

## RESEARCH ARTICLE

# The Nagoya Protocol and nitrogen-fixing maize: Close encounters between Indigenous Oaxacans and the men from Mars (Inc.)

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In this article, we discuss the Nagoya Protocol and its implications for access and benefit-sharing (ABS) agreements related to genetic resources and biodiversity. We analyze a case study of the appropriation of *olotón*, a maize variety with an unusual nitrogen-fixing trait grown in many communities throughout Oaxaca and probably beyond that region. Samples of *olotón* were acquired by scientists affiliated with Mars, Inc., the University of California-Davis, and the University of Wisconsin-Madison. The article unpacks how the *olotón* ABS agreement with the single Oaxacan community of Totontepec became a topic of controversy despite its approval by the Mexican government under the auspices of the Nagoya Protocol. We pose the question: Is the *olotón* ABS agreement to be considered “fair and equitable” or could it be an example of the unjust appropriation of genetic resources known as “biopiracy”? To answer that question, we proceed to analyze the “procedural,” “distributive,” “commutative,” and “representational” forms of justice as they apply to the acquisition of *olotón*. The Nagoya Protocol was created in part to impede biopiracy by providing a framework for acquiring and using biodiversity in a “fair and equitable” way, but the Nagoya Protocol’s provisions are ambiguous and allow for confidentiality clauses that favor the acquisition of genetic materials in ways that we do not consider fair and equitable. We join other researchers and academics who cite the need for an improved approach for ethically accessing, using, and sharing genetic resources and knowledge.

**Keywords:** Access and benefit-sharing, Biopiracy, Indigenous peoples, Maize, Nagoya Protocol, Nitrogen fixation, Oaxaca, Plant genetic resources

*A multidisciplinary team from the University of California, Davis, the University of Wisconsin-Madison, and Mars, Incorporated have found that an Indigenous variety of corn can “fix nitrogen” from the atmosphere instead of requiring synthetic fertilizers. Biological materials were accessed and utilized under an Access and Benefit Sharing (ABS) Agreement with the community and with permission from the Mexican government. An internationally recognized certificate of compliance under the Nagoya Protocol has been issued for such activities. (Mars Inc., press release, August 7, 2018)*

*The Secretariat of Environment and Natural Resources (SEMARNAT) is pleased that Mexico already sees the benefits established by the Nagoya Protocol regarding legal certainty for using genetic resources by establishing measures to prevent their misappropriation. (SEMARNAT press release, August 9, 2018)*

*We view with concern the international agreements Mexico has been pressured to ratify, such as the Nagoya Protocol . . . These are instruments that legitimate the theft of genetic resources . . . We consider the actions of these North American scientists to be an act of biopiracy. We declare that . . . [they] did not “discover” anything, but rather are only attempting to appropriate our ancestral knowledge and demonstrating an ignorance of and a disdain for the traditional science that is still practiced in our communities and expresses itself in our customs. (Espacio Estatal en Defensa del Maíz Nativo de Oaxaca, Declaration of the State Conference “Oaxacan Communal Corn for the World,” September 28, 2019)*

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## Introduction

A fundamental and enduring feature of agricultural science and development history has been the free and uncompensated collection of crop genetic resources from farmers for the ownership, use, and enrichment of the powerful. The violent appropriation of plants and human beings was critical to colonial expansion (Brockway, 1979) and the consolidation of industrial capitalism (Beckert, 2015). Crop genetic resources worldwide have been the raw material for an advancing science of plant breeding and the rise of a global seed industry. Commercial cultivars were made available as commodities and subject to intellectual property rights. But the landraces and cultivars of peasant and Indigenous farmers, to which plant scientists continue to need access, were treated as an open access resource—the “common heritage of mankind”—for which no compensation was merited (Kloppenborg, 2004).

At the United Nations Food and Agriculture Organization meetings in the 1980s, nations rich in agricultural biodiversity agitated for recognition and reward for their farmers’ contributions. The eventual outcome of this struggle was the creation in 2004 of the International Treaty on Plant Genetic Resources for Agriculture (ITPGRFA). The ITPGRFA recognizes “farmers’ rights” as a nominal—but inadequate—counterpart to “breeders’ rights” and establishes a framework of access and benefit-sharing (ABS) for crop genetic resources that are held in a multilateral system of public collections and genebanks. This system has been wracked since its inception by dysfunction and disagreement, still lacks an effective mechanism for appraising and enforcing benefit sharing, and there is not even agreement on whether germplasm in situ in farmers’ fields is covered by the Plant Treaty (Marden et al., 2023; Williams, 2023).

Concerted attention to the use and value of crop genetic resources was soon extended to all forms of plant, animal, and microbial biodiversity. Advances in biotechnology, the emergence of “bioprospecting” by the pharmaceutical industry (Reid et al., 1993) and increasing awareness of biodiversity loss focused attention on the contradictory juxtaposition of genetic material as freely available common heritage with genetic material subject to intellectual property rights and available as a commodity. The iconic and potent word “biopiracy” was coined in 1995 with the founding of the Coalition Against Biopiracy (ETC Group, 1995). The term soon became ubiquitous in both academic and advocacy literature as an umbrella term for a wide range of pursuits and enterprises involving some form of appropriation of biological material—and their associated Indigenous and local knowledge—that was deemed to be illegal, inappropriate, or unethical by a wide range of criteria (see, e.g., Mgbeoji, 2006; Mushita and Thompson, 2007; Robinson, 2010).

When the Convention on Biodiversity (CBD) entered into force in 1993, 1 of its 3 core objectives was specified as “the fair and equitable sharing of the benefits arising out of the utilization of genetic resources” (CBD, 1992, Article 1). CBD Article 15 specified that the authority to enact rules to achieve this objective would rest with

national governments in recognition of the “sovereign rights of States over their own natural resources.” Further, national legislation regulating access to genetic resources should provide for “mutually agreed terms” (MAT) and the “prior informed consent” (PIC) of the nation involved. In 2003, the CDB created a Working Group on ABS that was charged with elaborating and negotiating a legally binding instrument to effectively implement the provisions of Article 15. In October 2010, after 7 years of protracted negotiations, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization was adopted. Prospective collectors of genetic resources are issued an Internationally Recognized Certificate of Compliance (IRCC) from the national government of the nation in which the resources are located when evidence is provided that collection is being undertaken with the “PIC” of the supplying nation and with a specification of appropriate “MAT.”

On August 7, 2018, the journal *PLOS Biology* published an article titled “Nitrogen fixation in a landrace of maize is supported by a mucilage-associated diazotrophic microbiota” (Van Deynze et al., 2018). The study reported that a team of scientists had demonstrated that a variety of maize collected in the Sierra Mixe of Oaxaca, Mexico, could obtain 29%–82% of its nitrogen needs from the atmosphere. This phenomenon is accomplished by developing numerous aerial roots on the maize stem, which exude quantities of mucilage that supply conditions where bacteria can thrive, fix atmospheric nitrogen, and give it to the plant. Given the prominent role of synthetic nitrogen fertilizers in contemporary agricultural production and the sustainability, economic, and ecological issues associated with their intensive use, this was a finding with substantial implications.

The *PLOS* paper listed 21 authors: 14 associated with the University of California-Davis (UCD), 6 from the University of Wisconsin-Madison (UWM), and a lone representative from Mexico’s Instituto Tecnológico del Valle de Oaxaca. Funding for the research was provided by Mars, Inc. and its subsidiary BioN2. The “Comisariado [sic, ‘Comisariado’—Commissioner’s Office] of the Sierra Mixe, Mexico” was acknowledged “for their support and access to community genetic resources” (Van Deynze et al., 2018, p. 18). The authors were careful to state that “Biological materials were accessed and utilized under an Access and Benefit Sharing Agreement between the Sierra Mixe community and BioN2, Inc., and with permission from the Mexican government. An internationally recognized certificate of compliance under the Nagoya Protocol (ABSCH-IRCC-MX-207343-3) has been issued for such activities” (Van Deynze et al., 2018, p. 11).

Publication of the article in *PLOS Biology* was accompanied on August 7 by simultaneous press releases from UCD, UWM, and Mars. These were predictably rhapsodic in their enthusiasm for the “discovery” (Hamilton, 2018) and “significant breakthrough,” suggesting that “If this trait can be bred into conventional varieties of corn, it could reduce the need for added fertilizer and increase yields in regions with poor soil” (Fillmer, 2018; Mars, Inc., 2018). Dramatic photographs of the aerial roots dripping



**Figure 1.** From Montross (2019), published in *The California Aggie*.

mucilage (Montross, 2019; see **Figure 1**) accompanied the press releases. News outlets took up the story with enthusiasm, often verging on hyperbole: “The wonder plant that could slash fertilizer use” (*The Atlantic*, Yong, 2018), “‘Crazy’ corn could revolutionize farming” (*The Times*, Blakely, 2018), “The corn of the future” (*Smithsonian*, Daley, 2018), “Revolutionary corn discovery” (*USA Today*), “Corn variety grabs fertilizer from the air” (*Scientific American*, Intagliata, 2018), and “Nitrogen-fixing corn is farming’s holy grail,” (*Farm Progress*, Wilson, 2019).

In a press release 2 days later on August 9, the Mexican Secretariat of the Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT]) welcomed the publication of the *PLOS* article and, notably, put as much emphasis on the community’s approval of the ABS agreement and the “full and effective participation of Indigenous peoples” (SEMARNAT, 2018) as on the study’s agronomic promise. But the publication on November 5, 2018, of an article by Paris Martínez (2018) in the Mexican journal *Animal Político* had a very different interpretation of the deal. Titled “Two US public universities and a transnational are pirating Oaxacan maize,” the article asserted that negotiation and approval of the ABS agreement suffered from serious procedural irregularities, that the “discovery” of the nitrogen-fixing maize inadequately recognized the agency of Indigenous farmers in its development, and that a single

community should not be able to agree to dispose of a collective resource unilaterally.

Martínez’s article was followed on November 16, 2018, by another unrelated but parallel intervention. Six prominent Mexican academics—including the current Director of CONACYT (Consejo Nacional de Ciencia y Tecnología), Mexico’s National Council for Science and Technology—published a comment on the Van Deynze (2018) article in *PLOS Biology*. The statement charged a failure to adequately credit previous work by Mexican researchers and Indigenous farmers, alleged only “perfunctory” oversight by Mexican authorities, and questioned the efficacy of efforts to consult the community. The authors concluded that “this example clearly illustrates the heart of the problem of bio-piracy and resource expropriation, characteristic of this new epoch of conquest through the use of science and technology” (Álvarez-Buylla et al., 2018).

It took only a week for word of the agreement to reach the Indigenous communities of Oaxaca. The *Smithsonian* article on the corn was sent to members of the Espacio Estatal en Defensa del Maíz Nativo de Oaxaca (State Space for the Defense of Oaxaca’s Native Corn, hereafter “Espacio”) by friends in the United States. Espacio is a network of Indigenous and peasant organizations that defends Oaxaca’s native maize, the traditional *milpa* system of polycultural agriculture, Indigenous forms of community, and their territories. Although the authors of the





**Figure 2. Encuentro Estatal “Maíz Comunal de Oaxaca para el Mundo” (State Gathering: Oaxaca’s Communal Maize for the World).**

*PLOS* article had carefully avoided specifying the community that had cut the deal, identifying it inaccurately as the “Comisariado [sic] of the Sierra Mixe,” it was quickly determined that Totontepec was the partner. It also became clear that the eponymous “Sierra Mixe maize” referred to in the article was *olotón*, a variety initially found in Totontepec showing interesting phenotypic characteristics but also found beyond the Sierra Mixe and the larger Sierra Juárez (Pankievicz et al., 2022). These phenotypic characteristics are also found in teosinte (Van Deynze et al., 2018, p. 5) and in sorghum (Venado et al., 2023), indicating that the presence of this trait may be widespread in the grasses (Poaceae) family. For Espacio, the appropriation of the maize constituted an illegitimate alienation of a collective resource by a tiny part of a much larger sociocultural collectivity. They regarded that action as an erosion of customary norms threatening an Indigenous cosmivision that Espacio was committed to maintaining. Within a year, Espacio had organized a 2-day conference on “Oaxacan Communal Corn for the World” (Figure 2) and issued multiple declarations objecting to what they perceived as crude biopiracy (Espacio, 2019; Randall and de Ávila, 2019; Espacio, 2020; Espacio, unpublished), and reached out internationally for solidarity and assistance.

Here is an interesting conundrum. How is it that charges of biopiracy are leveled at the UCD–UWM–BioN2–Mars researchers despite the validation of an IRCC issued in accordance with the Nagoya Protocol by the relevant Mexican authorities? We engage that question in this article and address the following objectives.

First, we want to chart and understand the practical and legal dynamics involved in the process by which the men

from Mars concluded the ABS agreement with Totontepec. Second, we will use that analysis as a portal to assess the functional adequacy of the Nagoya Protocol as a framework for impeding misappropriation and for facilitating fair and equitable benefit sharing of genetic resources. Third, we will explore in what sense the appropriation of *olotón* might be characterized by the loosely defined and pejorative term “biopiracy.” To frame this enquiry, we apply the concepts of “procedural,” “distributive,” “commutative,” and “representational” justice to our understanding of how the Mars–Totontepec ABS agreement was developed, shaped, and concluded. Finally, we will explore how we are trying to craft an approach to researching nitrogen fixation in maize that we hope may move in the direction of adequately recognizing, respecting, involving, and rewarding the peoples and communities that have developed and stewarded these remarkable plants.

### **The Nagoya Protocol: A masterpiece of creative ambiguity**

In response to accumulating evidence of biopiracy generated by scholars and civil society and advocacy organizations (see especially Robinson, 2010 and Wynberg, 2023 for extensive accountings), governments in many biodiversity-rich nations have for the last several decades been monitoring and, increasingly, introducing regulatory frameworks to manage access by scientists and corporate bioprospectors to their fields, forests, and waters.

Under increasing pressure from such measures, advocacy groups, and the sentiments of civil society, researchers and companies wanting to access genetic resources began to negotiate and implement arrangements that could be regarded or defended as meeting the vague

mandate of the CBD for fair and equitable sharing of benefits. Few of the arrangements in this varied patchwork of ABS arrangements have been found to have functioned as intended or to have provided an effective sharing of benefits with either states or communities (see, e.g., Hayden, 2003 and Heinrich et al., 2020 on drug bioprospecting; Andersen and Winge, 2012 on Teff; Gaberell, 2016 on Stevia; and Wynberg, 2023 on Hoodia, Rooibos, and 2 other southern African species).

In October 2010, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization was adopted as an instrument under the Convention on Biological Diversity. The Nagoya Protocol has several critical operational features:

- It reaffirms the CBD's recognition of national sovereignty over genetic resources.
- It requires issuing a permit—the IRCC—when access to genetic resources is regulated.
- Issuance of the IRCC requires evidence of PIC of the donor country or community.
- Issuance of the IRCC requires evidence of MAT for benefit sharing.
- It requires that States take measures to ensure that traditional knowledge associated with genetic resources held by Indigenous and local communities be accessed with the PIC of and under MAT established by those communities.
- It creates an ABS Clearing-House to enhance the availability of information to “provide greater legal certainty and transparency for providers and users of genetic resources and traditional knowledge” (Access and Benefit-Sharing Clearing-House, 2023).

As the product of contentious and complex negotiation between unequal geopolitical contenders, the Nagoya Protocol has been called “a masterpiece in creative ambiguity . . . allowing flexible interpretation, but possibly also too wide a berth for implementation” (International Institute for Sustainable Development, 2010, p. 26). Practically, the affirmation of “national sovereignty” means that national states determine how the Protocol's requirements are implemented. This also means that the rights of farmers, communities, and Indigenous peoples to genetic resources are subject to national law that might—or might not—serve their agency or interests (Fredriksson, 2021). The authority to approve PIC/MAT and subsequently issue the legitimating IRCC is also vested in the state. In somewhat equivocal language, the Nagoya Protocol instructs states to take the interests and participation of Indigenous and local communities “into consideration,” “as appropriate,” and “where applicable” (see the language in Articles 6.2, 6.3(f), 12.1, and 12.3). Furthermore, the state is tasked with establishing clear policies for MAT and reporting them to the ABS Clearing-House.

But this mandate to enhance “transparency” by reporting MAT arrangements to the Clearing-House is made subject to the qualification that disclosure may be accomplished “without prejudice to the protection of

confidential information” (NP, 2011, Article 14.2 and Article 17:(a)(iii)). Unfortunately, the Nagoya Protocol does not define “confidential information.” Effectively, absent a legal requirement to disclose, confidential information is whatever the possessor decides is confidential. We will have multiple occasions to note the impeding effects of confidentiality on this research. It is important to note that permission to refuse disclosure is structurally embedded in the Nagoya Protocol.

Finally, the Nagoya Protocol fails to specify the meaning of the critical phrase “fair and equitable.” Given the prevailing political economy, we do not suggest that agreeing on such a determination would have been possible. We suggest that without such a determination, a default assumption that if PIC was undertaken and MAT were arranged then an agreement approved under the Nagoya Protocol can be expected to be fair and equitable is unwarranted. If confidentiality claims obstruct access to the terms of agreements there is no way to accurately assess the degree to which fairness or equitability are realized. So, the authors of the *PLOS Biology* article may intend to legitimate their appropriation of Totontepec's genetic resources by citing their receipt of an “IRCC under the Nagoya Protocol,” but we should not—and do not—simply accept that the issuance of the IRCC is conclusive evidence of either fairness or equitability.

### A methodological note: Positionality and confidentiality

The authors of this article are directly engaged as principals and advocates in the matters treated here, and our analysis should be understood as the result of “interested”—as distinguished from “disinterested” or “neutral”—participant observation.

The first author, Jack Kloppenburg, is a professor emeritus at the University of Wisconsin, a long-time seed issue analyst, and a corporate concentration critic. He is a founder and board member of the Open Source Seed Initiative, which advocates applying “copyleft” methods to keep new crop varieties free of the encumbrances of intellectual property rights (Kloppenborg, 2014). Kloppenburg was unaware of the *PLOS* article and the associated controversy until he was contacted by a member of Espacio in January 2019 and asked for counsel on “ways of preventing the patenting or other arrangements that limit access to these native seeds,” which are “communal ‘property’ not just of the community involved, but of all the indigenous communities in Oaxaca” (Felipe Dahl-Bredine, personal communication, 16/01/2019).

Learning from Espacio that a colleague at his university was an author of the *PLOS* article and was actively involved in research on nitrogen-fixing maize, Kloppenburg contacted and met with Jean-Michel Ané, who is the third author of the present article and a coauthor of the *PLOS Biology* article. Ané explained that he had been recruited to the Mars–UCD team in 2011 to bring specialized expertise in the analysis of nitrogen fixation to the project. Ané subsequently withdrew from the Mars–UCD team but continues to pursue his research independently and on material not encumbered by the BioN2–

Totontepec ABS agreement. Ané expressed an interest in reflecting on how his research fits with the significant issues raised by Espacio and committed to participating in an open-ended exploration of what it might mean for his lab to enact “fair and equitable sharing of benefits” with the people and communities of Oaxaca.

Unpacking the process by which the *olotón* ABS agreement was developed and exploring these complex issues with Indigenous organizations has required specialized language and intercultural skills. The second author of the present article is Claudia Irene Calderón, a UW-Madison plant scientist and agroecologist. As a Guatemalan, Calderón is a native speaker of Spanish. She has extensive experience working with maize and with Indigenous peoples and communities in Latin America. She is the translator of Spanish language documents and interviews referenced in this article. She has operated as our essential link to Mexican institutions and authorities and especially to the people and organizations of Indigenous Oaxaca.

Over the past 4 years, the 3 of us have endeavored to piece together the story of how *olotón* maize moved through different physical, scientific, geographic, social, and legal spaces as it was carried physically from the fields of Oaxaca to the laboratories of Davis, California, and Madison, Wisconsin. Our entrypoint was the ABS Clearing-House, which aggregates and maintains the IRCCs for material collected under the Nagoya Protocol. The IRCC for the Sierra Mixe *olotón* is available at <https://absch.cbd.int/en/pdf/ircc-certificate/absPermit/ABSCH-IRCC-MX-207343/3>. The Mexican “COMPETENT NATIONAL AUTHORITY” charged with assessing and approving the IRCC is identified as the “National Service of Seed Inspection and Certification” (SNICS). The “Date of issuance of the permit” is given as “15 July 2015.” “Confirmation that PIC obtained or granted” is answered with a simple “YES,” and no further information about PIC is provided. “The person or entity that holds the right to grant access to the genetic resources in accordance with domestic legislation” is specified as “CONFIDENTIAL INFORMATION.” The “Entity to whom PIC was granted” is given as “Sr. Bruce S. Manheim, BioN2, Inc. (BioN2), WilmerHale Avenida Pennsylvania 1875, Washington, DC 2006.” Under “Additional information about the PIC,” the response is simply “Ninguna” [nothing]. The answer to “Confirmation that MAT have been established” is simply “YES.” The response to “Additional information about the MAT” is simply “Ninguna” [nothing]. Under “Subject-matter or genetic resources covered,” “CONFIDENTIAL INFORMATION” is all that is provided.

Amazingly, a standard web search for “BioN2” yielded scanty results: links to the personal profiles of 2 ex-officers of the company and a link to a Mars, Inc. site (“mars-us-entities-covered-under-privacy-shield-application”) that was and is inaccessible without a Mars username and password for further access. A web search for “Bruce Manheim” and “WilmerHale” revealed that Bruce Manheim is an attorney with the Washington, DC, law firm WilmerHale, a prominent law firm with global practice. Manheim is a partner at WilmerHale who has “developed special knowledge on issues surrounding research, development, and commercialization of products under the Biodiversity

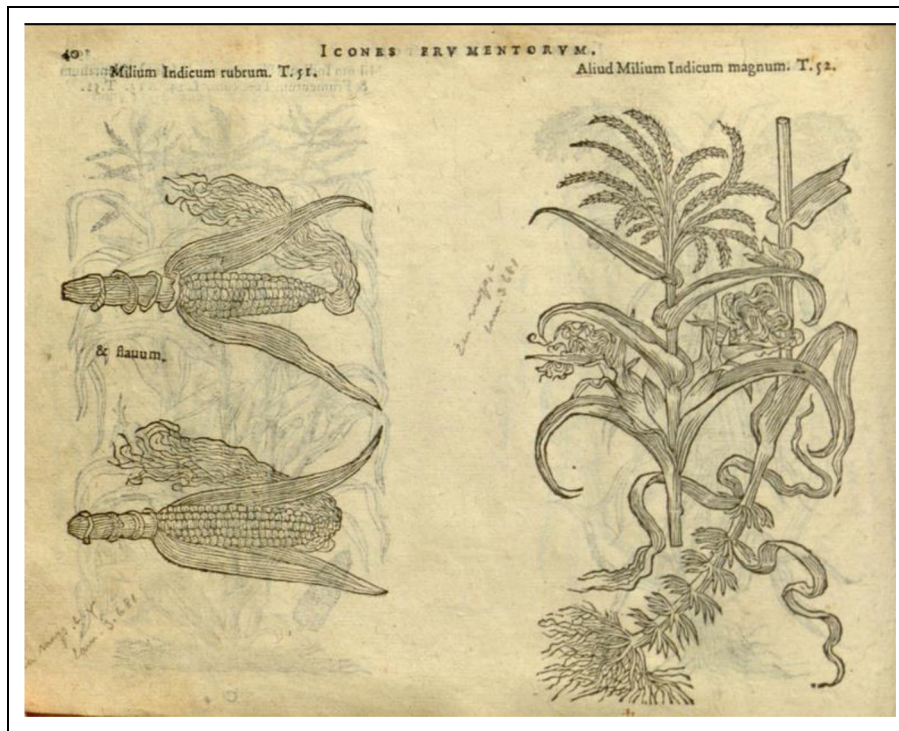
Convention and Nagoya Protocol” (WilmerHale, 2023). When contacted for an interview, Mr. Manheim declined, referring us to his client, “Mars-BioN2.” From such tenuous starting points, we gradually connected with a variety of individuals in the United States and Mexico who had some knowledge of *olotón*'s history and the circumstances of its emergence as a topic of controversy.

Because it is indeed a controversial topic, confidentiality and lack of transparency have been complicating and confounding features of our inquiries into *olotón*. Most of those we interviewed—Espacio members, representatives of other Mexican NGOs, and Mexican academics—knew only disparate and very partial pieces of the story. The ones who do know the most about the story—Mars executives, BioN2 staff, UCD academics—preferred not to share what they know or to share only selected and carefully phrased parts of what they know. “Studying up” to financial, cultural, and scientific elites (Nader, 1972) is complicated and rendered more so with highly charged accusations of biopiracy. The executive staff of BioN2 and attorney Bruce Manheim declined to be interviewed. We are grateful that 3 key principals from UCD and Mars did agree to be interviewed. They are Alan Bennett, Distinguished Professor, Department of Plant Sciences, University of California-Davis; Carl Jones, Plant Sciences Director, Mars Advanced Research Institute, Mars, Inc.; and Howard-Yana Shapiro, Senior Fellow, Department of Plant Sciences, University of California-Davis, Mars Advanced Research Institute Fellow (and formerly Chief Agricultural Officer), Mars, Inc.

The attempts of journalists to communicate with the leadership of Totontepec have been met consistently with refusal and evasion (see Martínez, 2018; Jovaag, 2019; Pskowski, 2019). We were also made aware of conflicts among communities in the area and did not wish to exacerbate these tensions. Nor did we wish to be perceived as seeking to assign personal responsibility for decisions that had been made, for whatever reasons, on behalf of the community. Therefore, we decided not to attempt to interview the leadership of Totontepec.

We did reach out to officials in relevant Mexican government agencies. As journalist Paris Martínez (2018) had found in his reporting for *Animal Político*, this was a frustrating undertaking. We first contacted SEMARNAT that is designated as the “ABS National Focal Point” for the Nagoya Protocol. At an initial on-line video meeting, SEMARNAT officials told us that no copy of the BioN2–Totontepec agreement was publicly available. We then submitted a written set of 10 questions that we hoped to have answered. SEMARNAT apologized for being unable to answer our questions and referred us to SADER'S office of SNICS, noting that SNICS is the designated “Competent National Authority” for the Nagoya Protocol and is the institution which mediated, signed, and issued the permission for BioN2 to access, research, and commercialize the genetic resources. SNICS confirmed that it had taken notice of the agreement but, surprisingly, asserted that it had lacked legal authority to act and had simply expressed its opinion to SEMARNAT, which as National Focal Point should have been the agency to follow-up the application. We have been unable to reconcile these





**Figure 3. Maize representation in *Stirpium seu Plantarum Icones* from Plantini (1591).**

conflicting accounts of responsibility. SEMARNAT also directed us to the Comisión Nacional para el Uso de la Biodiversidad (CONABIO) since that was the agency that had promoted the Mexican ratification of the Nagoya Protocol. A representative of CONABIO informed us that CONABIO had not participated in and had no knowledge of the terms under which the Mars–Totontepec ABS agreement was granted.

While we learned some significant things about the involvement and oversight—or lack thereof—of Mexican agencies in negotiating and monitoring the Mars–Totontepec ABS agreement, we were refused access to the agreement itself. SNICS specified that as an agreement between individuals (*entre particulares*), the content was confidential under both the Nagoya Protocol and the Mexican *Ley General de Transparencia y Acceso a la Información Pública*. Accordingly, SNICS did not provide answers to most of our queries and referred us back to the “National Focal Point” (i.e., SEMARNAT) and to the ABS Clearing-House for further information.

Our study’s most illuminating data point is the ABS agreement concluded between Totontepec and BioN2. We formally requested permission from 3 Mexican agencies (SEMARNAT, SNICS, and CONABIO) and Mars, Inc. to access that agreement. Our requests were uniformly denied based on “confidentiality” or lack of involvement. Fortunately, we did receive—unexpectedly and unsolicited—a copy of the agreement from an anonymous source.

### **Olotón and the men from Mars (Inc.)**

The farmers of the Indigenous communities in the sierras of Oaxaca, Mexico, are responsible for developing and stewarding the maize type that is the subject of the Van

Deynze et al. article published in *PLOS Biology*. Maize cultivars with similar nitrogen-fixing traits are grown in multiple locations in Oaxaca (Pankiewicz et al., 2022), also in Yucatán, and as far away as Guatemala (Pskowski, 2019). As mentioned earlier, these phenotypic characteristics have also been found in wild relatives of maize, namely *Zea mays* subsp. *mexicana* (Van Deynze et al., 2018, p. 5) and could potentially be found in other teosintes and, more broadly, in the Poaceae clade (Venado et al., 2023). What can we learn about the Nagoya Protocol by examining the application of this blunt instrument to the appropriation and study of *olotón* by U.S. scientists? What can we learn about what might or might not be biopiracy? We have assembled the account below from many different sources. For a parallel but limited report from Mexican analysts living in the Sierra Mixe, see Randall and de Ávila (2019).

An illustration of a maize plant with many adventitious, aerial roots similar to the plants described in Van Deynze (2018) appears in an herbal published in 1591 and attributed to the Flemish botanist Matthias de L’Obel (**Figure 3**). Having developed and maintained this landrace, Indigenous farmers in Mexico have understood its beneficial characteristics even if they did not understand the operation of its underlying biological functions.

American botanist Thomas Boone Hallberg visited the Sierra Mixe village of Totontepec in 1948 and was struck by *olotón*. In 1990, Hallberg and Gabor Bethlenfalvai, a U.S. Department of Agriculture (USDA) microbiologist, gathered samples of plants from Totontepec, and Bethlenfalvai subsequently confirmed the existence of nitrogen-fixing bacteria in the aerial roots of the Totontepec *olotón* (Hallberg, 1995). Bethlenfalvai recalls hypothesizing “that

the ooze on these roots functions as a growth medium for associative N<sub>2</sub>-fixing bacteria, and that is why these plants are so green” even in poor soil (Bethlenfalvai, 2011, p. 403). In 1992, Hallberg and Bethlenfalvai returned to Totontepec with Mexican microbiologist Ronald Ferrera-Cerrato whose later laboratory analysis also identified nitrogen-fixing bacteria in the mucilage secreted by the *olotón* plants (Vega-Segovia and Ferrera-Cerrato, 1993).

Cataloguing types of maize in the Oaxaca Valley in early 1980s, another American agronomist—Howard Yana Shapiro—also noticed the *olotón* (Mars, Inc., 2018; Shapiro, 2018). He purchased a house in the village of Totontepec and established a close and enduring relationship with the community. Joining Mars, Inc. and assuming an adjunct professorship with UCD, he focused personal and professional attention on the scientific and commercial promise of *olotón*. Fostering the interest of other faculty at UCD in nitrogen-fixing maize, he was instrumental in arranging in 2005 a Material Transfer Agreement (MTA) between the Municipality of Totontepec, represented by the Municipal President, and the Regents of the UCD represented by Professor and Associate Vice Chancellor Alan Bennett (UCD, unpublished).

The MTA permitted transferring “varieties of maize” to UCD for research purposes only and explicitly *excluded* commercial activities. UCD researchers were also prohibited from sharing the material or any progeny without the permission of Totontepec. The MTA further specified, somewhat ambiguously given the commercial activity exclusion, that “any patentable invention or discovery” resulting from UCD research would be subject to “applicable property law which will determine the authorship and, therefore, the owner of the invention.” The Regents of the University of California are accorded the right to determine whether to apply for a patent. Should a patent be issued, the MTA commits UCD to share with Totontepec “equal parts” of net income derived from anything patented. Although the agreement leaves ownership of any potential invention uncertain, the commitment that fully half of any net receipts from using patented material by UCD would accrue to Totontepec is significantly—not to say unprecedentedly—generous. The agreement was not widely publicized.

Although Mexico is not a Party to ITPGRFA, several Mexican laws were in place to manage such transfers of biological material. However, Mexican governmental or scientific authorities were not involved in or informed of the UCD–Totontepec arrangements (Álvarez-Buylla et al., 2018; Martínez, 2018). Pskowski (2019) reports that UCD’s Bennett “said that the U.S. side did not believe it was necessary to consult with the federal government because Indigenous communities are autonomous under the Mexican constitution.” Mars itself was not a party to the MTA, although it was undoubtedly aware of the agreement through Shapiro, who was affiliated with both UCD and Mars. The MTA was initially set to terminate in 2010 but was extended to 2019, with all other agreement terms remaining unchanged and in effect.

By 2006, Totontepec germplasm was flowing to UCD for analysis. In return, Totontepec was provided with

significant money for such benefits as improvements to municipal buildings and the publication of a children’s book about biodiversity. There are varying accounts of how and how well the money was used, and it is not clear whether UCD or Mars was the source of the funds. At least within Totontepec, UCD–Mars worked to publicize their activities and the projected benefits to the community. The university and the company are presented as partners in publicity materials distributed in the community (Montecinos and Zamora, 2011). Additionally, a researcher at UWM, Jean-Michel Ané, was recruited in 2011 to join the UCD–Mars team and bring specialized expertise in the analysis of nitrogen fixation to the team. Although the MTA and its extension prohibited commercial research, in 2012, Mars created a subsidiary company, N<sub>2</sub>Genetics. N<sub>2</sub>Genetics became the conduit in 2013 for 2 grants to UCD’s Alan Bennett totaling \$4.3 million to study “Mechanisms of N<sub>2</sub> Fixation in a Diazotrophic Microbiome Associated with an Indigenous Landrace of Corn.”

In October 2012, Mexico ratified the Nagoya Protocol. This action spurred the UCD–Mars team to rethink the MTA’s legal and operational status and to bring its relationship with Totontepec into compliance with the Nagoya Protocol. In late 2014 or early 2015, Mars’ N<sub>2</sub>Genetics subsidiary was reconstituted as BioN<sub>2</sub>. It was BioN<sub>2</sub>, not UCD and not Mars, that entered into negotiations for a Nagoya Protocol ABS agreement with Mexico’s Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (Servicio Nacional de Inspección y Certificación de Semillas [SAGARPA]—which has itself been reconstituted as SADER—Secretaría de Agricultura y Desarrollo Rural) and the municipality of Totontepec. This is a transition of fundamental importance. No longer would it be a public university—subject to public oversight, nominally committed to public service, sensitive to public opinion—that would be partnering with Totontepec. Now, the deal was to be cut with BioN<sub>2</sub>, a private, profit-oriented firm created by Mars specifically to pursue the commercial possibilities of *olotón*.

We have been unable to learn much about the negotiations. We have been unable to determine what Mexican agencies were represented or how they participated. SNICS explained to us that although Mexico had ratified and signed the Nagoya Protocol in 2014, by 2015 when BioN<sub>2</sub> made its application there were as yet no juridical instruments established to authorize such applications. In its capacity as “National Competent Authority” for the Nagoya Protocol, SNICS explained that it took notice of BioN<sub>2</sub>’s application, but that “nevertheless, **this institution had no power to authorize access to the said resources**, and only expressed its opinion to the National Focal Point which is the one to follow up the application” (Servicio Nacional de Inspección y Certificación de Semillas, personal communication, 01/02/2023, emphasis in the original).

For BioN<sub>2</sub>, the negotiation and execution of the ABS agreement were undertaken by Kenneth Sharples, BioN<sub>2</sub>’s General Counsel, and Bruce Manheim of the law firm WilmerHale. Both Sharples and Manheim declined to be interviewed. As noted earlier, our requests to the Mexican



authorities for a copy of the agreement were refused because it is “confidential.” Both Howard-Yana Shapiro and Alan Bennett express pride in the agreement, though both deny ever possessing or even seeing the final copy (Howard-Yana Shapiro, personal communication, 18/10/2022; Alan Bennett, personal communication, 09/11/2022). We suggested to Shapiro, Bennett, and Carl Jones, Mars’ Plant Sciences Director, that if the agreement reflects the “fair and equitable sharing” envisioned by the Nagoya Protocol, there is good reason to make it public. That transparency would do much to deflect or contradict the allegations of biopiracy being leveled at Mars, the UCD, and the UWM. Nevertheless, Mars declined to supply the agreement, citing obligations of confidentiality.

Although we could not access the BioN2–Totontepec ABS agreement through official channels, we received a copy of the agreement from an anonymous source. Or, rather, we received copies of 2 contracts; one executed in July 2015 (SAGARPA, 2015a) and a second, amended agreement signed 4 months later, on November 16, 2015 (SAGARPA, 2015b).

The initial July agreement states that it is being concluded with the authorization of SNICS under Article 102 of the Law of Sustainable Rural Development. Clause E.1 of the agreement declares that the “Provider” gives its “complete and informed consent” to the activities described. In response to our inquiries, SNICS did inform us that although the details could not be revealed for reasons of confidentiality, since Mexico had not established applicable juridical instruments, the PIC arrangements were formulated “according to a free format” (Servicio Nacional de Inspección y Certificación de Semillas, personal communication, 01/02/2023). The arrangements for MAT are detailed. The genetic resources covered by the agreement are defined not only as the seeds of maize varieties “whose principal race is ‘OLOTON’” but also to all plant parts, mucilage, associated microorganisms, adjacent soils, nucleic acids, and biochemical and molecular compounds (SAGARPA, 2015a, D.4). “Just and Equitable Sharing of Non-Monetary Benefits” is envisioned as sharing of data and publications and the inclusion in research activities of local institutions and investigators “to the extent that suitable equipment and staff are available and where there exists interest, resources, and experience” (SAGARPA, 2015a, E.3).

Remarkably, this initial July agreement contains no provision for sharing monetary benefits. Indeed, clause E.2 of the contract specifically imposes a blanket prohibition on all commercial possibilities: “Commercial Use. Nothing in this Research agreement authorizes the User to use the Genetic Resources and Derivatives for commercial purposes” (SAGARPA, 2015a, E.2). This construction is difficult to understand since it was clear that BioN2 had clear commercial ambitions and was concerned to acquire “sufficient IP to support a business proposition” (BioN2, unpublished, p. 3) in its work with *olotón*. Clause E.4 of the agreement prohibits BioN2 from applying for patents on the covered genetic resources “in the same form they were provided to the User.” That is, BioN2 could not patent the original material itself, which would in any case have

been universally castigated as the crudest form of biopiracy. However, the agreement does authorize the company to apply for plant variety protection and patents on “inventions developed using the Genetic Resources and Derivatives” (SAGARPA, 2015a, E.4). We do not know if these contradictory features of the first agreement are purposeful, strategic choices by the parties or are simply an egregious oversight on the part of the BioN2 negotiators.

Whatever motivated the drafting of the initial agreement, it was replaced 4 months later in November by an amended agreement noting BioN2’s formal “change of intention” to pursue explicitly commercial objectives with the genetic resources obtained from Totontepec (SAGARPA, 2015b). In this amended version, “the Provider [Totontepec] gives its complete and informed consent that authorizes the User [BioN2] to access, collect, use and export the Genetic Resources and Derivatives for commercial activities” (SAGARPA, 2015b, E.1). Those activities are listed at length and include licensing and sale of products involving nitrogen fixation, traits, carbohydrates, oligosaccharides, glycoproteins, and microorganisms. As in the first agreement, BioN2 is not permitted to apply for patents on the covered genetic resources “in the same form they were provided to the User,” but intellectual property rights may be asserted on modifications of the original material. In this amended agreement, there is a provision for “*Just and Equitable Distribution of Monetary Benefits*” (SAGARPA, 2015b, E.4). BioN2 retains ownership of all products developed from modifications of the covered genetic resources but is obligated to pay Totontepec 1% of net annual income from any commercial “Product” incorporating “the Genetic Resources, or any of their genetic parts, or their components, or Derivatives” (SAGARPA, 2015b, E.4). How such future royalty flows might be calculated, and on what basis, is uncertain. What is unmistakable is the transition from the 50% royalty in the 2005 MTA to the 1% royalty specified by the 2015 ABS agreement.

Notably, the second version of the ABS agreement explicitly notes the existence of “traditional knowledge.” This is likely in response to the Nagoya Protocol’s Article 12, which treats “Traditional knowledge associated with genetic resources” (NP, 2011). The ABS agreement follows the Protocol insofar as it describes traditional knowledge as “technical knowledge, skills, innovations, practices, teachings” that are “associated” with but distinct from genetic resources (SAGARPA, 2015b, E.2). But rather than maintain that distinction, it conflates genetic resources and their associated traditional knowledge when it comes to payment. The agreement specifies that any payment accruing to use and commercialization of genetic resources is simultaneously payment for using traditional knowledge (SAGARPA, 2015b, E.3). BioN2 gets genetic resources *and* its associated traditional knowledge for the price of the genetic resources alone. Furthermore, the agreement goes on to acknowledge that agricultural practices associated with collected genetic material are not confined to the community of Totontepec (SAGARPA, 2015b, E.3). As such, they are termed “Traditional Knowledge of No Identifiable Origin” (SAGARPA, 2015b, E.3). The agreement states that Totontepec’s consent to authorize

BioN2 to access genetic resources includes permission to access the Traditional Knowledge of No Identifiable Origin that is associated with those resources (SAGARPA, 2015b, E.3) (even though Clause 2 implies that PIC for traditional knowledge had not yet been obtained). BioN2 not only gets 2 for the price of 1 from Totontepec, but it also claims permission to use the traditional knowledge of an open-ended set of additional communities for the price of Totontepec's germplasm alone.

In November 2017, BioN2 was dissolved by its parent company Mars. This action was taken in response to financial stress caused by high personnel costs and some significant failures of scientific judgment by the company's management team. Another factor was the rejection for the second time of a patent application on *olotón*-derived material that had been made to the U.S. Patent and Trademark Office. We have been unable to obtain documentation of these applications from either BioN2 staff or the U.S. Patent and Trademark Office. There are a variety of reasons that these applications might have been rejected and/or withdrawn. As a result of BioN2's dissolution, Mars, Inc. inherited legal responsibility for the Totontepec agreement. Work on Totontepec *olotón* lines continues at UCD, apparently under a license from Mars, which is now responsible for the ABS agreement.

The turbulence attending BioN2 figured in the decision of UWM's Jean-Michel Ané to withdraw from the UCD–Mars enterprise in 2018 and to pursue his research independently. Although Ané has ceased to work on the germplasm obtained through the BioN2/Totontepec agreement, he continues his research on *olotón*-type lines. He acquired accessions of these lines from genebank collections maintained by the U.S. National Germplasm System and the International Maize and Wheat Improvement Center (CIMMYT). These materials were collected in decades past from communities in Oaxaca and share the nitrogen-fixing traits that made the Totontepec seeds attractive. The *olotón*-type material supplied by CIMMYT is subject to the benefit-sharing arrangements mandated in the 2001 ITPGRFA. *Olotón*-type material obtained from the USDA after the ratification of the Treaty by the United States in 2016 is also subject to the ITPGRFA benefit sharing. However, current policy set by the U.S. Department of State is that any of the USDA accessions that were acquired before the 2016 ratification by the United States are entirely unencumbered by the ITPGRFA or the Nagoya Protocol when distributed within the United States.

Work on *olotón*-type lines received from U.S. and CIMMYT genebanks continues at UWM. Research is proceeding not only on the seeds but also on the symbiotic microorganisms obtained from the mucilage. Classical breeding is used to introgress traits from the *olotón*-type lines into temperate zone maize varieties. The long-term objective is to create commercial nitrogen-fixing varieties adapted to the United States. To this end, the *olotón*-type lines are being grown, bred, multiplied, and assessed in research plots in Chile, Hawaii, California, and Wisconsin. More importantly, the research goal at UCD and UWM is to characterize and elucidate the genetic mechanisms

underlying the plant's nitrogen-fixing capabilities and associated microbial populations (Hildon et al., 2020; Pankevicz et al., 2022). Although we have little information on their activities, similar work is underway at other universities and private companies.

The publicity accompanying Van Deynze et al. publication in *PLOS Biology* in August 2018 brought attention to scientific activities and socio-legal arrangements that had gone unnoticed. Surprisingly, critical reporting in outlets such as *Animal Político* (Martínez, 2018) and *Yale 360* (Pskowski, 2019) has not yet occasioned much concern in mainstream NGOs and policy communities, even in Mexico. The reaction in Mexican academic circles has been more vigorous. Álvarez-Buylla et al. (2018) focus on the inadequate attribution of credit to Mexican scientists' contributions and the parallel deficiency of recognition of involvement by Totontepec farmers. The National Autonomous University of Mexico released a video charging UCD and UWM with biopiracy (UNAM Global TV, 2022). Two prominent Mexican biologists are organizing a study in which they intend to characterize *olotón* so that it can be registered in the National Catalog of Plant Varieties and to apply for breeder's rights on behalf of Sierra Mixe farmers (Turrent Fernández, 2022).

The most forceful response to the Nagoya Protocol-mediated appropriation of *olotón* from Totontepec has come from community organizations. Espacio comprises representatives of multiple advocacy and civil society organizations from around Oaxaca. In September 2019, it coordinated a conference on "Oaxacan Communal Maize for the World" to consider and explicitly confront the challenges presented by the recent biopiracy of the so-called "Sierra Mixe corn from an Oaxacan indigenous community" (Espacio, 2019). The meeting produced several documents, including a "Notice to the Universities, Centers of Investigation and Corporations Working in Indigenous Pueblos and Communities With Their Biodiversity" (Espacio, unpublished) and the role of "The Communal *Milpa* in the Time of Pandemics" (Espacio, 2020). As a concrete and symbolic act of resistance, Espacio gifted seeds of *olotón* to representatives of La Via Campesina:

*TODAY we gift our seeds of olotón, corn which is planted in many communities of Oaxaca [and elsewhere], along with seeds of other corn varieties and other plants, to a representative of Via Campesina, the most critical small farmer organization in the world, so that through this organization small farmers in their respective countries may plant them without having to buy them from transnational corporations. Our seeds are now under your care that you may cause them to adapt to other circumstances, to flourish and reproduce. MAY THE SEEDS BE FREE SO THAT FREE COMMUNITIES MAY FLOURISH!* (Espacio, 2019)

Espacio is communicating with various institutions and groups to give popular and political weight to its position.

### Is it biopiracy?

The creation of the Nagoya Protocol is part of the continuing struggle to counter the wholesale and largely uncompensated or imperfectly compensated appropriation of human and natural resources for the ownership, use, and enrichment of the powerful, a persistent feature of the history of capitalism. The Nagoya Protocol provides a legally binding but ambiguous framework of obligations for national states to follow as they set the operational specifics of what should be “fair and equitable” arrangements. If the Nagoya Protocol’s validation of compliance via the IRCC is to be meaningful, then it is incumbent on the Mexican government and the UCD–Mars team to show that the ABS agreement with Totontepec is indeed “fair and equitable.” Absent that indication, there need be no presumption of legitimacy for claims of fairness or equity unsupported by evidence. Although the Mexican government, Mars, and the Comisariado de Totontepec all consider the ABS agreement to be confidential, the only requirement for confidentiality we find in the agreement relates narrowly to data and not to the agreement itself (SAGARPA, 2015a, 2015b, E.10). The refusal to divulge information about the agreement is not legally compelled but represents a deliberate choice to conceal information.

The choice to conceal rather than illuminate the details of the BioN2–Totontepec agreement fosters and enables the promulgation of a narrative that is misleadingly positive and sometimes demonstrably false. In April of 2023, the British Broadcasting Corporation (BBC) released a film on *olotón* with the hyperbolic title “This slime could change the world” (BBC, 2023). The film reprises the common media characterizations of *olotón* as the agricultural “Holy Grail.” It promises to “explore how this wonder crop could help tackle world hunger, and even end farming’s toxic reliance on chemical fertilizers for good!” It does note that some critics are “labeling it as what’s known as biopiracy.” In response, Howard-Yana Shapiro is cameoed with the falsehood that “Every time at [sic] one seed is sold, half the value of the royalty goes to the community.” The mere existence of a Nagoya Protocol-compliant agreement appears to be sufficient for a representative of the Union for Ethical Biotrade (UEBT) to voice onscreen approval that “In Mexico, an agreement was negotiated between a company and a local community in a way to secure PIC for this research and also to agree on sharing some of the potential benefits.” As of August 28, on YouTube, the film has received 3 million views and 55,000 likes and is linked and shared on platforms such as Facebook, Reddit, LinkedIn, Future Farming, and Kidz-Search. The charge of biopiracy is defused with a falsehood and the legitimating imprimatur of the Nagoya Protocol. Similarly, in the widely distributed book *Eating to Extinction* (Saladino, 2022, p. 185), the agreement between Mars and Totontepec is lauded for directing financial benefits to farmers in the Sierra Mixe in what UCD’s Alan Bennett mistakenly claims is “a fifty-fifty arrangement.”

This choice to withhold information has implications beyond the specific case of *olotón*. The ABS Clearing-House was established so Indigenous peoples, communities, and national states whose genetic resources are the target of

acquisition could share experiences in arranging access and benefit sharing. There is little opportunity to learn from the successes or mistakes of others when all that is required in an IRCC is a simple assertion of “Ninguna” or “confidential.” A quick survey of the reports on the Clearing-House website (<https://absch.cbd.int/en/>) reflects highly uneven levels and quality of information. Failure to provide helpful information deprives others of insights that might contribute to more just and equitable outcomes. Open access to ABS agreements is critical because while the Nagoya Protocol mandates broad principles and frameworks for PIC and MAT, it does not define what practices and procedures are either “fair” or “equitable.” Effectively, it approves whatever a national government sanctions with an IRCC. Confidentiality impedes the kind of third-party assessment of the adequacy of an ABS agreement that we are engaged in here.

According to the formal requirements of the Nagoya Protocol, the ABS agreement arranging the acquisition of Totontepec seeds and microbes by the UCD–Mars team is, by implication, to be considered “fair and equitable.” It was duly certified as such by the Mexican authorities who authorized the issuance of the IRCC. Could it nevertheless also be biopiracy, as alleged by Espacio, by journalists, and by Mexican academics? Or, less pejoratively, is it a form of “misappropriation” (Robinson, 2010, p. 21)? Or, reworking the language of the Nagoya Protocol, is it nevertheless “unfair and inequitable”? Here, we simplify this complicated semantic parsing by organizing our analysis around the single term “justice.” We proceed by following De Jonge (2011) and Deplazes-Zemp (2019) in their framings of the “procedural,” “distributive,” “commutative,” “cognitive,” and “representational” forms of justice as they apply to the acquisition of genetic resources and associated traditional knowledge.

*Procedural justice* refers to the quality of a decision-making process. Although Mexico adopted the Nagoya Protocol in October of 2012, it did not have—and still does not have—laws or regulations explicitly designed for the negotiation and implementation of ABS agreements under the terms of the Protocol (UEBT, 2019). This appears to have contributed to a process that Álvarez-Buylla et al. (2018) charge was “strictly within the limits of bureaucratic procedures” that were not appropriate to the gravity of the issues. The degree to which effective PIC was or even could be achieved under these conditions and within 9 months is contested. We have been unable to determine how community consent was accomplished in Totontepec. The amended agreement states that if BioN2 intends to use traditional knowledge associated with *olotón*, it “will have to obtain prior and informed consent from the Provider” (SAGARPA, 2015b, E.2), which implies that the PIC process was incomplete. We do not know who represented the government of Mexico in negotiations with BioN2. Seven individuals with positions of municipal authority signed the ABS agreement, though we do not know how they participated in negotiations. It seems unlikely that the experience and expertise of Mexican or Totontepec representatives matched that of BioN2’s General Counsel or of WilmerHale’s attorney, who lectures

internationally on constructing Nagoya Protocol ABS agreements (Manheim, 2015).

Most simply and most seriously, whatever procedures were followed, they excluded all *olotón*-growing communities except some members of the community of Totontepec. Indeed, precautions were taken in the IRCC and in public statements by UCD–Mars, the Mexican government, and the Comisariado of Totontepec to avoid revealing Totontepec as the source of the material covered by the ABS agreement. The systematic and purposeful exclusion of other legitimate parties from participation and consent is the single most fundamental flaw in the *olotón* case. On its own, it is sufficient grounds for designating the agreement as unjust.

Without the participation of all parties with rightful interests in the disposition of *olotón*, there can be no *distributive justice* whereby all entitled parties receive rewards. Whatever benefits might accrue to Totontepec from the terms of the ABS agreement, there is no provision that they also flow to other communities with legitimate claims of having developed and stewarded *olotón*. Land disputes among Oaxacan communities growing *olotón* are already a source of conflict. It seems likely that the precautions taken by the Comisariado of Totontepec, by UCD–Mars, and by the Mexican government to keep the source of the material confidential were intended to avoid exacerbating inter-community conflict. The exclusion of other communities from participation in the *olotón* ABS agreement ironically implicates Totontepec itself as an accessory to something unjust that many call biopiracy.

We were gratified to receive a copy of the BioN2–Totontepec ABS agreement since it gives us direct knowledge of the MAT agreed upon for access to *olotón* and its associated resources. This enables an assessment of *commutative justice*, the degree to which fair and proportionate compensation is provided. BioN2 retains ownership of all inventions and modifications developed from the covered genetic resources. Still, it must pay Totontepec 1% of the net sales of any “Product” or 1% of the proportional contribution to net sales made by some constitutive part of the Totontepec material when the product in question is comprised of components from multiple sources. The 1% figure is in line with arrangements for benefit sharing established by a Brazilian ABS legislation, with that proposed for the ITPGRFA (1.1%), and with that put forward for digital sequence information at the recently concluded Conference of the Parties of the CBD (Van Vooren, 2022). Of course, those financial benefits are predicated on future prospective resource use. The 1% specified in the 2015 agreement with BioN2 represents the cold standard of an uncertain future market value rather than the special considerations reflected in the generous 50% share allocated to Totontepec in the 2005 MTA with UCD.

Strangely, the section on “Just and Equitable Sharing of Non-Monetary Benefits” included in the agreement’s first version has been deleted from the second version. Various analysts have criticized the tendency for ABS agreements to take a narrow, transactional approach to benefit-sharing, prioritizing financial benefits over other possibilities, such as technology transfer (Laird et al., 2020;

Wynberg, 2023), training or knowledge sharing. Seeds of *olotón* and its associated bacteria are now the subjects of basic research on plant genetics and microbial nitrogen fixation in the laboratories of UCD and UWM. Classical plant breeding is already being used to hybridize *olotón* and U.S. varieties to develop nitrogen-fixing corn cultivars for the Midwestern Corn Belt. Although public pronouncements by Mars and UCD personnel commonly tout the potential for benefits to “poor farmers trying to grow maize in poor soils in the developing world” (Shapiro, 2018, see also Fillmer, 2018; Mars, Inc., 2018; and **Figure 1**), the farmers who will have the first opportunity to purchase such cultivars will be in the United States, not Oaxaca. Will the benefits of new knowledge or technology generated through access to Oaxacan *olotón* be made available to—or shared with—Mexican scientists or campesinos? When? Under what conditions? At what price?

We suggest that the critical issue with commutative justice is not that Totontepec is being underpaid for access to genetic resources (though it probably is) but that it considered a too-limited set of possible benefits. Might they have asked for license-free use of any inventions derived from research on *olotón* or its associated bacteria? Might they have required parallel and contemporary development of finished maize cultivars adapted to the climate and needs of Totontepec and U.S. farmers? Might they have required a voice in the research laboratories of California and Wisconsin so that they could understand and influence the course of scientific research? Might they have required access on behalf of the Mexican science community? Might they have required that a scholarship for a PhD student be provided for someone from their community? Might they have asked that U.S. researchers participate in a delegation to Oaxaca where they would spend time immersing themselves in Indigenous practices and cosmologies?

They could have. The tool with which they might have negotiated and perhaps even enacted such demands is precisely the one they concluded with BioN2. The ABS agreement is a contract. A contract is an agreement between parties who agree legally to be bound by specific terms. Those terms are open-ended, the product of negotiation. Companies and institutions worldwide use contracts for a multitude of purposes. The Nagoya Protocol sets some broad parameters to which its ABS agreements should adhere, but the specific terms of those contracts are left to the contracting parties. How might Totontepec’s negotiators have proceeded? Consider how “reservation-of-rights” clauses work:

*License agreements broadly define the terms of a technology provider (licensor) that will transfer intellectual property and/or tangible property to a technology user or developer (licensee), usually for commercial development. In many cases, the license agreement is nonexclusive, or it carefully defines the use of the technology for a specific field or geography. In such cases, the license does not grant—but instead retains—rights to the technology*



*in all areas other than those defined within the scope of the license. . . .* (Bennett, 2007, pp. 41–42)

The problematic feature of commutative justice in the BioN2–Totontepec ABS agreement is that they did not consider the full range of available benefits. This is also a problem of procedural justice because the Mexican/Totontepec negotiators almost certainly did not know—and were not informed—that they had such options.

The ABS agreement between Mars and Totontepec includes terms involving establishing and licensing intellectual property rights such as patents. This raises some fundamental issues of *cognitive justice*. Many Indigenous peoples and communities summarily oppose and reject “Western” forms of intellectual property rights—especially patenting—as a deeply offensive, illegitimate, and improper arrogation by humans of rights to and ownership of sacred and living beings with whom they believe they have a relationship of mutual responsibility and care (Fredriksson, 2021). Espacio (2019) takes this position: “Communal corn is a communal practice, a form of sharing, a way of life. In Oaxaca, it is the *guelaguetza*, the mutual sharing among people: it is not just money or profits.” Bond and Scott (2020, p. 31) phrase the problem accurately and succinctly: “how to reconcile ontological distinctions between understanding Earth as a resource and Earth as our collaborator?” Absent serious engagement with this conundrum, we feel there can be no conclusion that the BioN2–Totontepec agreement is just.

Mexican Indigenous, community, and scientific voices (Álvarez-Buylla et al., 2018; Espacio, 2019; Randall and de Ávila, 2019) consistently express a desire for *representational justice*. They are offended by a persistent trope of “discovery” that they perceive as characterizing the attitudes and public statements of the U.S. scientific community, institutions, and press. The desire to be seen, recognized, respected, and attributed with agency is a common theme among many groups whose presence, visibility, and contributions have been ignored, minimized, obscured, and appropriated by more powerful others. Regarding *olotón*, Espacio (2019) asserts that the UCD–Mars team “did not ‘discover’ anything, but rather are only attempting to appropriate our ancestral knowledge and demonstrating an ignorance of and a disdain for the traditional science that is still practiced in our communities and expresses itself in our customs.”

Álvarez-Buylla et al. (2018) join Espacio in condemning the failure to recognize the work of Oaxacan farmers and the foundational contributions of Mexican researchers. Although they commonly make cursory references to the source of *olotón* in Oaxaca, the statements of UCD, UWM, and Mars scientists, the press releases of their institutions, and the widespread press coverage of the *PLOS Biology* article commonly frame the discourse in terms that emphasize their achievements and agency. As the *California Aggie* phrased it: Mexican farmers and scientists may have “hypothesized for decades” that *olotón* might be fixing nitrogen, but it was UCD researchers who were able to “gather conclusive evidence . . . on what has been speculated for the past 30 or 40 years” (Montross, 2019).

## Conclusion: What is to be done?

The Nagoya Protocol was nominally intended to address and impede the longstanding and deeply entrenched practices that have been termed—broadly and pejoratively—as biopiracy. It purports to put in place a framework for acquiring and using biodiversity that tends toward the “fair and equitable.” But the Nagoya Protocol bears the scars of its birthing in longstanding and deeply entrenched conditions of geopolitical inequality. The Nagoya Protocol is widely recognized as a flawed instrument by those who would move the world in more appropriate and equitable directions (e.g., Laird et al., 2020) and by those who would prefer to maintain existing power distributions and benefit (e.g., Sara et al., 2022). Much of the debate about the Nagoya Protocol now is over how the products that embody some use or transformation of a genetic resource can be tracked for benefit sharing. The recent decisions taken at the CBD’s COP15 in Montreal have now determined that ABS obligations will apply to digital sequence information (DSI) as well as the physical material of genetic resources. The relationship between the CBD’s newly created Global Benefit-Sharing Mechanism and the Nagoya Protocol has not yet been clarified (Van Vooren, 2022). As important as these issues are, they beg the question of what happens at the point of appropriation. If material is not acquired fairly and equitably in the first place, whatever happens to it downstream is unlikely to be fair and equitable.

We have examined the conditions at the point of appropriation under which *olotón* was obtained from the municipality of Totontepec by BioN2, Inc. through an ABS agreement. That agreement was approved by the Mexican government and sanctioned by issuing an IRCC under the terms of the Nagoya Protocol. According to what Álvarez-Buylla et al. (2018) call “the institutional standards of the moment,” the BioN2–Totontepec arrangements for PIC and MAT were acceptable to the Mexican authorities. How could it be biopiracy?

Unfortunately, the Nagoya Protocol allows information to be kept confidential. We believe that allowing confidentiality is a deep flaw of the Protocol. We note that the Nagoya Protocol defers such decisions to national states. We found that the Mexican government had not established—and still has not established—a dedicated framework for implementing the Protocol, but it does permit confidentiality. Confidentiality is fatal to an adequate assessment of fairness and equitability. Where there is no transparency on these critical features of an ABS agreement, there can be no indisputable presumption that biopiracy is not occurring. Had we not been gifted—unsolicited—a copy of the agreement from an anonymous source, we would not have been able to come to many of the determinations and judgments we have described here.

Since neither the Nagoya Protocol nor the Mexican government has established criteria for what is “fair and equitable,” we framed our assessment of the Totontepec–BioN2 arrangements by applying various conceptions of “justice” to information we gathered from documents and interviews. Chief among our conclusions is that excluding

all other *olotón*-growing communities except Totontepec from participation in the agreement is an egregious violation of procedural justice. Not only were appropriate participants excluded, but the negotiations between BioN2 and Totontepec representatives were compromised by radically differential access to knowledge and information. From that fundamental error proceeded additional deficiencies. Absent the inclusion of all parties with a legitimate interest in the proceedings, there can be no appropriate distribution of benefits, and so no adequate expression of distributive justice. The royalty arrangements of the agreement appear to be consistent with prevailing patterns. But we suggest that the narrow reliance of benefit-sharing on a commoditized, marketized royalty arrangement unnecessarily limited the possibilities that could have been opened by a reservation of rights approach that could have offered a richer expression of commutative justice.

The imbalance between attributions of credit and agency that characterize both popular and scientific accounts of *olotón*'s "discovery" warrants the conclusion that representational justice is not being served as well as it ought to be. Our assessment of cognitive justice has been shaped powerfully by our interactions with the representatives of Espacio, who insist to us that "When you enter into these Indigenous territories, you are entering into another civilization . . . and into a different economic system where your intellectual property interests, interests in privatization and breeders' rights don't apply. YOU CANNOT PATENT COMMUNAL PROPERTY" (Espacio, unpublished). It would be instrumental to hear from the Indigenous leadership and people of Totontepec on this question. We feel that ignoring and overriding Espacio's claim cannot now be regarded as just.

We cannot and will not exempt our own activities at the University of Wisconsin from the charge of biopiracy. The Ané Laboratory at the UWM—with which we are formally and informally associated—continues to proceed with research on *olotón*-type plant germplasm and its microbial symbionts. The *olotón*-type seeds have been sourced from genebanks rather than Totontepec and are not subject to the BioN2–Totontepec agreement. Seeds from the International Maize and Wheat Improvement Center (CIMMYT) were obtained under the ITPGRFA and are subject to the Treaty's Standard Material Transfer Agreement. Seeds from the U.S. Genetic Information Resources system are, by U.S. policy, subject to no encumbrances despite being collected from Mexico over previous decades.

Contacted by Espacio in January 2019, we were prompted to respond to their request for assistance regarding the BioN2–UCD–Mars initiative and to engage in a reflexive assessment of our responsibilities. We began by listening to what the representatives of Espacio wanted to say to us. In their "Declaration of the State Conference: Oaxacan Communal Corn for the World" (Espacio, 2019), they put forth this call:

*To the scientific community: act with an ethos of respect for traditional Indigenous wisdom and knowledge by putting yourselves at the service of*

*the Indigenous pueblos and, together, helping to find solutions to our problems. When using cutting-edge technologies, respect the natural world in your research and proposals.*

For more than 2 years now, we have been conversing with members of Espacio, trying to create a relationship of trust and understanding that might enable us to shape our research in ways that authentically respect the principles to which they are committed.

This has not been easy. Indigenous peoples have little confidence in the motivations and promises of scientists and outsiders, and they, in turn, harbor problematic assumptions and misunderstandings about the needs and desires of Indigenous peoples. The ontological distance between Indigenous and commercial/scientific worldviews is considerable. We have reached out to Indigenous communities in both Oaxaca and Wisconsin and have succeeded in obtaining resources to arrange mutual visitations. In October 2023, representatives of Espacio traveled to Wisconsin to meet Ho Chunk, Menominee, and Oneida communities for discussions on the common concern of seed sovereignty. There was also conversation between UWM researchers and the Oaxacan visitors in an effort to foster mutual understanding and to try to envision productive paths forward. This initial encounter will be followed by a visit of Wisconsin tribal and UWM representatives to Oaxaca to expand and deepen the relationship. We are also seeking collaborations with Mexican researchers who share our openness to alternative work. We are exploring how agroecological thinking might apply to our work and how participatory breeding approaches might be introduced to our portfolio of skills. We have begun a conversation with the university's intellectual property staff to understand how we might create innovative arrangements for sharing research results.

In *Science's* policy forum, Laird et al. (2020, p. 1202) criticize the Nagoya Protocol's approach to ABS as having "calcified over the years around a bilateral transaction for physical samples" and call for a "new approach for ethically sharing the benefits of science and technology." We agree but find their construction too unidirectional. The benefits of science and technology *and* the benefits of Indigenous knowledge and technology should be *mutually* shared. We especially like the proposal made by Tsioumani (2021, p. 165) that fair and equitable benefit sharing should be conceptualized as "reward-and-enable." Farming and Indigenous communities should be rewarded—monetarily, yes, but also through knowledge sharing and capacity building—by being supported and enabled to continue their practices in the future.

#### Data accessibility statement

All materials acquired as part of this research are available from the authors.

#### Acknowledgments

The authors extend their gratitude to the reviewers and editors of *Elementa* for their insight and advice. We also wish to express our appreciation to Jodie Randall and to

the other members of Espacio Estatal en Defensa del Maíz Nativo de Oaxaca for their ready cooperation and steadfast support. Additionally, we are deeply grateful to the anonymous donor of the Mars–Totontepec ABS agreement for their courage and trust in providing information that was essential to our analysis.

### Funding

Jean-Michel Ané was supported for this work by USDA grant #2020-67013-32675.

### Competing interests

Jean-Michel Ané was funded by BioN2 via UC Davis until December 2016.

### Author contributions

All authors made substantial contributions to conception and design, data acquisition, analysis and interpretation of data, drafting and revising the manuscript, and final approval for publication.

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**How to cite this article:** Kloppenburg, J, Calderón, CI, Ané, J-M. 2024. The Nagoya Protocol and nitrogen-fixing maize: Close encounters between Indigenous Oaxacans and the men from Mars (Inc.). *Elementa: Science of the Anthropocene* 12(1). DOI: <https://doi.org/10.1525/elementa.2023.00115>

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**Knowledge Domain:** Sustainability Transitions

**Published:** January 18, 2024    **Accepted:** November 22, 2023    **Submitted:** September 14, 2023

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