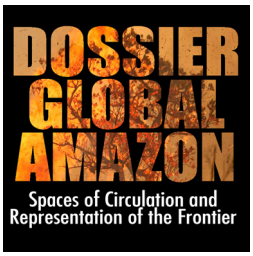
rev. hist. (São Paulo), n.178, a05918, 2019
http://dx.doi.org/10.11606/issn.2316-9141.rh.2019.145623



ARTICLE

THE BRAZILIAN AMAZON, THE WORLD'S BREADBASKET: SCIENCE, AGRICULTURE AND ECOLOGY AT THE AGRONOMIC INSTITUTE OF THE NORTH IN THE 1940S AND 1950S*

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Abstract

This article addresses scientific research conducted at the Agronomic Institute of the North (IAN), a scientific institution created under the Brazilian government's developmentalist policy to promote the agricultural use of the Amazon in the 1940s and 1950s. We place special emphasis on the research related to the so-called "forest ecosystem theory", developed at the institute by the German limnologist Harald Sioli, which guided the following institutional research agenda during these decades: polyculture, the excavation of siltation channels along the Amazon River, the cultivation of food crops, and the development of buffalo ranching. IAN predicted that the Amazon would be the world's breadbasket and a solution to world hunger. The main instrument of this transformation would be the knowledge of its ecology.

Keywords

The Amazon – ecology – The Agronomic Institute of the North – Harald Sioli – agronomy.

* Both authors are responsible for the article's arguments, the documentary research and the bibliographic survey. They also collaborated to develop the theoretical framework and write the text. This research project was funded by Proep – CNPq/Fiocruz/COC/Nº4/2015–2018.

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Introduction

This article discusses research conducted by the Agronomic Institute of the North (*Instituto Agronômico do Norte* – IAN), a scientific institution located in Belém do Pará, created as part of the Brazilian government's developmentalist policy to promote the agricultural use of the Amazon in the 1940s and 50s.

With this paper we seek to engage in a dialogue with recent analytical perspectives about the history of development. Developmental programs and international relations which were in force from the 1930s to the 70s have traditionally been the object of study in various research projects: international diplomacy, military conflict and political tensions between the US and the USSR during the Cold War. In the past years, an extensive bibliography has focused on the actions carried out by multi–lateral agencies involved in geopolitical disputes, as well as on the internationalist and reformist tendencies displayed by development as a supporting program behind economic growth, agricultural reform and public health incentives. Another recent area of research, known as anthropology of development, seeks to understand cultural appropriations and local uses of international developmental patterns by exploring different national contexts.[1]This research agenda is in line with the works by Eric Carter about the uses of ecological thinking in developmental projects, mainly in malaria control programs in the US and in Argentina in the 20th century. In his works, Carter analyzes how statements which claim a universal validity, such as those made by developmentalism, were connected to local circumstances by the very nature of the ecological approach, which is based on the observation of specific interactions between abiotic and biotic factors of the ecosystem. The author analyzes research with an ecological perspective, conducted by professionals from different areas, such as geographers, agronomists, economists, and physicians, and carried out in detailed spatial inventories focusing on environmental management and total administration of regional landscapes in areas of dam construction. The incorporation of ecology in the historical experiences studied by Carter aimed at total planning towards the effective use of natural elements (CARTER, 2007, p. 619–650; 2014, p. 111–127). There are many similarities between the case studies analyzed by Carter and the Brazilian example illustrated by IAN, the focus of our analysis in

[1] For a wider view on this area of research, see Edelman and Hauguerud (2005).

this article: regional problems have also been framed in an ecological perspective in the Amazon in the 1940s and 50s.

In this article we will emphasize the discussion of research related to the so-called "theory of forest ecosystem", developed by the German limnologist Harald Sioli at IAN. This theory guided the international research agenda during those decades: polyculture, the construction of clogging canals in the Amazon river, the use of floodplain areas for food production – such as rice, corn, beans and manioc – as well as the development of bubaline culture on the region's dry land. IAN predicted that the Amazon forest would be Earth's food barn, the solution to the problem of famine on the planet. Knowledge about its ecosystems would be the main tool in the process of bringing about this transformation, a tool good enough to promote regional development.

Studies which are critical of the developmental perspective usually accuse it of privileging Western models in detriment of local specificities and of defending a homogenizing, linear and teleological approach, placing absolute trust on the intended achievements of technoscience. Only recently have the local repercussions and applications of the projects inspired by developmentalism been explored. Having IAN as an object of study as we approach the Brazilian case is part of our intention to contribute to this perspective.

The age of developmentalism

Works of modernization using high technology have been the foundation of political and economic projects on a global scale between the 1930s and 70s. These projects were related to an idea of development which meant, back then, the path humanity was supposed to follow – after the economic crises caused by the First World War and the Wall Street Crash of 1929 – towards the achievements that characterized "advanced" societies: industrialization, urbanization, modernization of agricultural processes, increase in the offer of social services, high standard of material productivity and high quality of life and health indicators (COOPER; PACKARD, 2005; LLEYS, 2005). The adoption and promotion of such projects, especially in the period following the Second World War, were considered key to overcoming the state of "underdevelopment", whose main features were economic slowdown, populational growth, deindustrialization, diseases, illiteracy, malnutrition, famine, poverty and the prevalence of extractive agricultural practices (STAPLES, 2006). Regional, national and international programs and agencies were created in those decades in order to make those projects vi-

able (projects which entailed geopolitical disputes) but, above all, in order to make sure that the main industrial power at the time – the US – would be able to wield its influence in both Latin America and Europe (STAPLES, 2006). State and international apparatuses had the goal to induce, finance and plan the course of modernization in various countries. They were involved in the creation of economic development programs on national level, such as the New Deal in the US (1933); multilateral agencies, such as the United Nations–UN (1945), the Food and Agriculture Organization – FAO (1945) and the World Health Organization–WHO (1948); as well as the implementation of bilateral programs such as the Point Four Program – an international technical assistance program proposed by president Harry Truman in January 1949.The rich historiography on the topic defines these decades as the *Age of Development*. It preached industrialization and a combat against diseases and poverty on a world scale and, in Brazil, the promotion of a modern capitalism based on strict economic planning by the state, its main propeller and intervener.

Important projects and plans, aimed at stimulating industrial and agricultural growth, were implemented in Brazil throughout the whole period: the Ministry of Labor, Industry and Commerce; the National Coffee Council; the Cocoa Institute; the Ministry of Education and Public Health; the National Department of Coffee; the Sugar and Alcohol Institute; the Federal Council of Foreign Commerce; the Code of Minas; the Code of Waters; the General Plan of National Transport; the Institute of Animal Biology; the National Geography Council; the Public Service Administrative Department; the Mate Herb National Institute; the Brazilian Institute of Geography and Statistics; the Public Works Plan and Defense Apparatus; the National Economy Defense Commission; the National Salt Institute; The National Steel Industry Company; the Vale do Rio Doce Company; the National Pine Institute; the National Industrial Education Service; the Economic Mobilization Coordination; the Foundation of Central Brazil; the Volta Redonda Steel Industry Power Plant; the São Francisco Hydro Electric Company; the Consolidation of Labor Laws; the Industry Social Service; the Works and Equipment Plan; the Industrial and Commercial Policy National Council; the Wheat Expansion Service and Superintendence of Currency and Credit (FERREIRA; DELGADO, 2003). Besides the creation of state agencies whose mission was to plan the economy, two other guidelines can be inferred from the economic policy formulated in Brazil during these decades, which Bielschowsky calls "the ideological cycle of developmentalism" (BIELSCHOWSKY, 1988). Firstly, the primacy of occupation and economic harnessing of the geographical

borders in the Center–West and in the Amazon, seen as "demographically empty" and underdeveloped areas. Secondly, the conviction that it would be necessary to promote the development of a national science and technology, since they would allow economic growth in the country. Therefore, there was considerable investment in Science, Technology, and Innovation in the period, as well as the foundation of agricultural research centers, which were regarded as the driving force of economic development.

Science and agriculture

One of the greatest outcomes of the plans for agricultural development in Brazil during the period was decree–law no. 982 of December 23, 1938, which created new agencies of the Ministry of Agriculture. A leading role was assigned to the National Center for Agricultural Training and Research (*Centro Nacional de Ensino e Pesquisa Agrícola* –CNEPA), whose overriding functions at the federal level were to:

> deliver agricultural training; guide, conduct and coordinate all research aimed at the individualization of natural and artificial factors of agricultural production; increase and improve the yield of cultivated plants, modifying, in a positive sense, the physical environment, climate and soil, and creating, through selection and crossing, different varieties of cultivated plants particularly adaptable to the different regions; coordinate all factors of agricultural production, in order to adapt agriculture to the environment, increasing and improving harvests. (BRASIL, 1938a)

The center was comprised of the National School of Agronomy, Institute of Agricultural Chemistry, Institute of Agricultural Ecology, and the Institute of Agricultural Experimentation. The structure of the center was reshaped on December 30 1943 to comprise two key institutions: the Rural University and the National Agricultural Research Service. The latter had the following goals: coordinating agricultural research carried out in Brazil, inspecting the agricultural experimentation institutions, and demarcating the country's natural regions in accordance with their climate characteristics. The service was composed of a national experimental agricultural research network made up of five regional agricultural institutes and their respective experimental stations (BRASIL, 1938a). Created in May 1939, the IAN was the first of the regional agricultural institutes, followed by four others between 1943 and 1946: the Agronomic Institute of the Northeast in the State of Pernambuco; the Agronomic Institute of the West, in the State of Minas Gerais; the Agronomic Institute of the South, in the State of Rio Grande do Sul; and the

Agronomic Institute of the East, in the State of Bahia. It should be emphasized, however, that the North remained the first priority. The Amazon was defined as a strategic region by the State since it represented more than half of the Brazilian territory, more than two thirds of the country's border and over four fifths of its forests. Besides, the rubber economic cycle was past its golden period at the time. At the beginning of the 20th century, the center of rubber production in the world had shifted from Pará and Amazonas to the forests of rubber trees in Malaysia. Native to the Amazon, the rubber tree, or *Hevea brasiliensis*, seemed to thrive in Southeast Asia. Among other reasons for this was the fact that it was not assaulted by plagues, such as the fungus known as leaf malady, present in Brazil at the time (DEAN, 1989; WEINSTEIN, 1993). Due to a drastic economic decline, the region was considered by many government officials the least developed in the country (BRASIL, 1954). The diagnosis of economic underdevelopment in the Amazon region led to the creation of several state institutions dedicated to regional development, such as IAN. The Institute was founded to solve the problems related to the rubber economy in the Amazon, as well as to stimulate local agriculture. The federal version of the program included the production of raw materials and food to be absorbed by the national economy.

During the same period and in the same conceptual frame, we can trace the career of the agronomist Felisberto Camargo (1896–1977), who had become a director with IAN soon after its foundation. Camargo graduated from the Luiz de Queiroz College of Agriculture (*Escola Superior de Agricultura Luiz de Queiroz*[2] – ESALQ) in 1917 and undertook postgraduate studies in tropical fruit growing at the University of Florida between 1919 and 1920. He also founded the School of Agronomy of the Amazon (*Escola de Agronomia da Amazônia*) in 1945 and was director of the National Agricultural Research Service (*Serviço Nacional de Pesquisas Agronômicas*) between 1952 and 1957, and of the National Center for Agricultural Training and Research between 1955 and 1957 (FERREIRA; QUADROS, 2011).One of the hallmarks of his administration at the IAN was research and policies aimed at promoting the agricultural use of the Amazon, notably field trials for the introduction and domestication of animal and plant species conducted in the region formerly conceded to the Ford Motor Company's, known for this reason as Fordlân-

[2] On the history of the institution see: Perecin (2004), Mendonça, (1998) and Habib (2010).

dia, located in the lower reaches of the Amazon.[3] This state, with an area of one million hectares, was located on the banks of the River Tapajós a day–and–a–half boat trip from Santarém, in the State of Pará. The Agronomic Institute of the North was created by the decree–law no. 1,245 of May 4, 1939. Conceived to drive agriculture in the Amazon, it received a significant amount of funding at the time. In a speech given in Belém in the 1940s, the then president of Brazil Getúlio Vargas outlined the functions of IAN:

> a fully–equipped center of research into the wealth of the forest in the Amazon valley, for the purpose of classifying it, as well as of enhancing and developing experimentation fields, with a view to replacing the old extractive processes by methodical and scientific agriculture. Designed to serve the whole region, this institute shall promote systematic planting, not only of the rubber plant, (…) but also of those various native and acclimated plant species (…), in order to supply, free of charge, early production

3 This project was started in 1928 to supply latex to Ford's factories in the United States. Fordlândia had hundreds of prefabricated houses, warehouses, a hospital and various stores. In the middle of the forest, Henry Ford (1863–1947) sought to replicate the business model that made him the world's first automobile magnate. He was obsessed with mastering all stages of the industrial production chain. And, for him to master the complete cycle, all that was missing was the production of latex, the raw material of tires. In July 1927, Ford succeeded in obtaining a free concession from the Brazilian government to produce rubber in the region. The agreement anticipated an annual payment equivalent to 7% of the profits of production to the Brazilian State and 2% to local municipal governments; but only after the first 12 years of operations. By 1928, the Brazil's rubber production had been overcome by the production from Southeast Asia. For Ford, however, Brazilian production of competitively priced latex could be revived by simply employing the mass production logic in the rubber plantations of Pará. In the Amazon, approximately five rubber trees grew per 10,000 m² of forest. Using traditional extractive practices, rubber tappers would spend weeks in the forest collecting latex. In the eyes of Ford, the extractive method was incomprehensible. In Fordlândia, hundreds of thousands of rubber trees would be planted in a much smaller area to maximize collection in the shortest possible time. Latex extraction would be timed. His goal was to plant 70 million rubber plants. The concentration of plants favored the worst pest of the rubber plantation, the *mal das folhas (leaf malady)*, a fungus that destroyed the leaves and killed the tree. The fungus was endemic to the forest, but the monoculture in small areas gave rise to a veritable epidemic of the disease in the plantations of Fordlândia. Furthermore, workers carried out numerous protests against the strictness of the routine. In 1945, with the advent of synthetic latex, Fordlândia descended into bankruptcy and was transferred to the government for a sum of US$250,000. In the same year, the spoils of the Ford Motor Company were transferred to the IAN (GRANDIN, 2010).

> seedlings (…) and develop, at the same time, modern plant cultivation and acclimatization processes. (VARGAS, 1941, p. 55–58)

The choice of location for the IAN was subject to technical and political debate within the Ministry of Agriculture. The advantages and disadvantages of different locations – Maranhão, Pará, and Amazonas – were considered, but the option fell on Belém, capital of the State of Pará. A commission made up of agronomists from the agricultural department chose, after studies of the initial location for the headquarters, a place called Fazenda Murutucu, on the banks of the River Guamá, with an area of 3,000 hectares made up of *terrenos de várzeas* (land subject to seasonal flooding by white waters), *terras firmes* (higher ground not subject to seasonal flooding), and *igapós* (land subject to seasonal flooding by black waters). The activities only started in December 1940 with the preparation of areas to build tree nurseries where rubber plants and Manila hemp could be cultivated.

A team of technicians from the Agronomic Institute of Campinas was appointed a year later, in 1941, to coordinate the activities of the IAN. The team was made up of experts in cytology, genetics, and horticulture, and included Felisberto Camargo, who was appointed director in April 1941 and remained in the post until 1952. In 1945, the headquarters were moved to Fordlândia.

IAN's research program included the gradual conversion of the extractive economy into an agricultural one, tantamount to the colonization, settlement, and national integration of the Amazon region.

Besides significant funding from the Vargas government, the institute received support from the U.S. Department of Agriculture (USDA) beginning in 1940 (GARFIELD, 2009, 2014; MENDONÇA, 2010). In charge of the promotion and development of tropical agriculture in the Americas as conditions for full trade privileges with the United States, the Bureau of Plant Industry and Office of Foreign Agricultural Relations developed a wide-ranging program to promote research and support the systematic cultivation of rubber and pest control, which was implemented by the IAN (BRASIL, 1943a, p. 51; 1943b, p. 142). In 1942, with the advent of the Washington Agreement to encourage the supply of rubber and minerals to the American economy as part of the war effort (CAMPOS, 2006, DEAN, 1989), the IAN began to receive additional funding and support from the United States in the form of infrastructure and technicians to set up laboratories. The most fruitful scientific collaboration was the Brazilian–American Food Commission (*Comissão Brasileiro-Americana de Gêneros Alimentícios*), a bilateral agreement signed in September of the same year (BRASIL, 1943c, p. 2139). This agreement aimed

at providing technical assistance, seeds, agricultural machinery, and credit to promote horticulture, poultry and fish farming in Brazil's North and Northeast . It focused particularly on increasing the production of maize, beans, rice, manioc and potato in these regions (BRASIL, 1943b, p. 143). The program, implemented in partnership with state governments, concentrated on the Amazon, or more specifically, on the states of Amazonas and Pará (BRASIL, 1943b, p. 146). The goal was to transform the Amazon region into a giant laboratory farm under the guidance of scientific agriculture, for which the IAN would be the most important spearhead in the region (GARFIELD, 2009, p. 30). Its applied research agenda emphasized elements related to the disturbance of biological balance. This theme was a constant presence in areas of study then called agricultural ecology or "scientific agriculture", as well as in regional research institutions from different countries (PALLADINO, 1996). It was assumed that every agricultural practice was aggressive to the natural dynamics of the vegetation and the role of such institutes must have been to mitigate the damages caused by the simplification of ecosystems, thus preserving the productivity of different plant species (ACOT, 1990). The IAN developed its activities through two large services, each with specific work sections. The first was the biological research service, which was subdivided into the following sections: phytopathology, chemistry, rubber technology, experimental works, entomology and parasitology, cytology, horticulture, plant introduction, agricultural botany, and genetics. The second was the rural engineering and technology service, subdivided into the following sections: soil, agricultural climatology, irrigation and drainage, and soil conservation. In addition, the institution had the following sectors and commissions: the design and photography sector, the documentation and statistics sector, the experimental coordination commission, and the seminars and lectures commission (ALBUQUERQUE; LIBONATI, 1964, p. 13–33). The institute had experimental sections in the States of Acre and Maranhão and in the federal territory which today is the State of Rondônia. In 1943, the Economic Expansion Section and Laboratory of Rubber Technology were created and in 1944 the Plant Improvement Section was established. The IAN created the Phytopathology Service using the Fordlândia collection and conducted studies on the introduction and interspecific hybridization of different species of the genus *Hevea* to create high-yielding clones resistant to the fungus *mal-das-folhas* (CARMARGO, 1948). According to technical reports, IAN's research priorities between 1942 and 1949 were artificial selection, genetic improvement, and acclimatization of plant species. In 1942, the organization performed studies on grafting of the rubber tree plant, spac-

ing, and fertilization of rice and maize varieties (INSTITUTO AGRONÔMICO DO NORTE, 1942). Reports were not found from1943 to 1945. In 1946, the research focused on sweet potato and cocoa improvement (INSTITUTO AGRONÔMICO DO NORTE, 1946), while in 1947 the emphasis was on cocoa, manioc, and banana (INSTITUTO AGRONÔMICO DO NORTE, 1947). In 1948, the focus turned to jute, rice, manioc, tomato, pineapple, and coconut. In the same year, records show that specific studies on forest farming were conducted in areas of *terra firme* on the institute's lands, specifically aimed at the improvement of the Brazil nut and oil palm trees and determining the insecticidal properties of the plant *timbó* (INSTITUTO AGRONÔMICO DO NORTE, 1948). In 1949, activities concentrated on research into the selection and acclimatization of varieties of *babaçu*, cocoa, rice, and manioc (INSTITUTO AGRONÔMICO DO NORTE, 1949), while in 1950, reports underline studies in the areas of pedology and limnology (INSTITUTO AGRONÔMICO DO NORTE, 1950). Regarding these areas, it is important to highlight the creation of IAN's hydrochemistry laboratory in 1945 for the analysis of water from the Amazon's waterways and rivers, initially from the River Tapajós, and the appointment of the German limnologist Harald Sioli as a researcher at the lab. Most studies developed by Sioli during his time at the IAN (1945 to 1954) consisted of the collection of hydrobiological material through various expeditions into the Amazon's interior . By studying the waters of the Amazon, Sioli elucidated the main processes involved in shaping the region's ecosystem. Based on his findings, he began to defend agricultural development initiatives that took into account the dynamics of the relationship and dynamics between water, the vegetation, the fauna and the soil.

Harald Sioli in the Agronomic Institute of the North

The German biologist and limnologist Harald Felix Ludwig Sioli (1910–2004) came to Brazil in 1938 with the initial aim of carrying out research into the phenomenon of "hibernation" during the dry season in a species of frog in the Caatinga, in the country's northeast region. His interest in this phenomenon was aroused when he took part as an assistant in an expedition to the northeast between 1934 and 1935 led by the biologist Friedrich Lenz.[4] His

[4] According to Sioli (2006, p. 288), Lenz's expedition, linked to the Institute of Limnology of the then Kaiser Wilhelm Society (as from 1948, the Max Planck Institute), was dedicated to the study of the reservoirs of the semi-arid lands of the Northeast Region of Brazil and he was

return to the country was made possible three years later by an exchange agreement between the Reich Research Council (*Reichsforschungsrat*) and the Biological Institute of São Paulo (*Instituto Biológico de São Paulo*), thanks to the efforts of its director, Henrique da Rocha Lima.[5]The study on frog "hibernation" during the dry season did not prosper. During one of his trips to the northeast, Sioli headed to the Amazon, more specifically to Belém, where he contacted the Swiss zoologist Gottfried Hagmann at the *Museu Paraense Emílio Goeldi*.[6] Hagmann showed him the Amazon region, according to Sioli, a "decisive experience" that steered his career towards a new direction (SIOLI, 2007, p. 15). Back in São Paulo, he applied for a scholarship at the Reich Research Council to carry out research into the waters of the Amazon. The agreement between the Council and the São Paulo Biological Institute was expected to last until August 1939. The outbreak of World War II in August 1939 prevented Sioli from returning to Germany. In October 1940 he went to Belém, where he embarked on a journey throughout various regions of the Amazon River basin. The journey was interrupted when Brazil joined the war in 1942. Accused of being a spy, Sioli was imprisoned in the Tomé-Açu prison camp, where citizens from the Axis powers were held. He remained there until September 1945. Before these events, he had applied for a position in the Agronomic Institute of the North. Sioli went directly from the prison camp to Belém to take up his new post. He lived in an accommodation provided by the institute for researchers on the outskirts of the capital. According to Sioli, he received a warm welcome, which was not to be taken for granted considering the climate of hostility he had witnessed during the war. He also mentioned that IAN's laboratories were well equipped. In his

invited by the director of the Pisciculture Service of the Northeast (*Serviço de Psicultura do Nordeste*) to take part in the mission.

[5] On the role of Henrique da Rocha Lima in mediating academic exchange between Brazil and Germany see Silva (2011).

[6] Gottfried Hagmann (1874–1946) was zoology assistant and Inspector of the Zoological Garden at the Museu Goeldi between 1899 and the middle of 1904. Misunderstandings with the creator and then director of the Museu Emilio Goeldi led to his departure from the organization to work for a rubber plantation on Ilha Mexiana located at the mouth of the Amazon (SANJAD, 2010, p. 209). According to Sanjad, he returned later to Basel, but came back to Brazil around 1910, living in the region of Santarém up to his death in 1946 (SANJAD, 2010, p. 228). In his memoirs, Sioli (2007, p. 13) mentions that Hagmann purchased a farm, fazenda Taperinha, in Baixo Amazonas, where he lived with his family and built a meteorological station. According to the work organized by Papavero and Overal about the property and Hagmann, the area became an important center for research in natural history and received a number of scientists (PAPAVERO; OVERAL, 2011).

memoirs, Sioli highlights the flexibility of the science division and Felisberto Camargo's "wide general vision of agricultural research" as especially positive factors (SIOLI, 2007, p. 132). Sioli also alludes to the liberty and autonomy that he was afforded by Camargo, confirmed by his wide range of research interests during his time at the IAN. A large well-equipped laboratory was made available to him, where he undertook his research into the waters of the Amazon which, until then, had been restricted to the collection of hydrobiological material using the scant equipment that he had brought from Germany or purchased in São Paulo. At the IAN he was able to perform hydrochemical analyses of the waters collected in the different rivers, lagoons, lakes and streams he visited on his journeys through the Amazon between 1940 and 1942. For Sioli, the study of water chemistry was an ideal point of departure to understand the ecology of the Amazon basin 's landscapes, since they act as links between larger landscape units "from which they receive their individual characteristics" (SIOLI, 2007, p. 134).[7] With this objective in mind, Sioli began to equip his hydrochemistry laboratory to enable him to conduct quantitative analyses of the composition of water. Besides the chemical analyses performed in the hydrochemistry laboratory, a large part of the studies developed by Sioli at the IAN consisted of the collection of hydrobiological material and *in situ* observations made during various expeditions to the interior of the Amazon.

During his six months in Belterra, Sioli carried out a series of short expeditions to neighboring regions focusing on the study of the region's waters. This research involved hydrobiological sampling and chemical analysis, as measurement of pH and carbon dioxide, bicarbonate and organic matter content. He found out the waters were generally chemically poor, which he interpreted as a sign of impoverished soils. This assumption was confirmed by subsequent experiments and agronomic studies (SIOLI, 1951, p. 32). These findings provided the initial platform for one of Sioli's main contributions to the understanding of the ecology of the Amazon. According to Sioli, the waters that circulated in the region's ecosystems acted as "renal systems" of

[7] In other publication, he asserted: "One of the most important factors of Amazonian nature is water. It occupies a considerable area in this region (…) Water has played and continues to play a decisive role in the formation and transformation of the landscape. For populations in the interior, rivers and lakes substitute roads and furnish the basis of the diet with their fish, turtles, aquatic birds, etc. In studies of pure science, to understand the Amazon region as a whole, water should be considered as the most characteristic factor of the '*hileia*' complex" (SIOLI, 1951, p. 4).

the catchment area, whose final metabolites were removed and transported to the ocean. The poor chemical quality of the waters – and, consequently, of the soils – was interpreted by Sioli as a sign of lack of reserve substances in the soils, which should otherwise be liberated through decomposition by atmospheric and biological action and thus made available as nutrients for plant growth. Contrary to what the exuberance of the vegetation might suggest, the Amazon soil was characterized by an extreme lack of nutrients and reserves. This immediately gave rise to the following question: how could such poor soils maintain such a dense tropical forest in *terra firme*? Observing the root system of a fallen tree, Sioli noted that its roots were extremely superficial. In addition, he observed that the majority of the animals in the region spent most of their lives in the forest canopy. The product of digestion did not reach the forest floor, but rather ran down the trunk in rainwater, falling directly on the roots and thus did not act as nutrient repositories. For Sioli, the growth and maintenance of the forest relied on an extremely closed cycle among plants, animals and microbes, etc., whereby losses were reduced to a minimum. The Amazon soil thus only acted as a physical support for the forest. Only a thin surface layer was involved in the circulation of metabolites. Instead of forming humus, decomposed organic matter was immediately reincorporated back into the forest biomass. According to Sioli, the closed circulation of substances involved decomposition in various smaller cycles, through which the development of the characteristic biodiversity of the Amazon would have been possible. The same system did not apply to *várzeas*, where flooding led to deposits of organic compounds and the consequent renewal of soil nutrients. Sioli believed that this theory was essential to understand the ecology of the Amazon Forest: "for me today, this seems to be the most important scientific finding of my work on the Amazon" he wrote in his memoirs (SIOLI, 2007, p. 153).[8]Besides the studies that led to the development of this idea, Sioli observed in Belterra the formation process of the so-called *"terra preta"* (black earth). He attributed it to the activities of indigenous peoples over the centuries, principally the burning of forest vegetation. He also visited the so-called *"campos"* (plains) between the banks of the River Tapajós and the plateaus and observed the shape of the Lake Grande Curuai, a lake near Santarém, where he noted cattle raising activities in various areas. In Fordlândia, he examined the streams that ran through

[8] For more on Sioli's theory, which is the fulcrum of his understanding of the ecology of the Amazon, also see Sioli (1985a).

the rubber plantations. The higher pH of the waters, compared to those in Belterra, suggested that the subsoil had nutrient reserves.

Interested in comparing the composition of the waters in Belterra with those of areas with a similar geological formation, Sioli headed to Tomé-Açú, where he found that the waters had the same level of acidity but, unlike those in Belterra, flowed through a region that had been cleared.

Upon analyzing the potential of the Amazon for agricultural development, Sioli highlighted that the lack of nutrients and reserves in the soils in regions of *terra firme* made them unsuitable for crop production and more apt for silviculture.[9] In his opinion, the annual production of short-cycle crops should be concentrated in the *várzeas*, which were fertile due to their young alluvial soils, rich in nutrients: "Currently, *várzeas* are the most important zones in the Amazon valley for rational agriculture and their importance for this purpose will tend to grow more and more in the future", Sioli forecasted (1951, p. 17). The idea of using areas of Fordlândia previously used for rubber production for cattle ranching took shape. Camargo even went as far as putting Nelore cattle in some areas, which Sioli viewed as problematic. It would be more appropriate to create pastures in areas of *terra firme* with alluvial soils from the lower Tapajós region. In the dry season, these areas could complement grazing areas and throughout the rest of the year be used for grazing water buffalo that were introduced to the Island of Marajó in the nineteenth century and had become wild. For Felisberto Camargo, ideally, buffalo could be raised on alluvial lands, without harming the potential biological productivity of these areas. Camargo and Sioli visited the region around the Tapajós and the rubber plantations. They aimed to evaluate the best way of using these areas for agriculture. At the beginning of 1949, Camargo decided to purchase a larger piece of land close to the River Tapajós to raise cattle. Resuming his research activities in Belém, Sioli soon went on another field trip, this time to the *várzeas* of the lower Amazon river region. According to Sioli, Felisberto Camargo had already realized that *várzeas* were different to *terra firme* because of their soil, which was rich in nutrients, deposited through annual flooding by white waters with high concentrations of suspended solids. For this reason, they were more suitable for agriculture

[9] "The crops extract the last nutritious substances from the soil and are finally taken by the harvest. Later, the impoverished soil becomes almost sterile and, as a legacy of agricultural activity, we find vast devastated zones, now useless and covered only by a rickety secondary forest, which is called '*capoeira*'" (SIOLI, 1951, p. 33).

than *terra firme*. Furthermore, according to Sioli, Camargo wanted to promote the rational agriculture aimed to optimize crop production and to this end concentrated on technical assistance and improving agricultural practices.

The Amazon – "breadbasket of the world"

From IAN's perspective, Sioli's research findings did not invalidate Alexander von Humboldt classical theory, formulated in the 19th century, according to which the Amazon could be the "breadbasket of the world" due the huge potential of its soil and forests. Such findings were celebrated by Felisberto Camargo as the biggest scientific contribution to the promotion of agriculture in the Amazon – and not only that. That was the point of view defended by Camargo in the international events he took part in during those years, such as the Inter-American Conference on Conservation of Renewable Natural Resources, held in Colorado (US) in 1948. Camargo called it "the theory of forest ecosystem" and claimed that only with this theory was it possible to understand the circulation of mineral resources and the conservation of soil fertility in humid tropical areas. In 1949, the same theory was embraced in Wisconsin, US, in a summit on the "Itinerant Agriculture in Tropical Forests" (CAMARGO, 1949). On such occasions, Camargo also suggested that monocultures could not do well in a humid tropical climate. He argued that, in these regions, a great number of plant and animal species were interconnected by multiple and fragile mutual relations. Replacing this ecosystem with monocultures was to risk having an alien species invading and devastating the plantations. Sioli's theory led to a spatial reclassification of the crop areas of the IAN as *várzeas* located in the estuary and *várzeas* in the interior. Furthermore, it reinforced a focus on specialization in crop production through the artificial reproduction of natural phenomena of tides and riverine flooding. Given the assumption mentioned above that the *várzeas* were suitable for annual crops because their fertility was renewed by flood deposits, "causing" floods in controlled periods of time would suffice to multiply the production of short-cycle crops, such as rice, maize, beans, and manioc in *várzeas* rich in nutrients located on the banks of rivers of the Amazon region (SIOLI, 1951, p. 17). The *várzeas* in the interior of the Amazon suffered from major flooding, to a depth of four to five meters, caused by the rise in levels of the Amazon River during a period of six to seven months each year. These areas were the target of IAN's most grandiose project of the 1950s, based on Sioli's research: siltation channels, also aimed at expanding

the area of land under cultivation.[10]Despite covering a reasonably large area, IAN's lands dedicated to research on crop production and animal husbandry did not include areas with similar characteristics to the *várzeas* of the lower Amazon region. In October 1949, the institute purchased a piece of land with these characteristics located on the northern banks of the Amazon River between Santarém and Cacoal Grande, where Felisberto Camargo developed his plan to build these canals. Their purpose was to drain the waters of the Amazon into the interior of Lake Grande de Monte Alegre, following a natural process whereby the waters drained from the river through a hole would lead to the formation of sediment deposits in the lake. The siltation channels increased the sedimentation of solid matter carried by the Amazon River, preventing it from being transported to the sea. The sediment served to increase the area under cultivation, particularly where jute and pasture production was intended. Sioli's role in this major undertaking was to determine the quantity of suspended solids transported by the river into the interior of the lake in order to calculate the time necessary to form these areas of sediment (SIOLI, 2007, p. 167).A total of five siltation channels were excavated, although Camargo planned to dig 10 by December 1952 to divert waters and mud from the Amazon River to the interior of Lake Maicuru in Monte Alegre. With an optimistic outlook, the institute diversified its basic research program. Research into artificial selection, genetic improvement and acclimatization of plant species began to include black pepper, oil palm, soy beans, sugarcane, beans, cotton, and fruits such as pineapple, coconut and avocado, as well as rice, cocoa, and jute, which were already the object of systemic studies (AlBUQUERQUE; LIBONATI, 1964). A detailed report on "The use of Amazon floodplains for intensive food production" was presented in 1951 to CNEPA, illustrating the application of Sioli's theory to the diversification of the Institute's accountabilities:

> Dryland forests in the Amazon region have only but fueled the fantasies of men of letters and a few scientists.
> This great green mantle that covers the Amazon plains has deceived men, both those native to the region and foreigners, and only recently has the truth been uncovered.

[10] The idea of siltation channels emerged from the observation of sediment transport and sedimentation processes in the muddy waters of rivers like the Amazon, which intensified during flooding upon reaching the *várzeas*. Sioli meticulously describes this process in (1951, p. 45–65).

> As a rule, the Amazon drylands, mainly formed by sediments which are thousands of years old, are poor in the mineral elements essential to sustain intensive cultures.
> Above all, lands from the "tertiary", which are part of the drylands in the Amazon plains, are very poor and do not contain enough mineral reserves to sustain intensive cultures. In such regions, minerals, which are indeed available, reside in plant tissues and in the water circulating in the soil. The land itself is extremely poor. Its fertility runs out in less than 4 years.
> However, the Amazon flood lands (…) may potentially be used for the intensive production of food and development of agriculture at a rate which could live up to Humboldt's dream. (CAMARGO; CARVALHO, 1951, p. 1)

In the same period, the press presented further data which recognized the alliance between basic and applied science at IAN as potentially able to solve the problem of world famine in the short term.

> Rice will be the main Amazon cereal: IAN reaps, without fertilization, from 3,500 to 5,000 kilos of rice per hectare. The Brazilian average is 1,500 kilos; the North American, 2,390; the Indian, 1,180; the Japanese, 3,750; the European, 4,080; the Argentinian, 3, 390. (…) The Amazon will be able to produce incalculable amounts of banana (…) The Amazon can also produce, on an almost astronomical scale, beans, soy, manioc, sweet potato, pumpkin, watermelon and many other annual cultures. (AMAZÔNIA…, 1952; VALORIZAÇÃO…, 1953)

About the rice culture, Camargo also stated that, in an area equivalent to 10% of the forest flood lands in the Amazon estuary, it would be possible to produce 400 thousand tons of rice, in years of consecutive cultures, in the same land and without artificial irrigation. According to him, the production would be more than enough to eliminate the cereal world deficit.

> The proposal championed by the IAN thus focused on polyculture, or so–called "forest agriculture", a general model that could be applied to promote the economic exploitation of land throughout the world's humid tropical regions. This model envisaged the organization of plantations around nuclei of small farmers, each dedicated to specific crops and with the additional aim of encouraging farmers to settle permanently in the region. The residential areas would be located in the dividing boundaries between the *várzeas* and *terra firme* (CAMARGO, 195–?). However, the project did not get off the drawing board. Another ramification of the research on the potential of areas in the region was the fate of *terras firmes* with poor soils in Fordlândia, which IAN had planned to use for cattle raising. The institution's beef production program, as mentioned above, initially envisaged the large–scale production of Nellore cattle. Subsequently, water buffalo would be transferred to lowlands (*terras baixas)* for breeding, as well as meat and milk production, and traction. In 1951, the IAN expanded its cattle raising activities after purchasing Jersey cattle, considered by experts at the time and still today

to be the best dairy cattle breed. In 1952, Camargo went to Pakistan to select groups of Sindhi cattle, also considered excellent for milk production. His idea was to cross the Jersey with the Sindhi to create a new breed of dairy cattle, probably the best in the world, for the development of cattle ranching in the Amazon (APERFEIÇOAMENTO…, 1956; CAMARGO, 1956). His trip provoked a veritable scandal and led to Camargo's exit from the IAN, occupying the pages of the newspaper *Jornal do Pará* and magazine *O Cruzeiro* (MOREIRA, 1952, p. 126–136). Camargo faced opposition from the Department of Agriculture of the United States, from cattle producers from the *Triângulo Mineiro*, an important region for cattle breeding, and from the Department of Animal Research of the Ministry of Agriculture, which claimed that importing Sindhi cattle would bring rinderpest to the American continent. After two months in Pakistan, the plane that brought Camargo and the animals did not land in Belém, but rather on Fernando de Noronha Island, for quarantine purposes. Camargo spent two days on the island, while the cattle stayed there for 15 months. The cattle were liberated only after Camargo had stood down as directorof the IAN to take up the leadership of the National Agricultural Research Service, where he remained until 1957. Regarding this matter, he was also summoned to appear before the Senate in 1955 to provide further clarification.

Despite efforts to promote development through activities that were sensitive to the characteristics of the Amazon ecosystem, as it can be seen, the consequences were catastrophic, both in environmental terms and for institutional and individual reputations.

Final considerations

The reports produced by the IAN during the period covered here not only mention major projects: pests, budget constraints, disputes with the Rubber Credit Bank (*Banco de Crédito da Borracha*) about the lawful control of Belterra's rubber plantations, continuous disputes with the Pará Trade Association (*Associação Comercial do Pará*), and understaffing also marked the institute's daily routine. Strictly speaking, none of the projects planned by the IAN under the leadership of Felisberto Camargo took root. The Second World War once again placed Amazon rubber at the center of global interests. However, with the end of conflict and the emergence of synthetic rubber, Brazilian production once again faced collapse. The agreement with the United States that had guaranteed Brazilian sales at twice the world market price had expired. The market for Sindhi cattle did not experience expansion. The siltation channels caused silting in parts of the bed of the Amazon River, expanding the land area available for the production of jute and pasture. However, silting extended across the whole of Lake Maicuru, affecting aquatic fauna and, consequently, fishing. The buffalo ranching and

jute cultivation activities promoted by the IAN led to the clearing of large areas of the region's forest.

Memorial narratives of the Agronomic Institute of the North define the ecology practiced at the IAN simply as the sustainable use of natural resources. One of the many questions that motivated us to carry out this study is how this anachronism affords not only coexistence, but also synonymy between developmentalism and the protection of nature within public policies directed at the Amazon.

We have sought to show that ecological concepts were part of the body of knowledge that informed these development projects in the Amazon region and framed the adaptions made to the developmentalist program itself. As a matter of fact, IAN sought to design modernization projects that could be in conformity with the ecology of the Amazon region. These concepts made a decisive contribution to shaping ecology as a scientific specialty and to its acceptance in the institutional settings of the Brazilian state.

Sioli's studies on the Amazon region, in their turn, covered the intricate relations between the different landscape elements and the human populations. The analysis went from a microscopic level – the chemical components in the water as well as its microbiota – to the processes of geological formation and its role in the formation of the hydrographic basin, as well as opportunities to occupy the area and profit economically from it. Concerning his individual career, he was later able to go deeper into his research. The general outline of his agenda for the Amazon ecology had been made during his journeys through the rivers and forests in the region. First as a scholarship holder with the German Research Council as an IAN researcher and then, from 1955 onwards, as director of the limnology sector with the Amazon National Research Institute (INPA). In this period, he combined field observations with lab analysis. In 1956, he went back to Germany, where he took over as director of the Limnology Station, connected to the Max Planck Institute.

The Amazon remained his specialty and main area of interest. Sioli established himself as a key figure in the field of Amazon ecology, being co-responsible for the creation of what is currently known as "tropical ecology", becoming, in 1966, director of the tropical ecology department in the Max Planck Institute for Limnology, in Plön (now the Max Planck Institute for Evolutionary Biology). He formed a group of researchers dedicated to investigation of a number of different aspects related to the Amazon ecosystems. In 1969, the increased international cooperation between German and Brazilian researchers was made official through an agreement between the

Max Planck Institute and the CNPq. It was decided that the INPA would be the institutional HQ of this collaboration.[11]

Sioli also contributed to the institutionalization of the sciences connected to the Amazon environment by creating, in 1965, in partnership with Djalma Batista, the "Amazoniana", a journal specially designed to the publication of limnology and landscape ecology.

With regard to the individual path taken by Harald Sioli, the research he conducted at IAN consolidated his approach to the study of the ecology of the Amazon. It also propelled him toward becoming one of the leading international experts on the matter. This reputation sealed his role as a fierce critic of development projects in the region in following years, particularly during the military dictatorship, when the government escalated interventions, presented as symbols of modernization and occupation of this supposedly "demographically empty" region. By identifying the central role played by the waters of the region, not only in the natural, but also in the social and cultural formation of the Amazon, Sioli unveiled the complex elements that make its ecology so unique. Thenceforth, he sought to formulate development strategies based on agricultural activities and optimization of extractive practices. His voice in defense of sustainable development, before this concept came into use, reverberates to this day. The defense of initiatives to promote improved living conditions for those living in the Amazon – from forest peoples to the migrants that settled there –, sensitive to the *modus operandi* of the ecosystem and to the customs of traditional societies is, now more than ever, pressing. The resilience of the leitmotifs that stimulate actions which promote development in the Amazon is an unfortunate and surprising fact, especially now, when the consequences of the devastation of that biome are more clear than ever.

[11] About INPA and the history of its foundation, having its origins in the International Institute for the Amazon Hileia, see Maio (2001, 2004), Maio and Magalhães (2005), Magalhães and Maio (2007), Maio and Sá (2000), Maio et al. (2005).

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Received: 25/04/2018 – Approved: 26/11/2018

Editores responsáveis pela publicação:
Júlio Pimentel Pinto e Flavio de Campos

Organizadores do Dossiê
Amazônia Global: Espaços de Circulação e Representação da Fronteira:
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