macroeconomic scenario (SOARES-FILHO et al., 2005). The advance of logging, agribusiness, creation of reservoirs, mining projects and infrastructure works associated with these large projects contribute to the deforestation scenario in the Amazon, since it stimulates forest conversion into pastures and agricultural areas, and the consequent loss of socio-biodiversity and environmental services. Furthermore, this scenario contributes to the reduction of rainfall and the consequent increase in forest flammability (NEPSTAD et al., 1999; FEARNSIDE, 2003; SOARES-FILHO et al., 2005; Figures 14 and 15).

Figure 14 – Riparian forest burning in the Jaci Paraná River, area of influence of the Santo Antônio Hydroelectric Power Plant/state of Rondônia (Photo: Josué Pereira).

Figure 15 – Forest suppression in the area of influence of the HPP Santo Antônio/state of Rondônia (Photo: Daniely Félix-Silva).

The conversion of the forest into pasture and/or agricultural fields has serious social and environmental costs, such as changing the parameters of the hydrological cycle and the local and regional water balance, disorderly occupation of human populations, erosion, silting up and pollution of water bodies (ARAÚJO; PONTE, 2005). These changes in the landscape have a direct and indirect impact on terrestrial and aquatic organisms.

Turtles use both aquatic and terrestrial environments for some phase of their life history. The margins of water bodies are used during the reproductive period for egg deposition and during the flood period for access to vegetation available for feeding. In addition, some aquatic species use substrates located on the margins of water bodies to sunbathe (CONWAY-GOMES, 2007; ALCÂNTARA et al., 2013). *Podocnemis unifilis*, for example, uses microenvironments associated with shrub vegetation to lay its eggs (FELIX-SILVA, 2009). *Peltocephalus dumerilianus* lays its eggs in microenvironments within the flooded forest (PRITCHARD; TREBBAU, 1984; FELIX-SILVA, 2004). Semi-aquatic species such as *Rhinoclemmys punctularia* (spot-legged turtle), *Kinosternon scorpioides* (scorpion mud turtle) and *Platemys platycephala* (red side-necked turtle) uses hard ground soils to nest, seek new environments or reproductive partners.

The transformation of the landscape due to the human expansion interferes with the flood regime and may contribute to the loss of nests by flooding (FELIX-SILVA, 2009). Soil compaction leads to large differences in rainfall runoff rates, causing flooding (FEARNSIDE, 2003), and can significantly increase the loss of nests in rivers that drain highly anthropized regions, especially in Rondônia, Acre, Mato Grosso, and southern Pará. This is a real threat to important nesting areas and other nesting grounds in the Amazon (FÉLIX-SILVA, 2009).

Forest fragmentation and/or forest conversion can have a major impact on aquatic and semi-aquatic turtles, since, in addition to destroying the environments used, these changes present alterations in the microclimate and the quality of the environments. Especially for reptiles that have their life history related to environmental temperature, these changes are especially important. It is also worth mentioning the impacts, in the long term, related to the global temperature rise, as a result of the landscape change. Besides the physical modifications due to deforestation, elevations in temperature can contribute to the deviation in sexual ratio and, in more extreme cases, to the increase in embryo mortality. In already fragmented populations, with low recruitment and uncontrolled direct exploitation, these changes may contribute to population decline.

Fragmentation has a synergistic effect with hunting and allows not only its intensification in terms of access, to the hunter, to remote areas previously inaccessible, with severe impacts on the vertebrate community (PERES, 2001). This effect is particularly important for the tortoises (*Chelonoidis* spp.), highly appreciated by indigenous and traditional peoples (BALÉE, 1985; PEZZUTI et al., 2010a; FÉLIX-SILVA et al., 2013), as well as for semi-aquatic species of the estuarine region (JOHNS, 1987; CRISTO, 2016).

Disorganized tourism and direct and indirect impact on Amazon freshwater turtles

Nature tourism – one of the most prominent areas of tourism – has the potential to create benefits to the environment and contribute to its conservation, because at the same time as it strengthens the appropriation by society, it increases the economy and promotes the generation of employment and income for local populations (MMA, 2006).

Tourism activities focused on observation and interaction with animals in nature enhance the conservation of focus-species. However, when carried out in a disorderly manner, without planning, monitoring or control, they generate negative impacts, compromising the environment and the safety of visitors, considered, in some cases, a threat to many species (ORAMS, 1996; BOO, 2001; ROMAGNOLI et al., 2011).

Several studies (DYCK; BAYDACK, 2003; KING; HEINEN, 2003; LABRADA, 2003; ALVES et al., 2009; MELETIS; HARRISON, 2010) on hiking, diving and feeding activities for wildlife show that, in general terms, these behaviors interrupt or modify crucial activities for impacted species, such as oviposition in turtles; surveillance in polar bears and sea lions; and feeding and resting in manatees and dolphins.

Turtles, especially the giant South American river turtle, can play an important role in the evolution of tourism in certain areas (WILSON; TISDELL, 2001). However, although these animals attract tourists and fascinate adults and children, this type of activity is not always positive for turtles. Negative effects of tourism can result mainly from ignorance, lack of monitoring and information (TISDELL; WILSON, 2005).

Although tourism directed to the interaction with Amazon freshwater turtles in nature is incipient, some species already suffer the negative impacts of the increase in tourist activities in the habitats where these animals occur, with consequences in crucial aspects – biological and behavioral – such as feeding, copulation, oviposition and survival of hatchlings.

In the Jaci-Paraná River, the main tributary of Madeira, in the stretch directly influenced by the Santo Antônio Hydroelectric Power Plant /state of Rondônia, in the Iriri River, an important tributary of the Xingu River/state of Pará, and in the Araguaia River and its tributaries, one of the great problems on the beaches used for nesting yellow-spotted river turtles (*Podocnemis unifilis*) is the increase in tourism focused on sport fishing (Figure 16). It is common in this modality of fishing to install a support camp on the banks of rivers. Overnight activities on the beaches and their related structures (tents, chairs and tables) contribute to diminish the potential space for turtle nesting, and may also make nesting unfeasible because of the drilling or compaction of the sand caused by these structures, impacts also observed by Arianoutsou (1988), in areas of turtle nesting in Greece.

Figure 16 – Camping on nesting beach used by aquatic turtles in the Jaci-Paraná River, area of influence of the HPP Santo Antônio/state of Rondônia (Photo: Aderson Alcântara).

In these same regions, the large number of side roads opened in recent years has increased the traffic of vehicles and people on beaches used by the turtles. It is known that the intense traffic of vehicles and people on beaches, especially at night, disturbs turtles looking for a place to nest, causing them to return to the water without completing the nesting process or leading them to choose beaches less suitable for nesting (TISDELL; WILSON, 2005; MELETIS; HARRISON, 2010). The increase in traffic may also lead to the run over by car of already nesting females and hatchlings, as well as promoting the compaction and destruction of nests and their eggs (KUDO et al., 2009).

In the Alter do Chão region, near Santarém/state of Pará, the increase of leisure activities and day and night tourism has impacted the feeding and reproduction of yellow-spotted river turtles and red-headed Amazon river turtle (LEITE, 2010). The transit of small and large vessels and the disposal of waste on the Tapajós River may negatively affect the activities of foraging and aggregation of these species. In addition, the presence of artificial lights (flashlights, camera flashes, campfires) on beaches can also contribute to the inhibition of females to climb and nest, as well as disorienting hatchlings that seek the path to water (CAMPBELL, 1994).

In the Unini River Extractive Reserve, located in the Negro River Basin /state of Amazonas, leisure and tourism activities related to peacock bass sport fishing (*Cichla* spp.) have contributed to the establishment of conflicts with local residents, who claim to be being harmed because tourists collect turtles and their eggs on the beaches of intangible areas whose access is not allowed to residents.

Mining

The extraction of mineral resources causes the elimination of the natural ecosystem area established over the area to be mined (PRIMACK; RODRIGUES, 2002; Figure 17). In areas directly affected by mining, individuals of terrestrial and semi-aquatic turtle species are eliminated, including *C. carbonaria*, *C. denticulata*, *Platemys platicephala*, *Rhinoclemmys punctularia*, *K. scorpioides*. The same fate rests with chelids that inhabit small streams and puddles in the forest that may be suppressed. In the perspective that the entrepreneur provides the rescue of these individuals, usually the release occurs in adjacent or nearby areas, without any follow-up. Therefore, it is not possible to have access to the translocated animals nor to know the effects that such a procedure causes on the area that received these animals, which invariably was already occupied by other individuals of those species.

Figure 17 – Gold extraction rafts in turtle nesting area – Santo Antônio HPP, Madeira River/state of Rondônia (Photo: Josué Pereira).

An example of iron ore extraction is the cangas[30] from Serra de Carajás (Figure 18). In the plateau, there are sinkhole lakes full of individuals of *R. punctularia*, *Mesoclemmys gibba* and *K. scorpioides* (FELIX-SILVA et al., 2015), whose subpopulation was considered, until recently, an endemic sub-species (*K. scorpioides carajaensis*, Figure 19), and which represents variability and endemism. As the mined area constitutes precisely the canga environments, where these lagoons are located, the elimination of an aquatic turtle community unique in the Amazon occurs. At least part of these ponds should be kept intact, because it constitutes a unique ecosystem whose importance goes far beyond the restricted perspective of the studied group.

Figure 18 – Sinkhole lakes in the National Forest of Carajás/state of Pará (Photo: Daniely Félix-Silva).

Figure 19 – *Kinosternon scorpioides carajaensis*, National Forest of Carajás/state of Pará (Photo: Daniely Félix-Silva).

In addition, recent disasters in large mining enterprises in Mariana and Barcarena allowed us to learn two lessons. The first is that even mega enterprises are unsafe because they have weak and

30 TN: Brownish clay iron ore area.

negligent security, risk management, and surveillance systems, and a promiscuous network of private and public sector actors is common. Second, accidents of large proportions are frequent and reach extensive areas, especially drainage basins, with catastrophic effects downstream. The SAMARCO accident practically destroyed the Doce River and reached the sea, while the Hydro ALUNORTE spill reached the mouth of the Amazon River. The trend is that this will worsen, and we will have more accidents in the future if the environmental licensing system is relaxed.

In this scenario, all terrestrial and aquatic biota are affected, including the Amazon freshwater turtles of the dryland forest, the flood plains and the entire water network, from the site of the venture to the estuary.

Synergistic impacts of large enterprises on turtles

For the evaluation of impacts, it is important to consider that they do not happen in isolation, in the same way that they can potentialize each other effects. In addition, the "drag effect" of infrastructure projects, which is characterized by additional impacts, must be considered. In the case of the expansion of soybean monoculture, for example, it is the implementation of infrastructure additionally promoted to transport the production, such as the opening and paving of roads, construction of ports, railroads, waterways, etc. (ARAÚJO; PONTE, 2005). Roads, for example, can have catastrophic effects if they are built on moving routes to nesting areas.

Several infrastructure projects are spread throughout the Amazon Basin. There is a cascading effect, with construction sites becoming precarious urban centers. This increases the price of land, which stimulates squatting and, consequently, deforestation. In the Xingu River region, mere speculation about the construction of the Belo Monte Hydroelectric Power Plant has contributed to increased deforestation because of real estate speculation.

Thus, the population status of turtles can be of concern if we consider the sex ratio diverted to males, as well as the decline in population abundance due to proximity to urban centers (CONWAY-GOMES, 2007; ALCÂNTARA et al., 2013). These factors interfere with the recruitment of individuals. If the number of reproductive females remains low, the replacement rate of individuals tends to decline, compromising the maintenance of stocks (ALCANTARA et al. 2013). For Moll and Moll (2004), the removal of adult females (breeding matrices) is the worst blow to a turtle population.

The increase of human pressure along the areas of indirect influence of hydroelectric enterprises in the Amazon has proved to be a greater problem than the direct impacts themselves. In the lake of the Tucuruí Hydroelectric Power Plant on the Tocantins River, Félix-Silva (2009) found less *P. unifilis* abundance in environments where there was greater human population density. Similarly, Dreslik and Kuhns (2000), in the United States, and Luiselli (2003), on the African continent, also observed that the hunting pressure on turtles is more intense near human settlements. In the Belo Monte region, the impacts of intensified exploitation of fishing resources in general, including turtles, have been observed at great distances from the main dam, both downstream and upstream (CARNEIRO; PEZZUTI, 2015).

Other effects resulting from particularly dangerous ventures for aquatic communities, including turtles, are pollution and contamination. Both mining and farming, especially in Brazil, based on intensive use of fertilizers and agrochemicals, have proved extremely polluting and harmful to Amazon freshwater turtles because of domestic and industrial sewage (SOUZA, 1999), mercury (SCHNEIDER, 2007) or pesticides (PIGNATI et al., 2017). Major accidents, such as that of Mariana and Hydro, should be carefully monitored, especially because of the already mentioned lobby of the agricultural, mining and electrical sectors, whose unsustainable developmental progress has an impact on the entire Amazon ecosystem and whose effect on turtles has been insufficiently accessed.

A good example of this trend is the imminent prospect of installation of the Belo Sun Mining project, a Canadian company that intends to exploit gold in the Volta Grande do Xingu, based on a project involving the removal of gigantic volumes of soil and other structures, and the removal of gold using cyanide, near the Belo Monte hydroelectric power plant and, hydrologically, adjacent to six indigenous lands and upstream of three important conservation units: Verde Para Sempre Sustainable Development Reserve, Vitória de Souzel Sustainable Development Reserve e Refúgio de Vida Silvestre Tabuleiro do Embaubal Wildlife Refuge. It receives, annually, the largest reproductive population of turtles in the Amazon Basin, including 20 thousand females of *P. expansa* (COSTA, 2015) and populations not yet evaluated of *P. unifilis* and *P. sextubertulata*. A gigantic amount of cyanide tailings contamination over the ecological system of the Xingu River can also reach the area of the lower Xingu River, the lower Amazon River and the Amazon estuary.

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Chapter 9

Commercial breeding of Amazon freshwater turtles

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Historical context of the turtle production chain

Wild animals have been the target of exploitation since the dawn of time, serving as a source of protein for humans. Turtles are typical examples of this predatory action. In Brazil, the habit of consuming products from these animals has always been rooted in the traditional Amazonian cuisine. Although illegal, the sale of species captured in the wild is extremely high (ANDRADE et al, 2008). An example of the commercialization network of Amazon turtles of the genus *Podocnemis* was evidenced by Pantoja-Lima et al. (2014), in which the authors point out the main components involved in this activity.

In an attempt to mitigate this predatory action and find alternatives for the legalization of the trade of the giant South American river turtle (*Podocnemis expansa*), the Federal Government regulated the breeding of this species, in an attempt to meet the social demand.

The Amazon turtle conservation and management programs has the objective of maintaining the diversity and the minimum stocks of the species in nature, by protecting the reproductive sites and creating the possibility of generating income through sustained production, in confinement systems, to serve the riverside communities that are users of this resource.

Ordinance Nº 133, of May 5, 1988, was the first document published, regulating the breeding of the giant South American river turtle in the state of Pará. According to this legal instrument, the breeding began with hatchlings donated by the Brazilian Institute for Forest Development (BRAZIL, 1988), duly marked, which could be sold only after the reproduction of the matrices donated at the beginning of the activities was verified at the hatchery. The minimum weight stipulated for marketing was 12 kg live weight per animal.

In order to improve the viability of the enterprises with regard to the technical and legislative aspects of breeding, as well as to include specific data for the breeding of the yellow-spotted river turtle (*Podocnemis unifilis*), a revision of Ordinance Nº 133/88 was proposed, based on the debates that took place during the VIII Technical Administrative Meeting on Turtles of the Amazon, in Belém/state of Pará – PA, in 1991, which culminated in the publication of Ordinance Nº 142, of December 30, 1992, which revoked the previous instrument.

Thus, a new impulse was given to the turtle production sector. The main advance came with specific legislation for the breeding (BRAZIL, 1992) and marketing (BRAZIL, 1996) of the giant South American river turtle and the yellow-spotted river turtle. The Federal Government began to support the farming of these animals in their natural areas of occurrence, establishing that 10% of the hatchlings produced in natural nesting grounds would be made available for breeding in captivity, and commercialization would take place when they reached 1.5 kg live weight. In that decade, 120 breeding farms were registered, with more than a million animals in confinement, and about 200 thousand in the slaughter and marketing phase (RAN, 2004).

Difficulties such as the lack of knowledge about the biology, nutritional requirements, cost of the enterprise and barriers to trade due to the absence of specific standards that meet the requirements of sanitary quality, have decreased the interest of producers in the activity, observing a decline in the number of registrations of breeding farms. According to Cantarelli et al. (2014), there were only 83 breeding farms in 2012.

In an attempt to standardize procedures for the creation of wild animals, a new legislation was published (IBAMA Normative Instruction Nº 169 of February 20, 2008), regulating breeding farms, commercial establishments, slaughterhouses and processing of wild fauna, plus specific annexes to the zootechnical breeding of turtles and crocodilians. Later, this norm was revoked by IBAMA Normative Instruction Nº 7, of April 30, 2015. It is also important to highlight that, on December 8, 2011, Complementary Law Nº 140 was published, in which the licensing and operation of wild fauna breeding farms become administrative attributions of the states (art. 8˚, XIX).

Diagnosis of the turtle production chain

To diagnose the situation of the turtle production chain, the National Center for Research and Conservation of Reptiles and Amphibians (RAN/ICMBIO), in partnership with the Federal University of Tocantins (UFT), carried out between 2007 and 2010, the project Development and Organization of the Turtle Production Chain in the Legal Amazon, funded by CNPQ (File Nº 408759/2006-2). In this project, 25 breeding farms were evaluated, distributed in the states of Acre, Amapá, Amazonas, Pará, Rondônia, Tocantins and Goiás. Figure 1 shows an example of a breeding farm, showing a fattening tank.

Figure 1 – Example of a fattening tank used in the commercial breeding of turtles.

The results obtained show that the turtle breeding system has had some progress, but, like any new activity operating in a traditional market, it has encountered difficulties such as obtaining official credit from financial institutions, competition with trafficking, and the lack of self-sustainability of the enterprise in the reproductive processes of the species, making the producer dependent on receiving hatchlings obtained from nature through the Amazon Turtles Project.

Based on the interviews carried out during the development of the project, an attempt was made to draw the profile of the turtle producer and it was found that 47% of the producers have a college degree and 23% a high school degree. Therefore, most owners have a level of education that can help in understanding the operation of this chain, from production to marketing. This shows that, possibly, these producers have higher financial income than the riverside populations, who expected to profit from this activity.

Of the 22 interviewees, only 10 commercialize or have already commercialized. Of these, 51% said that they do not have any income from turtle breeding, 10% said that the activity corresponds to 10% of their income, 5% said it corresponds to 15%, and another 5%, that it corresponds to 20%, as shown in Figure 2. Most of the interviewees, that is, 80%, presented themselves as entrepreneurs of other activities such as livestock farming, pisciculture, commerce, and agriculture, which usually bring good incomes. Therefore, it can be said that the breeding of turtles becomes a secondary activity for these producers.

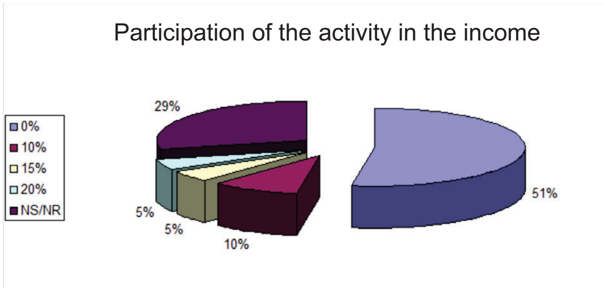

Figure 2 – Participation of the turtle breeding activity in the producer income.

Despite the fact that the producers showed affinity and attachment to turtle breeding, in relation to commercialization, 53% were totally dissatisfied, 31% dissatisfied, and only 16% felt partially or totally satisfied with the enterprise. In business, the area with the greatest need for assistance, cited by the producers, was commercialization. A large number of producers stated that they had difficulty with commercialization, representing 90% of the respondents (Figure 3).

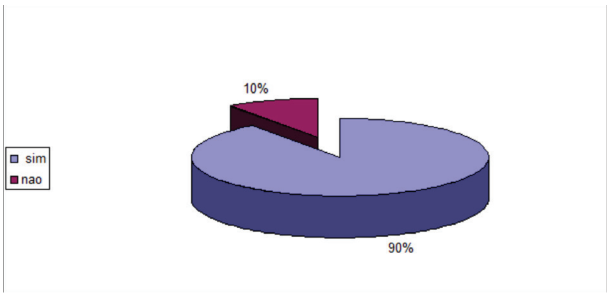

Figure 3 – Difficulty in marketing turtles from commercial breeding farms.

The main problems mentioned by the producers with the consumer were:

1. Few final consumers – in some states where culturally this product is not part of the regional cuisine, acceptance is a little difficult, as in Tocantins;
2. Low prices paid by consumers – in its great majority, turtle meat is still being commercialized legally or illegally in fairs and markets, in small quantities, to diverse individuals, because some difficulties are encountered that need to be adapted to meet the norms established by the Federal Inspection Service (SIF) and improve the sales flow (LUZ, 2005a). In general, prices vary according to the region, which makes that in states where the supply is large the price is lower than expected by the producer. Besides this, there is the problem of clandestine trade, that is, the commercialization, most of the time, with prices much lower than those of authorized producers, in a totally unfair competition with farmers. This situation was observed mainly in the state of Amazonas.
3. Middleman Knowledge. Partial knowledge of the market – the lack of knowledge of the consumer market was one of the bottlenecks in the commercialization of this product, because despite being part of the RAN/IBAMA requirements, during the implementation of the project, many producers claimed to have only partial knowledge of the consumer market.
4. As for the production process in the breeding of turtle, the main difficulties mentioned by the interviewees were: the feed used – which is suitable for fish, since there is no pellets for turtles yet; the workforce – which is not qualified, and disease control.

Other factors that contributed to the weakening of the activity are related to the lack of entrepreneurial spirit of the category that was being formed, lack of organization of the producing class, unsatisfactory technical assistance and high costs for the maintenance of the enterprise (LUZ, 2005a). It is worth pointing out that the results of the interviews show a lack of data on the costs of the enterprise, since only 27% of the producers stated that they controlled the costs, against 73% who said they did not do any kind of control.

Within the agribusiness view, the commercial breeding of turtles should be understood as a broad process that involves the entire production chain, because simple zootechnical management is not enough to establish the activity in a profitable and perennial way. All links in this chain must be organized and coordinated for the success and promotion of the activity.

The case study of farms in Amazonas

The state of Amazonas is the largest turtle breeder in Brazil, currently having 29 breeders authorized by IBAMA and IPAAM (79% of the national total) with a herd of more than 155,648 turtles in commercial breeding (it has already had 85 breeders and more than 215 thousand animals) and another 5,423 animals in community breeding systems (Andrade, 2008; Trajano and Carneiro, 2019). Chelonian are the fifth most created aquatic organisms in the state, only behind tambaqui (*Colossoma macropomum*), matrinxã (*Brycon amazonicus*), pirarucu (*Arapaima gigas*) and pirapitinga (*Piaractus brachypomus*) (PEIXE BR, 2019; IBGE, 2019; IPAAM, 2021). About 2,623 ± 561 animals / year (12.7 to 21.6 ton / year) are legally traded. Between 1999 and 2019, cheloniculturists from Amazonas managed to sell more than 61 thousand animals, producing more than 302 tons and raising about R $ 6,741,000.00 (US $ 2,075,000.00).

In 2017, Amazonas officially recognized the communities' conservation efforts, creating 265 chelonian protection areas and regulating a community-based chelonian breeding system, allowing communities to breed, recreate and fatten a percentage of *P. expansa* hatchlings (10%) and *P. unifilis* (20%) that they protect (CEMAAM Resolutions N° 25 and 26/2017). This possibility of *ex situ* management of turtles to raise them in semi-natural conditions to be commercialized, seems to be a solution, to generate income and cover part of the expenses for the protection of the species (Campos-Silva et al., 2018). What seems to be promising, not only for the economic aspect, but also for the relevance in food security and in the culture of the peoples of the region (Dantas-Filho et al., 2020).

Unlike other states, Amazonian breeders managed to sell all of their animal lots, with an average weight of 4.9 ± 1.9 kg and the current price ranging from R $ 25 to 40.00 / kg live (U$5-8.00). More than 80% of them have already managed to breed in captivity, becoming closed-cycle breeds and from 2002 to 2019, they have already produced more than 57 thousand young (45,070 turtles and 12,397 tracajás) (Garcez, 2009; Trajano and Carneiro, 2019).

The great advance of cheloniculture in this state seems to be related to some factors: 1) The great demand of the local market for the consumption of chelonian meat; 2) The great interest of the producers to regularize themselves (more than 198 processes under analysis); 3) The incentive and technical-scientific support (extension and research) provided by IBAMA/AM, the result of a partnership and technical cooperation with the Federal University of Amazonas (UFAM). Between 1996 and 2004, through a joint project, all the state's chelonian breeding sites were monitored, through bi-monthly technical visits, in which biometrics and animal weighing were carried out, the feed provided was analyzed and information was collected on the management adopted and the costs with the cost of the activity. With this, it was possible to systematize a minimum script on the creation of turtles, defining types of facilities, crop densities, diets and nutritional levels, analysis of production costs, aspects of health and reproduction of animals in captivity. After a seminar in 2004, which brought together farmers and technicians from the sector in Manaus, the state Agribusiness Agency started supporting the commercialization of legalized turtles and exhibitions and fairs along with fish from cultivation or from management areas, which helped to publicize and popularize the sale and consumption of turtles in captivity, helping in the marketing of this product.

In addition to all the incentive and the extension work and technical support received by the cheloniculturists in Amazonas, they brought together some characteristics that, possibly, may have favored the success of their ventures:

a) **Proximity to the large consumer center:** Most of the farms were located in the region of the metropolis Manaus and surrounding municipalities (90.3%) - Anízio (2009).

b) Small and medium-sized properties: The majority between 9–35 ha (50%), with an average of 22±18.4 ha (8 to 6,000 ha). The ponds ranged from 0.1 to 6.0 ha, although most were between 1 and 2 ha, and the nurseries from 30 to 1,000 m2. Most enterprises took advantage of the dams and tanks already built for fish farming (Andrade, 2008).

c) Socio-economic profile of the creator: Most of the farmers carried out other activities, cheloniculture being a complementary activity. Most of them were traders (33%) or farmers / rural producers (25%), aged between 40-59 years (66.3%), family income in the range of 5 to 10 minimum wages (41.7%) and level of education between elementary and high school (58.3%). In addition, most of the breeders had empirical knowledge about the biological characteristics of the turtles, such as their feeding, reproduction and habits in the wild (Lima, 2000).

d) Production systems: most of the farms were owned by individuals (61.5%) and who used their own resources to invest. They adopted breeding systems of the semi-intensive or extensive type (69%) intercropped with fish such as tambaqui, and started with lots of 1,000 to 5,000 animals (60%) - which today is considered a small number for commercial activity and for create working capital.

e) **Food supplied:** They used by-products found in the region such as bovine offal (20%), fish fillet residues (40%), remains of fairs, fruits and tubers (20%), with only 20% providing commercial pelleted feed for hatchery fish with 36 to 42% protein, thus reducing food costs (Andrade, 2008; Anízio, 2009). Currently, 55% of cheloniculturists use fish feed to feed their animals. In the breeding sites that provided food with a higher content of animal protein (fish and leftovers from slaughterhouses), the animals were heavier than those raised with vegetable protein (vegetables, fruits and soy and corn-based feed) (Andrade, 2008).

f) **Production and marketing costs:** The share of fixed costs over the totals ranged from 20 to 25% and variable costs were between 75 and 80%. The highest costs were for food and ranged from 52.5 to 61% of the total costs. The production cost is around 11 to 22% of the sale value (about U$2.00/kg), and currently turtles are being sold between R $ 25 to 40.00 / kg of live weight (U$5 to 8.00/kg), with profitability estimated at 158 to 582% (Lima, 2000; Anízio, 2009). As the animals are sold live, cheliculturists have chosen to sell larger animals with 36 months of cultivation, 4.9 to 8.2 kg (Garcez, 2009; Trajano and Carneiro, 2019). The months with the highest sales are December, March and May due to the Christmas, New Year, Easter and Mother's Day parties. And those with the lowest sales are the dry months of the rivers, when illegally captured turtles flood the regional market, competing directly with animals from authorized farms. During the flood, there are fewer trafficking animals (off-season), when legalized farms increase sales of their regularized turtles.

The reduction in the number of chelonian breeding in Brazil was motivated, among other factors, by the difficulties in commercialization, lack of promotion and technical support, and bureaucratic excess. Then, after 2010, when the registration and control of fauna breeding passes from IBAMA to state environmental agencies, many breeders chose to end their activities. Despite this, the number of animals traded and production (tons) increased in the last 10 years, going from 152 to 190 tons in this period.

The situation of the acquisition of initial batches of hatchlings by novice breeders, which seems to be a critical point in the breeding process, also tends to improve, with the increase in the number of hatchlings of turtles and tracajas in older farms. Despite the fact that the sale of the hatclings is not yet foreseen in the current Normative Instruction N ° 07/2015, there is an understanding by IBAMA that the hatchlings could be sold among breeders authorized to form new breeding and breeding stock and for breeding (COCFP/IBAMA , 2013).

Among the main obstacles found in Amazonas by those who want to create turtles, we can also highlight: 1) Lack of more specialized technicians in the creation of turtles; 2) Dissemination and popularization of technical-scientific knowledge and its extension to cheloniculturists; 3) Indefinition among state agencies as to who would be responsible for assisting the wild animal breeder (Secretariat of Rural Production or Environment); 4) Adoption of incentive, promotion and technical assistance policies by states interested in developing this activity; 5) Organization of commercialization, dissemination and marketing. 6) Organization of cheloniculturists in associations or cooperatives; 7) The need for the environmental agencies to make the activities that involve everything from the breeder's registration to commercialization more agile and efficient (more technicians and resources are needed to carry out all inspections). 8) Recognition and standardization of the slaughter methodology by the Ministry of Agriculture, Livestock and Supply.

Technology for the slaughter of turtles

One of the biggest problems faced by the turtle farmer is the inspection of the slaughter and the distribution of his production with quantity and frequency of sale sufficient to maintain the enterprise. The lack of a specific procedure for slaughtering turtles on a commercial scale is a major obstacle to the completion of the production cycle, forcing the practice of selling on a small scale, in an artisanal way, at prices incompatible with the amounts spent on production.

Given this scenario, the RAN/ICMBIO took the initiative to promote the development of a research that sought to define the components and the organizing processes of the production chain of the giant South American river turtle, with slaughter methods and techniques that meet the requirements of the *Serviço de Inspeção Federal* – SIF (Federal Inspection Service), the processing of the products, the transportation and the flow with sanitary quality for human consumption.

The *Regulamento de Inspeção Industrial e Sanitária de Produtos de Origem Animal* - RIISPOA (Regulation of Industrial and Sanitary Inspection of Products of Animal Origin) classifies turtles, which are reptiles, under the generic denomination of fish, in other words, there is no specific regulation for turtles (DORNELLES; QUINTANILHA, 2003). This fact made the experimental slaughter quite empirical, since there was no preliminary information that could direct the first steps of the slaughter.

Considering the characteristics of the meat, of the commercially used fish species, the closest species to the giant South American river turtle was the giant bullfrog (*Lithobates catesbeianus*). Therefore, the microbiological standards used followed the parameters used according to Ordinance N° 451, of September 19, 1997 (BRAZIL, 1997), which establishes norms for fish in general.

The experimental slaughters were carried out from 2002 to 2008 in the Rander Fish Warehouse, registered under SIF N° 2,840 with the Federal Agriculture Office of the Federal District, *Ministério da Agricultura, Pecuária e Abastecimento* – MAPA (Ministry of Agriculture, Livestock and Supply). This establishment is mainly dedicated to the slaughter of the giant bullfrog, to obtain frozen meat. These studies, including the microbiological evaluation, carried out by several partner institutions, were accompanied by veterinarians from the Federal Inspection Service of the Fish Sector, of the Inspection Department of Animal Products from the Ministry of Agriculture, Livestock and Food Supply – MAPA.

A proposed flowchart for slaughter (Figure 4) was sent to MAPA to obtain frozen and packaged giant South American river turtle meat. It is worth mentioning that there has been no official response from this Ministry yet. In this study, the industrial utilization of blood, fat, viscera, skin, head, carapace and paws was not included.

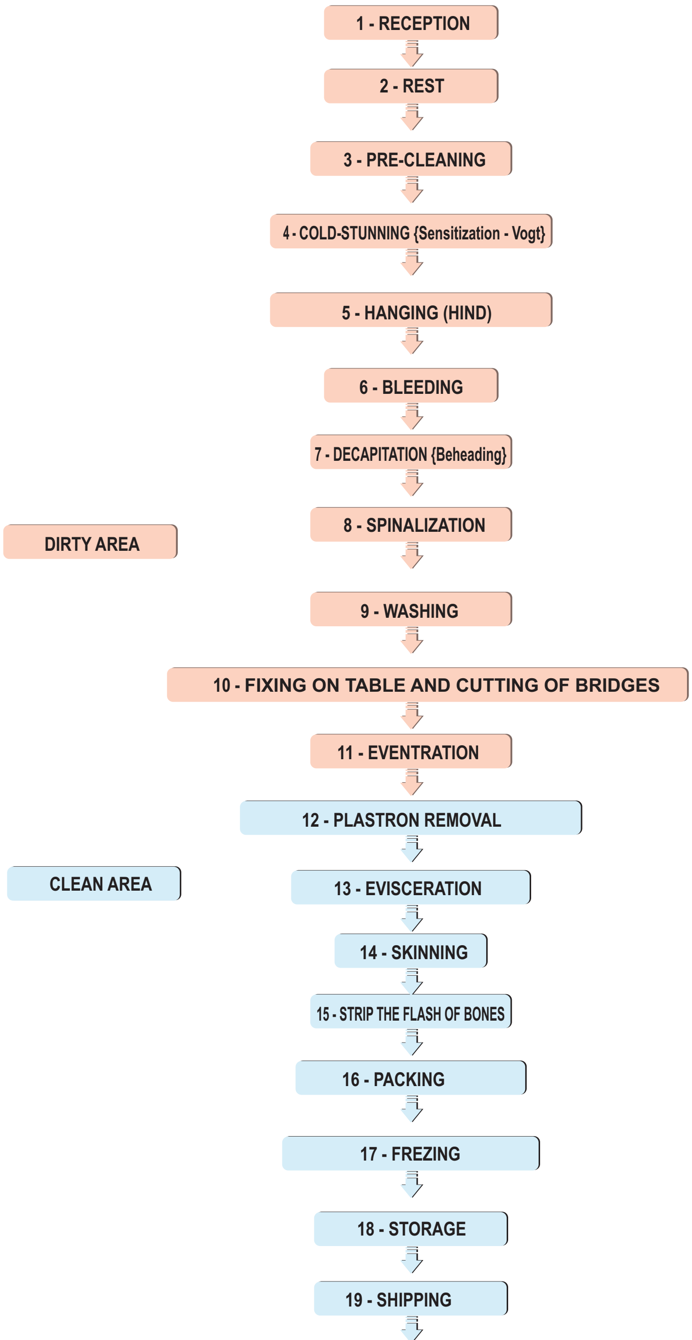

Figure 4 – Flowchart for the slaughter of the giant South American river turtle (LUZ, 2005b).

Description of the steps of the flowchart

Dirty area

Reception: place where the animals are received, right after transportation, with documentation (Animal Transit Guide – GTA, IBAMA's License for animal transportation and other state regulations, if any) and observing the general condition of the animals.

Rest: environment where turtles are placed in tanks, containing chlorinated and running water for a period of no less than 48 hours, to reduce the load of microorganisms present on the shell and skin. The turtles must be totally submerged in the water (Figure 5).

Figure 5 – Resting tank with captive-bred giant South American river turtle submerged in chlorinated running water.

Pre-washing: stage in which chlorinated water (5 ppm) is used under pressure (using a pressurization pump) for a period of 1 to 2 minutes, in order to remove the coarse residues located mainly on the carapace and plastron (Figure 6).

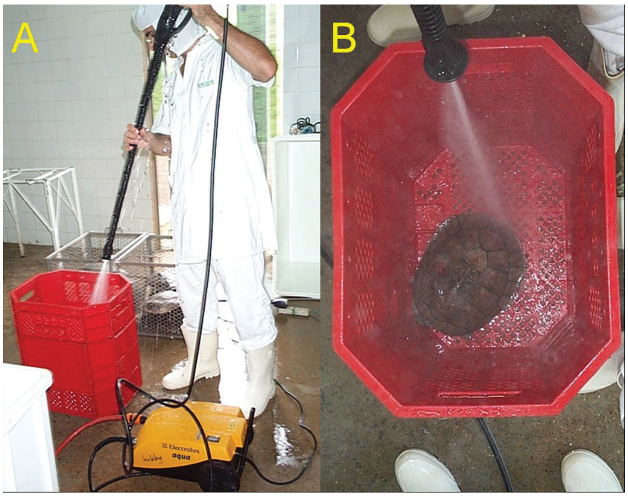

Figure 6 – Pre-washing of a giant South American river turtle specimen using the pressurization pump.

Cold-Stunning: the animals are kept for a period of 12 to 15 minutes immersed in water with ice and salt, at a temperature equal to or below 0 °C. Depending on the live weight of the animal (above 5 kg), the cold-stunning time increases (Figure 7).

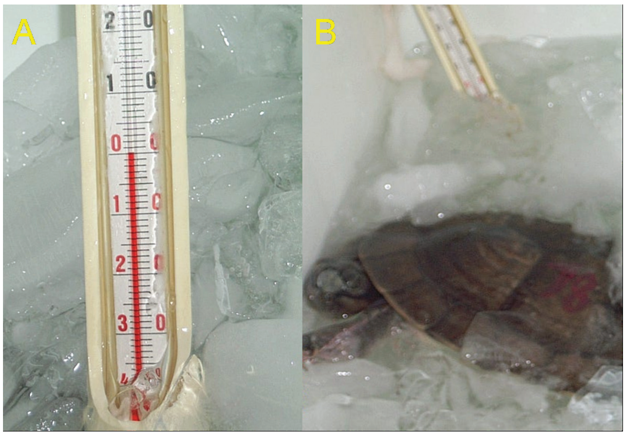

Figure 7 – Cold stunning in water with ice at 0 °C (a- container with a mixture of water, ice and salt used for stunning; b- Cold-stunning of Amazonian turtles by immersion in water, ice and salt at a temperature below 0 °C).

Hanging: fixing the turtles in the vertical position, with the head pointing downwards, attached by the hind legs, after cold-stunning (Figure 8).

Figure 8 – Giant South American river turtle fixed by the later limbs.

Bleeding and decapitation: sectioning the blood vessels of the neck to drain the blood for 15 minutes and removing the head after bleeding (Figure 9).

Figure 9 – Sectioning the blood vessels of the neck of the giant South American river turtle, to drain the blood from the animal carcass.

Spinalization: introduction of a stainless-steel rod into the vertebral canal, craniocaudal direction, to relax the limbs (Figure 10).

Figure 10 – Introduction of a stainless-steel rod into the vertebral canal of the giant South American river turtle.

Washing: Brushing of the specimen by hand using a small brush and alkaline detergent diluted at 0.2%. Afterwards, the turtle is rinsed with chlorinated water at 5 ppm under pressure to remove the residues (Figure 11).

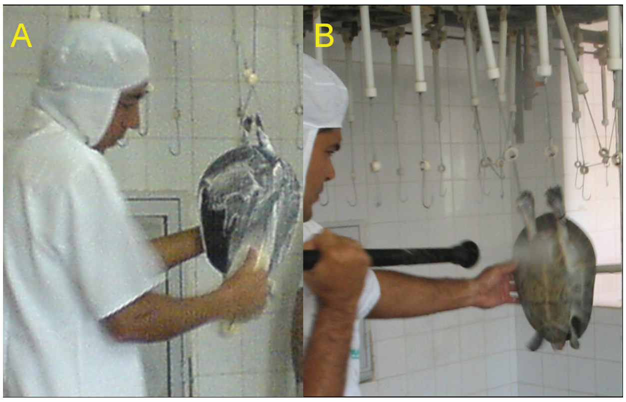

Figure 11 – Wash of the carapace and skin of the Amazon turtle (**a**- cleaning of the shell and skin, using a brush and neutral detergent; **b**- rinsing of the shell and skin with chlorinated water, using a pressurization pump).

Fixation on table and cutting of bridges: fitting the animal on a specific table for cutting and opening the shell, which consists of partially separating the carapace from the plastron and the plastron-humerus joint (Figure 12).

Figure 12 – Experimental pressing table for cutting the bridges and detachment of the plastron of the giant South American river turtle.

Eventration: total detachment between the carapace and the plastron. At the end of the operation, the plastron is detached from the shell, but not removed. The same occurs with the skin, which separates the insertions of the shell and plastron, but is not removed either. After the operation is over, the animal is transposed through the communication window between the dirty and clean areas. This operation marks the transition from the dirty area to the clean area (Figure 13).

Figure 13 – Total detachment of the carapace and plastron of the Amazon turtle.

Clean area

Removal of the plastron: disarticulation of the pelvis and acetabulum, disconnecting the plastron from the carapace. This step begins on the table, and is completed on the hanging hooks. The removal of the plastron is a critical passage due to the fusion of the pelvis, carapace, and plastron, anatomically related to the urinary bladder, which may break apart. Urine spillage into the cavity and into the meat can contaminate the carcass (Figure 14).

Figure 14 – Removal of the plastron from the giant South American river turtle, exposing the internal organs.

Evisceration: to detach the esophagus-trachea set it is necessary to close (tie) the esophagus and trachea to avoid reflux of the stomach contents. Afterwards, the animal is pulled to remove the respiratory, cardiac, digestive, and genitourinary organs (Figure 15).

Figure 15 – Removal of the internal organs of the giant South American river turtle (**a –** removal of the respiratory, cardiac, digestive, and genito-urinary organs; **b –** eviscerated carcass).

Skinning: removal of the skin, with circular cuts in the carpal and metacarpal joints, followed by longitudinal cuts in the forelimbs and hind limbs, which facilitate removal of the skin as a whole (Figure 16).

Figure 16 – Removal of the skin and exposure of the musculature of the carcass of the Amazon turtle.

Separating the meat from the bones: removal of the meat, detaching the spinal column from the carapace, with the help of a hammer and chisel (Figure 17).

Figure 17 – Removal of the meat from the giant South American river turtle (detachment of the spinal column from the shell; and meat and fat removed from the shell).

Packaging: vacuum packaging of the meat, which may or may not be packaged in trays. The packages must be labeled, following the legal guidelines (Figure 18).

Figure 18 - Packaging of freshly slaughtered giant South American river turtle meat (**a –** freshly slaughtered giant South American river turtle meat in the package; **b –** vacuum-packed giant South American river turtle meat).

Freezing: meat from slaughtered animals in cabinets at -25 C° to -40°C for a period of 2 to 6 hours (Figure 19).

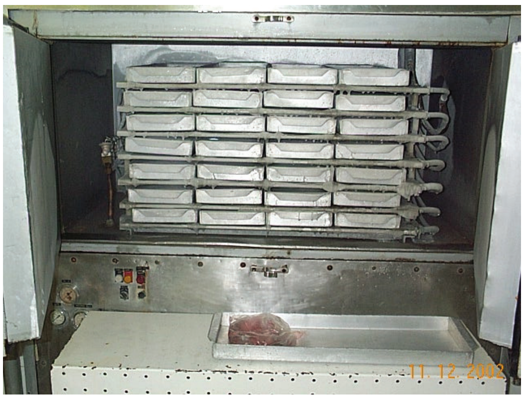

Figure 19 - Freezing in plate cabinets at -25 to -40°C.

Storage: in cold storage chambers at temperatures no lower than -25 °C (Figure 20).

Figure 20 – Refrigerated chamber containing the stock of giant South American river turtle meat.

Shipment: release of the meat to the consumer market.

Final considerations

The slaughter and processing of the turtle, as described in this study, lead to a product with satisfactory hygienic and sanitary quality. The microbiological analyses of the meat showed to be suitable for human consumption. The meat of the Giant South American River Turtle, after processing, presented satisfactory sensory and physicochemical characteristics.

The results obtained from the slaughter, processing and microbiological analysis were sent to the Department of Inspection of Products of Animal Origin of the MAPA. Although the methodology used in these steps has proven satisfactory, the Inspection Service has not yet released the product to most farms in Brazil, compromising the commercialization of the product. From the information from the turtle farmers, only one commercial farm, located in the state of Acre, has recently obtained the SIF. The slaughter and processing of the Giant South American River Turtle, with technology, allows for dynamic improvements that, certainly, must be adapted to the reality of each region, in the same way that occurred in the slaughter of other species.

It is also worth mentioning the need to develop further research to establish components and organizing processes of the production chain, such as the identification of production system models that are appropriate to the socioeconomic reality and infrastructure of the region, as well as in-depth studies on the environmental and commercial feasibility of this activity. It is worth noting that despite some obstacles in the breeding process, the protein value of *P. expansa* meat is quite high. As pointed out by Ribeiro (2010), it is around 88% to 94%, surpassing even some crustaceans.

In general terms, for the situation of the production chain of turtles to be reversed, it is necessary to have the support of research institutes, universities and public agencies. In this sense, we can highlight initiatives such as those of the Federal University of Amazonas and its various researches on the creation of turtles and actions of extension and dissemination with the producers of that state, in partnership with IBAMA. As well as the Brazilian Agricultural Research Corporation (EMBRAPA), which has been participating in a demonstration unit for the breeding of *P. unifilis*, in the state of Amapá. All of these institutions making progress in public policy, legislation and commercialization discussions in this market. Institutions in general must participate by providing practical guidance, from the moment of implementation to commercialization.

The commercial breeding of turtles in Brazil, is an activity that can complement the income of small and medium farms, integrated with other aquaculture crops, serving a regionalized (Amazon) or gourmet market, with high profitability, as long as the requirements are met supply food, facilities and appropriate handling techniques.

Despite the reduction in the number of farms in operation in the country, the number of sales and production in tons has increased, mainly leveraged by the state of Amazonas. This, due to a policy of incentives, partnerships for technical assistance, generation of scientific knowledge about the activity and demand for chelonian meat by the local market.

There was also an increase in the production of hatchlings, which can be used for breeding and fattening in the breeds, which are now mostly closed cycle. The legal possibility of selling chelonian hatchlings not only to new registered breeders, but also for sale as pets could be a potential income option for cheloniculture.

In Memorian

We thank Mr. Antônio Erlindo Braga for his efforts towards the development of commercial breeding of Amazonian aquatic turtles, always willing to keep alive the idea of making conservation and development compatible in the Amazon, our thanks to him and his family.

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PART II
Brazilian Action Plan for Amazon River Turtle Conservation

Creation process and progress of the Brazilian Action Plan for the Conservation of Freshwater Turtles

Roberto Victor Lacava e Rafael Antônio Machado Balestra

The workshop for the elaboration of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles took place in Brasília between August 18 and 22, 2014. It was attended by 69 guests, representing (Figure 2) six federal agencies, nine research institutions, three non-governmental organizations, six state agencies and three municipal environmental agencies, as well as turtle breeders and community leaders from riverside communities (Table 1).

The first step in the elaboration of the Brazilian Action Plan was to determine the main threats that the Amazon freshwater turtle species have been suffering. The participants, divided into groups of up to six people, answered the following question: what is the main problem affecting the conservation of Amazon turtles that is amenable to intervention, to bring about a change in the level of conservation of these species? The threats listed were: overexploitation of turtle populations by humans, inadequate conservation management, lack of continuity of public policies aimed at conserving these species, habitat loss/alteration, and impacts resulting from navigation, whether by noise pollution, collision, or collapse of river banks.

Thinking about how these threats could be reduced, the general objective, specific objectives, and actions were defined based on the following concepts:

- General objective: what is intended to be achieved for the conservation of species in order to cause changes in the current situation?
- Specific Objective: an intermediate result necessary to overcome the threats to the species, which should be measurable, achievable, and contribute to achieving the general objective of the plan.
- Action: activity that should be done if the specific objective is achieved. The action must have a start date and a deadline for completion, as well as being feasible, measurable and within the powers and duties of the institutions that make up the Brazilian Action Plan.
- Product: results obtained with the completion of the action.
- Articulator: responsible for articulating the execution of the action and presenting the product. The articulator and the collaborators are responsible for the execution of the action.
- Collaborators: co-responsible for the execution of the action.
- Estimated cost: estimated value to execute the action.

Based on these principles, the goal of this Brazilian Action Plan was to improve conservation strategies for Amazon freshwater turtles, especially the target species of its area of coverage (*Podocnemis expansa, Podocnemis unifilis, Podocnemis sextuberculata*), and promote their recovery and sustainable use until 2020.

The specific objectives that make up this plan were:

- Adequacy of legal frameworks related to the breeding, commercialization and community-based management of Amazon freshwater turtles;
- Expansion of information on the exploitation of Amazon freshwater turtle species;
- Control of the exploitation of Amazon freshwater turtle populations, especially the target species of the Brazilian Action Plan;
- Standardization of *in situ* management methods for Amazon freshwater turtle species;
- Review and improvement of *ex situ* management methods for Amazon freshwater turtle species;
- Creation of a governance system for the maintenance of conservation actions for Amazon freshwater turtles;
- Reduction of noise pollution, collision and collapsing of river banks (ravines/beaches) where Amazon freshwater turtles occur;
- Conservation and recovery of reproductive and feeding habitats, necessary for the life cycle of the target species of the Brazilian Action Plan.

Two characteristics make the Brazilian Action Plan for the Conservation of Freshwater Turtles very peculiar. The first is the fact that it is a plan whose target species are not considered endangered, despite being under great pressure. This, together with the fact that IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) is the coordinator of the main conservation program for these species, are the reasons why the Brazilian Action Plan is being coordinated by IBAMA.

The second characteristic is that the sustainable use of target species is one of the main tools for their conservation. It is undeniable that the Amazon freshwater turtles are an important food source for the Amazonian riverside community, therefore, the group that prepared the Brazilian Action Plan believes that it is possible to reconcile sustainable use with conservation. Thus, some of the proposed actions are aimed at testing and regulating the use of the species by breeding or direct management in nature.

The plan was published by Joint Ordinance IBAMA and ICMBIO Nº 1, April 4, 2015 (Appendix). The Technical Advisory Group of the Brazilian Action Plan was made official by the IBAMA Ordinance Nº 527, May 5, 2015 (Table 2).

Monitoring and implementation of the plan

Part of the methodology of the PANs are annual workshops to evaluate the proposed actions. Before these workshops, the coordinator of the Brazilian Action Plan distributes a questionnaire to the articulators, to classify the progress of the actions that are their responsibility, and reports what was achieved, the problems faced, and possible modifications.

During the workshops, the *Grupo de Assessoramento Técnico* – GAT (Technical Advisory Group), as well as people who can contribute to the process, meet to evaluate the answers presented. These workshops are fundamental to identify the main bottlenecks in the execution of the plan and propose solutions that can modify the action, the product, the deadline, the articulator, and even its exclusion.

Each action, according to the perception of its articulator and the members of the GAT, receives the following classification in accordance with the following progression:

- concluded;
- in progress within the forecasted period;
- in progress, but with an achievement problem;
- not started or not completed within the timeframe foreseen;

- started after the achievement of the monitoring;
- excluded or grouped.

To date, four monitoring workshops have been held. The first took place in Manaus/state of Amazonas – AM, at the *Centro de Estudos de Quelônios da Amazônia*/INPA, between April 5 and 7, 2016. The second, at the same location, from May 23 to 25, 2017. The third was held in Brasília/DF, at the headquarters of ICMBIO (Chico Mendes Institute for Biodiversity Conservation), between May 21 and 25, 2018. The fourth was held in Santarém/state of Pará – PA, at the Federal University of Western Pará, between June 4 and 6, 2019.

In a quick analysis of the monitoring, it is possible to see that there has been a clear evolution in the progress of the actions. In the first year of the Brazilian Action Plan, 32% of the actions had not been started or were delayed. In the following years, this number decreased to 3%. Similarly, the actions with progress problems, which corresponded to 44% in the first year, reduced to 24% in the fourth year, and completed actions rose from 10% to 25% between the second and fourth years. (Figure 1).

This shows that the group has matured in the sense of understanding each other role, as well as to better program the actions and, mainly, to have more engagement.

The plan was designed to last 5 years, so that its actions are executed during this period. As the plan was officially published in April 2015, it will end in April 2020. On this date, a final evaluation of the progress will be made and the group will verify the need for a new cycle, of another 5 years, and new specific objectives and actions may be proposed.

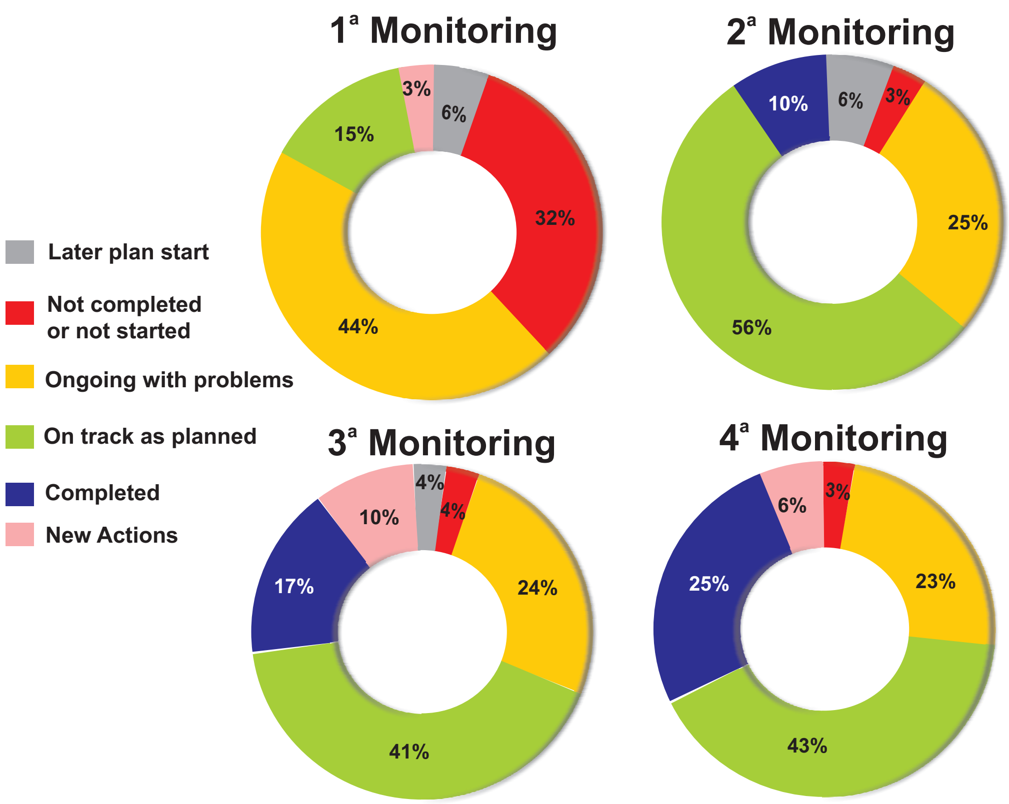

Figure 1 – Classification of the progress of the actions in each of the monitoring workshops.

Table 1 – List of participants of the workshop that prepared the Brazilian Action Plan for the Conservation of Freshwater Turtles

Name	Institution	E-mail	City
Adriana Malvasio	Federal University of Tocantins	malvasio@mail.uft.edu.br	Palmas/TO
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Table 2 – Members of the Technical Advisory Group of the Brazilian Action Plan for the Conservation of Freshwater Turtles (IBAMA Ordinances Nº 527/2015, Nº 54/2017, N 1796/2017, Nº 207/2018).

Name	Institution
Roberto Victor Lacava[1]	IBAMA
Rafael Antônio Machado Balestra	ICMBIO
Priscila Saikoski Miorando	Federal University of Western Pará
Sônia Luzia Oliveira Canto	Environmental Protection Institute of Amazonas
Rafael Bernhard	Amazonas State University
Leo Caetano Fernandes da Silva	IBAMA
Richard Carl Vogt	National Institute for Amazon Research
Paulo Cesar Machado Andrade	Federal University of Amazonas
Juarez Carlos Brito Pezzuti	Federal University of Pará
Camila Rudge Ferrara	Wildlife Conservation Society
Adriana Malvasio	Federal University of Tocantins
Rapahel Alves Fonseca[2]	IBAMA
Jenna Gomes de Souza[2]	SEMA/state of Amazonas – AM
Larissa Barreto[2]	Federal University of Maranhão
José Soares Neto[2]	Ecovale
Marcia Bueno[2]	IBAMA
Bruno Adorno[2]	Aliança da Terra
Rosenil Dias de Oliveira[2]	ICMBIO
Virgínia Campos D. Bernardes[2]	Institute for Ecological Research
Jamile da Costa Araújo[2]	EMBRAPA
Camila Kurzmann Fagundes[2]	Wildlife Conservation Society

[1]PAN Coordinator.

[2] Alternate.

Figure 2 – Photo of the participants of the elaboration workshop of the Brazilian Action Plan for the Conservation of Freshwater Turtles.

Table 3 – Planning matrix of the Brazilian Action Plan for the Conservation of Freshwater Turtles.

SPECIFIC OBJECTIVE 1 – Adequacy of the legal frameworks related to the breeding, commercialization and community-based management of Amazon freshwater turtles.

Nº	Action	Product	Period		Articulator	Estimated Cost (R$)
			Start	Finish		
1.1	Prepare a technical document that consolidates the demands of the sectors of society involved with the breeding and marketing of Amazon freshwater turtle species (IN IBAMA Nº 07/2015).	Report analyzed by MMA and CONAMA	1/1/2015	1/7/2018	Sônia Canto (IPAAM)	R$ 5.000,00
1.2	Prepare proposals for standardization of breeding and marketing of Amazon freshwater turtle in the Amazonas, to adapt to local realities.	Draft standard forwarded to the competent environmental agency	1/3/2015	1/3/2017	Sônia Canto (IPAAM)	R$ 5.000,00
1.3	Elaborate proposal for regulating the protection and breeding of turtles on a community basis in Amazonas	Standardization draft	1/7/2015	1/12/2017	Sônia Canto (IPAAM)	R$ 20.000,00
1.4	Support the elaboration and adequacy of legal mechanisms that enable the implementation of experimental management systems.	Standardization draft	1/12/2014	1/12/2018	Juarez Pezzuti (UFPA)	R$ 50.000,00
1.5	Prepare a proposal for a bill to include the provision of environmental compensation/ conversion of fines directed at the PQA.	Proposal forwarded to the federal legislative chamber	1/3/2015	1/8/2018	Leo Caetano (IBAMA)	R$ 0,00

Nº	Action	Product	Period		Articulator	Estimated Cost (R$)
			Start	Finish		
2.1	Raise information to estimate the illegal consumption and trade of Amazon freshwater turtles through a minimum protocol.	Monitoring protocol and consumption and trade reports	1/3/2015	1/12/2019	Virgínia Bernardes (IPÊ)	R$ 200.000,00
2.2	Generate information to evaluate the population status of the target species of the Brazilian Action Plan and species classified as Data Deficient (DD).	Biannual technical reports	1/3/2015	1/12/2019	Richard Vogt (INPA)	R$ 10.000,00
2.3	Compile, systematize and update information on the population status of species contemplated in the Brazilian Action Plan.	Database	1/3/2015	1/12/2019	Yeda Bataus (RAN/ICMBIO)	R$ 20.000,00
2.4	Compile and analyze information on seizures of Amazon freshwater turtles	Database updated annually and final report (2019)	1/3/2015	1/12/2019	Marilene Brazil (SEMA/state of Acre - AC)	R$ 0,00
SPECIFIC OBJECTIVE 3 – Control of the exploitation of Amazon freshwater turtles' populations, especially target species of the Brazilian Action Plan.						
3.1	Articulate and monitor inspection actions for Amazon freshwater turtles by state.	Inspection plan for Amazon turtles and reports of the results of annual inspection operations.	1/3/2015	1/12/2019	Sônia Canto (IPAAM)	R$ 10.000,00
3.2	Articulate the execution of inspection operations for turtles in federal and state conservation units.	Annual reports of results of surveillance operations in Conservation Units.	1/3/2015	1/12/2019	Ana Paula Lustosa (ICMBIO/RAN)	R$ 3.000.000,00
3.3	Elaborate, compile, implement and strengthen environmental education actions for the conservation of Amazon turtles	Educational material, workshops, training courses, lectures.	1/3/2015	1/12/2019	Camila Fagundes (WCS)	R$ 2.500.000,00

Nº	Action	Product	Period		Articulator	Estimated Cost (R$)
3.4	Implement the monitoring of the nesting areas of Amazon freshwater turtles, according to the Technical Manual of Conservationist Management and Population Monitoring of Amazon freshwater turtles.	Annual technical reports, preferably in Sisqueloniums.	1/3/2015	1/12/2019	Roberto Lacava (IBAMA)	R$ 10.000.000,00
SPECIFIC OBJECTIVE 4 – Standardization of in situ management methods of Amazon freshwater turtle species						
4.1	Conclude the technical manual for conservationist management and population monitoring of Amazon freshwater turtles	Technical Manual published.	1/12/2014	01/06/2016	Rafael Balestra (RAN/ICMBIO)	R$ 30.000,00
4.2	Train the different institutions/actors based on the technical manual for conservation management and population monitoring of Amazon freshwater turtles.	Courses, workshops and technical documents.	1/1/2015	1/12/2019	Paulo Andrade (UFAM)	R$ 1.000.000,00
4.3	Standardize in situ management methods provided for in the Technical Manual for Conservation Management and Population Monitoring of Amazon freshwater turtles.	Deliberation by the PQA Permanent Technical Committee and draft of circular memo	1/12/2015	1/12/2017	Roberto Lacava (IBAMA)	R$ 50.000,00
4.4	Conduct national biennial meetings to evaluate conservation management practices and population monitoring of Amazon freshwater turtles.	Technical report of the workshops with recommendations for the technical manual.	1/3/2017	1/12/2019	Richard Vogt (INPA)	R$ 500.000,00
4.5	Systematize data of reproductive management and population monitoring of Amazon freshwater turtles (Sisquelônios).	System database annually updated.	1/12/2014	1/12/2019	Rafael Balestra (RAN/ICMBIO)	R$ 100.000,00
4.6	Support the implementation of participatory protocols for population monitoring of target species.	Implemented protocols and their results	1/12/2014	1/12/2019	Priscila Miorando (UFOPA)	R$ 500.000,00
4.7	Evaluate and implement experimental community systems of sustainable management.	Results of the experiments.	1/1/2016	1/12/2019	Paulo Andrade (UFAM)	R$ 1.500.000,00

Nº	Action	Product	Period		Articulator	Estimated Cost (R$)
SPECIFIC OBJECTIVE 5 – Review and improvement of *ex situ* management methods of Amazon freshwater turtle species.						
5.1	Implement and evaluate experimental community systems for the breeding of turtles.	Community breeding units implemented.	1/1/2016	1/12/2019	Paulo Andrade (UFAM)	R$ 1.500.000,00
5.2	Elaborate a technical manual for the commercial breeding of Amazon turtle species.	Manual published.	1/12/2016	1/12/2018	Adriana Malvasio (UFT)	R$ 300.000,00
SPECIFIC OBJECTIVE 6 – Create a governance system for the maintenance of conservation actions for Amazon freshwater turtles.						
6.1	Establish cooperation network to protect Amazon freshwater turtles integrating the supporting actors and potential collaborators of the Brazilian Action Plan.	Network established.	1/12/2014	1/12/2019	Sônia Canto (IPAAM)	R$ 50.000,00
6.2	Institutionalize partnerships between the Brazilian Action Plan collaborating actors with governmental and non-governmental spheres of turtle conservation projects.	Cooperation agreements and/or authorizations via SISBIO.	1/12/2014	1/12/2019	Roberto Lacava (IBAMA)	R$ 50.000,00
6.3	Submit projects related to the Brazilina Action Plan to funding agencies	Projects prepared and submitted	1/12/2014	1/12/2019	Richard Vogt (INPA)	R$ 50.000,00
SPECIFIC OBJECTIVE 7— Reduction of noise pollution, ramming and collapse of the banks (ravines/beaches) of rivers where Amazon freshwater turtle occur.						
7.1	Identify sites of occurrence of noise pollution, collision and landslide of the banks of rivers where Amazon freshwater turtles occur.	Report elaborated.	1/1/2015	1/12/2018	Camila Fagundes (WCS)	R$ 0,00
7.2	Elaborate proposals for the flow of vessels with the competent agencies and associated agents, aiming to mitigate the impacts on the target species of the Brazilian Action Plan.	Proposals prepared and forwarded to the Port Authorities (Brazilian Navy)	1/1/2019	1/12/2019	Jenna Gomes (SEMA/state of Amazonas – AM)	R$ 200.000,00

Nº	Action	Product	Period		Articulator	Estimated Cost (R$)
SPECIFIC OBJECTIVE 8 – Identification and monitoring of impacts on reproductive and food habitats, necessary for the life cycle of the target species of the Brazilian Action Plan.						
8.1	Identify and map the main life history areas of Amazon freshwater turtles.	Geospatial information bank relating to species breeding and feeding areas and their respective maps	1/1/2015	1/12/2019	Camila Fagundes (WCS)	R$ 1.000.000,00
8.2	Develop diagnosis of the impact of tourism in areas with data that can subsidize the institutions responsible for the planning of these activities.	Diagnosis developed.	1/5/2016	1/7/2018	Adriana Malvasio (UFT/state of Tocantins – TO)	R$ 10.000,00
8.3	Develop and forward a protocol to guide the survey, monitoring, mitigation and compensation necessary for the process of licensing of enterprises with potential impact on Amazon freshwater turtles, including the flow of vessels of different sizes.	Protocol prepared and forwarded to licensing bodies, and a chapter of the Brazilian Action Plan book.	1/1/2015	1/12/2018	Juarez Pezzuti (UFPA)	R$ 60.000,00
8.4	Produce map of vulnerabilities (large enterprises, deforestation, opening of roads, traffic, dams, among others) relating threat information in nesting and feeding sites of Amazon freshwater turtles.	Map identifying the vulnerable areas.	01/07/2017	01/12/2019	Vivian Mara (RAN/ICMBIO)	R$ 0,00
8.5	Identify possible impacts or conflicts of fishing activity in Amazon freshwater turtles.	Report forwarded	01/05/2016	01/12/2018	Priscila Miorando (UFOPA)	R$ 100.000,00

Table 4 – Matrix of goals and indicators of the Brazilian Action Plan for the Conservation of Freshwater Turtles.

SPECIFIC OBJECTIVES	INDICATOR	BASELINE	MIDTERM GOAL	FINAL GOAL
Adequacy of legal frameworks related to the breeding, marketing and management of community-based Amazon freshwater turtles.	Number of regulations published, as proposed in the Brazilian Action Plan.	0	4	11
	Number of regulated turtle farms.	42	55	84
Expansion of information on the exploitation of Amazonian turtles species.	Number of localities (communities) with consumption and illegal trade of turtles, evaluated.	8	50%	100%
	Number of published population studies (dissertations, theses, articles, etc.) on species of the Brazilian Action Plan.	10	14	18
Control of the exploitation of Amazon freshwater turtles populations, especially the target species of the Brazilian Action Plan.	Number of reproductive sites of the protected target species.	225	248	270
	Number of annual inspection operations for Amazon freshwater turtles.	24	27	36
	Number of communities benefitting from environmental education actions, from the establishment of the Brazilian Action Plan.	0	108	216
Standardization of in situ management methods of Amazon freshwater turtle species.	Percentage of institutions integrated into the protocol of conservation management.	3	50%	100%
	Number of experiments with sustainable management of turtles implemented and evaluated in Conservation Units.	0	1	2
	Number of institutions registered in Sisquelônios.	3	8	15
Revision and improvement of *ex situ* management methods of Amazon freshwater turtle species.	Number of community experimental breeders evaluated.	39	41	44
	Number of commercial farms installed, evaluated for the preparation of the manual.	0	15	20
	Percentage of commercially viable farms, who use the manual.	0	25%	50%
Creation of a governance system to maintain the conservation actions of Amazon freshwater turtles.	Number of institutions involved in the actions of the Brazilian Action Plan.	28	30	40
	Percentage of the total amount provided for in the Brazilian Action Plan, raised by projects.	0	20%	40%
	Number of projects submitted.	0	70	140
	Number of projects approved.	0	7	28
Reduction of noise pollution, collision and collapse of the banks (ravines/beaches) of rivers where the Amazon freshwater turtles occur.	Number of areas classified as critical.	Number to be defined in diagnosis (December in 2015).	A 10% reduction in the number of areas classified as critical in 2.5 years.	A 50% reduction in the number of areas classified as critical in 5 years.
Identification and monitoring of the impacts to reproductive and feeding habitats, necessary for the life cycle of the target species of the Brazilian Action Plan.	Number of recovery projects in reproductive and feeding areas installed/monitored.	2	2	4
	Number of reproductive areas analyzed for presence or absence of impacts.	Indefinite	Indefinite	225
	Number of feeding areas analyzed per basin for presence or absence of impacts.	Indefinite	Indefinite	500
	Number of enterprises with studies and reports evaluated.	0	0	3

ANNEX

IBAMA AND ICMBIO JOINT ORDINANCE Nº 1, OF APRIL 4, 2015.

Approves the Brazilian Action Plan for the Conservation of Freshwater Turtles, establishes its general and specific objectives, actions, execution period, scope and forms of implementation and supervision

THE PRESIDENT OF THE BRAZILIAN INSTITUTE OF THE ENVIRONMENT AND NATURAL RESOURCES – IBAMA, appointed by Decree of May 16, published in the Official Gazette of May 17, 2012, in the use of his attributions provided by art. 22 of Annex I of Decree Nº 6. 099, of April 27, 2007, which approves IBAMA's Regimental Structure, published in the DOU of the following day; and the PRESIDENT OF THE CHICO MENDES INSTITUTE OF BIODIVERSITY CONSERVATION – ICMBIO, in the use of his attributions provided by Decree Nº 7. 515, of July 8, 2011, published in the Official Gazette of July 11, 2011, and by Ordinance Nº 304, of March 28, 2012, of the Chief Minister of the Civil House, published in the Official Gazette of March 29, 2012; Considering MMA–CONABIO Resolution Nº 3, of December 21, 2006, which establishes targets for reducing the loss of biodiversity of species and ecosystems, in accordance with the targets established in the Strategic Plan of the Convention on Biological Diversity; Considering MMA Ordinance Nº 43, of January 31, 2014, which establishes the National Program for the Conservation of Endangered Species (Pro-Species); Considering IBAMA Ordinance Nº 15, of July 19, 2013, which restructures the *Programa Quelônios da Amazônia* – PQA (Amazon Turtles Program); Considering ICMBIO Ordinance Nº 78, of September 3, 2009, which creates the Chico Mendes Institute's national research and conservation centers and confers attribution to them; Considering what is stated in the Files Nº 02001. 001961/2014-61 and Nº 02001.006133/2014-19; resolve:

Art. 1º Approve the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles.

§ 1º The Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles will be effective until January 2020, with annual supervision and monitoring.

§ 2º The coordination of the Brazilian Action Plan for the Conservation of Freshwater Turtles is the responsibility of IBAMA.

Art. 2º The objective of Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles is to improve conservation strategies for Amazon freshwater turtles, especially target species, and to promote actions for their recovery and sustainable use.

§ 1 º The target species of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles are:

I - *Podocnemis expansa*;

II - *Podocnemis unifilis*; e

III - *Podocnemis sextuberculata*.

§ 2º The Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles also considers the following species that occur in the Amazonian Region:

I - *Podocnemis erythrocephala*;

II - *Peltocephalus dumerilianus*;

III - *Chelus fimbriatus*;

IV - *Platemys platycephala*;

V - *Mesoclemmys nasuta*;

VI - *Mesoclemmys raniceps*;

VII - *Mesoclemmys gibba*;

VIII - *Phrynops tuberosus*;

IX - *Rhinemys rufipes*;

X - *Kinosternon scorpioides*;

XI - *Rhinoclemmys punctularia*;

XII - *Chelonoidis carbonaria*; and

XIII - *Chelonoidis denticulata*.

Art. 3º To achieve the general objective stated in art. 2º, the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles has the following specific objectives:

I – propose the adequacy of the legal frameworks related to the breeding, commercialization, and community-based management of Amazon freshwater turtles;

II – expand the availability of information on the exploitation of Amazon freshwater turtle species;

III – control the exploitation of Amazon freshwater turtle populations, especially target species;

IV – standardize *in situ* management methods for Amazonian freshwater turtle species;

V – review and improve *ex situ* management methods for Amazon freshwater turtle species;

VI – create a governance system for the maintenance of conservation actions for the Amazon freshwater turtles ;

VII – carry out actions aimed at reducing noise pollution, collision and collapse of river banks (ravines/beaches) in rivers where Amazon freshwater turtles occur, caused by vessels and other agents;

VIII – conserve and recover reproductive and feeding habitats necessary for the life cycle of the target species of the Brazilian Action Plan for the Conservation of Freshwater Turtles.

Art. 4º Institute the Technical Advisory Group of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles, in order to support, monitor, implement actions and carry out annual monitoring of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles:

Sole paragraph. The President of IBAMA designates the Technical Advisory Group.

Art. 5º The reference documents of the Brazilian Action Plan for the Conservation of Amazon Freshwater Turtles must be made available and updated on the websites of IBAMA and ICMBIO.

Art. 6º This Ordinance enters into force on the date of its publication.

VOLNEY ZANARDI JÚNIOR
President of the Brazilian Institute
of Environment and Renewable
Natural Resources – IBAMA

ROBERTO RICARDO VIZENTIN

President of the of the Chico Mendes
Institute for Biodiversity Conservation –
ICMBIO

Instituto de Desenvolvimento Sustentável Mamirauá · NATURATINS · SOS AMAZÔNIA · IPAAM · Eletrobras · UFAM · UEA Universidade do Estado do Amazonas · UFMA · INPA Instituto Nacional de Pesquisas da Amazônia · UFT · CEUC Amazonas

Aliança da Terra · Instituto Piagaçu · Ecovale · Juruti · Prefeitura de Afuá · Secretaria Estadual de Desenvolvimento Ambiental · Acre · Governo do Pará Secretaria do Estado de Meio Ambiente · IPÊ Instituto de Pesquisas Ecológicas · Embrapa

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