Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

The Hybridization Hypothesis of Ecological Knowledge Systems

Hipótesis de Hibridación de los Sistemas de Conocimiento Ecológico

Robert C. Thigpen III

Marine Conservation without Borders & Baruch Institute for Marine & Coastal Sciences, United States

robby@marinefrontiers.org https://orcid.org/0000-0001-9783-4228

Recibido: 29/07/2025

Aprobado: 14/11/2025

Doi: https://doi.org/10.48204/rea.v4n2.8847

Abstract

This paper examines the integration of Indigenous and Creole ecological knowledge systems with Western science through the lens of the Hybridization Hypothesis of Ecological Knowledge Systems. This hypothesis posits that synthesizing diverse ecological knowledge systems creates a more holistic framework for environmental management. Central to this integration is the concept of biocultural constants, shared features of biological and cultural systems that remain consistent across time and space within a species range or ecoregion. Through a case study of a bilingual mangrove curriculum, this study demonstrates that communities across linguistic groups independently recognize common ecological knowledge, supporting the existence of biocultural constants. The findings emphasize that hybridized ecological knowledge, delivered in the mother tongue, strengthens ecological stewardship, fosters cross-cultural collaboration, and enhances community resilience. Recognizing and integrating diverse ecological perspectives through hybridization provides a pathway toward more inclusive, adaptive, and sustainable environmental strategies.

Keywords: Biocultural education, ecological translanguaging, Indigenous ecological knowledge, hybridization, multilingual science education.

Resumen

Este artículo examina la integración de los sistemas de conocimiento ecológico indígenas y criollos con la ciencia occidental, a través del enfoque de la Hipótesis de Hibridación de los Sistemas de Conocimiento Ecológico. Dicha hipótesis plantea que la suma de sistemas diversos de conocimiento ecológico crea un marco más holístico para la gestión ambiental. Un concepto central en esta integración es el de constantes bioculturales, es decir, características compartidas de los sistemas biológicos y culturales que se mantienen constantes a lo largo del tiempo y el espacio dentro del rango de una especie o una ecorregión. A través del estudio de caso de un currículo bilingüe sobre manglares, esta investigación demuestra que comunidades de distintos grupos lingüísticos reconocen de manera independiente conocimientos ecológicos comunes, lo que respalda la existencia de constantes bioculturales. Los hallazgos destacan que el conocimiento ecológico hibridado, transmitido en la lengua materna, fortalece el compromiso ambiental, promueve la colaboración intercultural y mejora la resiliencia comunitaria. Reconocer e integrar perspectivas ecológicas diversas mediante la hibridación ofrece un camino hacia estrategias ambientales más inclusivas, adaptativas y sostenibles.

Palabras clave: Educación biocultural, translenguaje ecológico, conocimiento ecológico indígena, hibridación, educación científica multilingüe.

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Introduction

The integration of different ecological knowledge systems from diverse linguistic and cultural communities within shared ecoregions is pivotal to the long-term success and sustainability of conservation and resource management projects (Maffi, 1998; Berkes, 2009; Cajete, 2000; González & Gómez-Baggethun, 2011). The Hybridization Hypothesis of Ecological Knowledge Systems posits that blending local ecological knowledge with Western scientific paradigms can create a more comprehensive and culturally relevant framework. Importantly, this hybridization must occur without the imposition of Western ideological frameworks. The goal is to foster genuine epistemological integration, resulting in pedagogies where Indigenous and Creole knowledge systems retain their integrity and continue to shape ecological understanding and stewardship on their own terms. This goal also reflects global concerns, as UNESCO (2016) estimates that over 40% of the global population lacks access to education in a language they understand, significantly affecting learning outcomes and equity in education. As Aikenhead (1996, 2001) has argued, learning science for many students, particularly those from Indigenous communities should be reframed not as assimilation but as culture acquisition, guided by respectful border-crossing pedagogies.

These languages, often relegated to the market, the street, or the domain of elders have long been viewed as relics of the past, unsuitable for science or formal education. One of the central aims of this work is to flip that trajectory and to demonstrate that these languages are equal to all other languages. Through co-developed biocultural curricula, the study repositions these languages as contemporary, vital, and epistemologically robust. By bringing Kriol, Maya, Mopán, Yucatec Maya and other Indigenous and Creole languages into local classrooms, universities, and even biology laboratories, the research demonstrates that they are equal in status and capacity to national and colonial languages. They are not just part of the past, they are strategic tools for the future (UNESCO, 2003; Hornberger, 2008; McCarty, 2003).

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

In resource management, language plays an essential role in bridging divides between ecological knowledge systems (Gómez-Baggethun *et al.,* 2013: Gómez-Baggethun, Reyes-García, 2013: Soto et al., 2017). Local languages are increasingly being recognized as crucial to maintaining ecological knowledge systems (Reyes-García *et al.,* 2016; Maffi, 2001).

The hybridization of ecological knowledge systems is an organic phenomenon that occurs naturally within ecoregions (Berkes & Turner, 2006) and should include Western ecological frameworks. Historically, colonial institutions marginalized local ecological knowledge systems, displacing Indigenous and Creole understandings of biodiversity with Eurocentric scientific narratives (Nabhan, 1997). This erasure has led to a narrowing of ecological perspectives at a time when diverse ecological knowledge systems are critical for fostering resilience in socioecological systems. Aikenhead (1996) introduced the concept of cultural border crossing in science education to describe the negotiation students must undertake when moving between the worldviews of their communities and that of Western science, a process similarly central to hybridized ecological frameworks.

As part of this framework, the article introduces the concept of *biocultural constants* (a term introduced here), recurring ecological features, species, or landscape interactions that hold shared cultural significance across multiple Indigenous or Creole communities and Western biologists. These biocultural constants serve as conceptual anchors for aligning local ecological knowledge with formal science education, allowing STEM curricula to reflect and reinforce both ecological patterns and cultural continuity.

The study also introduces two interrelated pedagogical concepts and practices**:** ecological translanguaging (a term introduced here) and transknowledging. *Ecological translanguaging* refers to the intentional use of multiple languages in science education to support ecological understanding across linguistic, cultural, and epistemological boundaries. Drawing on the tradition of translanguaging as both a sociolinguistic and ecological practice (Fine, 2016; García & Kleyn, 2016; Lewis et al., 2012; Wei, 2018), and informed by language ecology theory (Haugen, 1972). The term here describes how multilingual learners mobilize their full linguistic repertoire to engage

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

with both Indigenous or Creole and Western ecological knowledge. UNESCO (2003) has long advocated for multilingual education as a key to ensuring linguistic rights, preserving cultural knowledge, and enhancing pedagogical quality in linguistically diverse societies.

Transknowledging refers to the integration of distinct knowledge systems, especially the blending of Indigenous ecological knowledge with Western science within multilingual educational societies (Nyblade et al. 2024). Together, these concepts offer a theoretical and pedagogical foundation for hybrid curriculum design that affirms linguistic rights, promotes epistemological equity, and supports biocultural resilience (Poot Cahun, 2025).

By embracing the Hybridization Hypothesis of Ecological Knowledge Systems, conservation efforts can draw on the empirical foundations of traditional ecological knowledge systems while leveraging the analytical tools of Western science. Hybridized systems allow for greater flexibility, inclusivity, and cultural relevance, offering new pathways toward environmental sustainability and the revitalization of biocultural diversity.

Methods and Materials

This study adopts a qualitative, practice-based case study design grounded in cross-cultural curriculum development and multilingual ecological education. Drawing on data from classroom implementation, pilot site feedback, researcher observations, and educator co-reflections across Belize and México, it explores how hybridized ecological knowledge systems function in real educational contexts. Although not structured as a conventional ethnography, the study incorporates narrative and observational elements that reflect its roots in lived educational practice. Prototypes were co-developed with teachers and community members, then implemented in over a dozen sites, serving as empirical tools for testing the hypothesis. This multi-sited, iterative approach allows for triangulation through field notes, informal interviews, and multilingual student and teacher feedback. The methods presented below are organized thematically to reflect the sequence and nature of the curriculum's development and deployment.

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

The initial efforts that eventually led to the Hybridization Hypothesis began with the development of *Lillian the Lobster*, a science book originally written in Belizean Kriol through a collaboration among Robert Thigpen, Celeste Castillo, Yarisel Castillo, and Zaida Majil for Belizean fishing communities. The Kriol text was later copy-edited by Silvanna Udz and Ms. Myrna Manzanares of the Belize National Creole Council. The book narrates the life cycle of the Caribbean spiny lobster (*Panulirus argus*), beginning with Lillian's hatching on the reef and her drift into the open ocean, where she lived as a zooplanktonic predator in the pelagic zone. After approximately 6–8 months, she returned to the coast and settled among seagrass meadows, mangrove roots, and algal mats, ecosystems essential to juvenile development. Along her journey, Lillian encountered iconic marine species of the Mesoamerican Barrier Reef System, including whale sharks (*Rhincodon typus*), manatees (*Trichechus manatus*), sea turtles, and invasive lionfish (*Pterois* spp.). Each species was introduced in a dedicated chapter, alongside chapters focused specifically on the ecological functions of mangroves and seagrasses. The narrative was deliberately designed to be both engaging and accessible for readers of all ages, while remaining grounded in scientific observation and community knowledge.

Lillian the Lobster was developed using a biocultural methodology that combined autoethnographic reflection, ethnographic collaboration, and ecological accuracy. In shaping the narrative, the inquiry was guided by the question: *If I had grown up in Belize, what would my grandfather have taught me about the life history of P. argus and the creatures it encounters during its life cycle?* This question, rooted in memory, identity, and cultural imagination became the project's conceptual and emotional anchor. It reflects the autoethnographic foundation from which the work emerged: an effort to envision the marine world not only through scientific observation, but also through inherited ways of knowing embedded in family stories, gestures, and traditions.

Ethnographically, the book grew from sustained engagement with Belizean fishers and educators, drawing on oral histories, linguistic expertise, and local ecological knowledge. The fishers treated the researcher as one of their own and freely shared the ecological knowledge their grandfathers had taught them, often around docks, in boats, or during quiet moments between work. Their trust, generosity and encouragement made this work possible, and it was never approached as an act of

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

cultural extraction, but as a relationship rooted in mutual respect and shared commitment to stewardship. Biologically, the narrative aligned with current marine science on lobster development and ecological connectivity. By embedding ecological content in Belizean Kriol and anchoring the narrative in both scientific and community-based epistemologies, *Lillian the Lobster* served as a prototype for the STEM Plus model being developed, demonstrating how multilingual, culturally grounded science education can promote epistemological equity and strengthen conservation efforts. This finding aligns with Poot Cahun's (2025) observation that "students not only learned about biology, but also strengthened their cultural identity by seeing themselves reflected in texts written in their own language and containing familiar cultural references".

This inquiry was guided by two working hypotheses. First (H-1), that through collaboration with Belizean fishers and the ecological knowledge passed down through generations, it would be possible to develop a science curriculum that was both culturally resonant and ecologically robust. Second (H-2), that similar approaches might allow the development of classroom science materials that are culturally meaningful and ecologically valid for each linguistic or cultural group within a shared ecoregion or species range. These guiding propositions informed the co-development of both *Lillian the Lobster* and the multilingual mangrove prototypes described below. Subsequent iterations of this methodology, including more advanced prototypes not detailed here, were later evaluated in formal Maya classroom settings by Poot Cahun (2025), whose findings offer additional empirical support for both the methodological approach and its cultural relevance.

In addition to these hypotheses, this study explored three interrelated research questions:

- Can co-authored science materials grounded in local language and ecological knowledge maintain both cultural relevance and scientific integrity?
- Did distinct linguistic communities recognize shared ecological understandings, described here as biocultural constants?
- How does mother-tongue ecological instruction affect student engagement and perceived relevance in science education?

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

This study follows a multi-phase, qualitative research design grounded in design-based research, ethnographic collaboration, and autoethnographic reflection. Lillian the Lobster was not formally piloted but was shaped through ongoing dialogue with Belizean fishers and Kriol-speaking community members, whose linguistic and ecological insights informed the narrative. Building on that foundation, the mangrove prototype (Thigpen et al., 2016) was co-developed by Robert Thigpen, in collaboration with José Antonio Romero Durón and Grazzia Matamorás Erazo, marine scientists with extensive experience working alongside Indigenous and Creole seafaring communities of Honduras.

The resulting bilingual prototype was piloted in Kriol- and Mopán-speaking classrooms in Belize, as well as in an Indigenous primary school in México where the materials were written in Yucatec Maya. These teachers also served as ethnotranslators. Feedback from these educators, captured through written comments and informal dialogue, was used to refine the curriculum. While no standardized instruments were employed, data were documented in field notes, correspondence, and narrative feedback, and subsequently analyzed thematically.

A striking outcome of this process was the independent recognition of key ecological insights, such as the role of mangroves as fish nurseries and the behavior of coastal birds across both participating classrooms and unrelated linguistic groups, including the Guna and Ngäbe, who were not directly involved in the project at that time. After reading a Wayuu–Spanish edition of the mangrove prototype, a Ngäbe participant in Changuinola, Panamá remarked that the descriptions reflected his own community's knowledge and asked when the researcher had visited his people to learn these things; in reality, this was the researcher's first encounter with a member of the Ngäbe community. Similarly, a Guna elder in Panamá City explained that he had learned about juvenile fish sheltering in mangroves simply by swimming in the sea as a child.

These thematic convergences contributed to the articulation of the concept of *biocultural constants*: shared ecological understandings that emerge across cultural and linguistic contexts within a common ecoregion. This participatory, community-engaged approach illustrates the

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

exploratory character of the Hybridization Hypothesis and its commitment to both scientific and cultural integrity.

Upon the return of the first science book written in Kriol to Belize, community reception was overwhelmingly positive. Many Belizeans expressed enthusiasm at encountering scientific material that reflected their own language and cultural identity. However, during a pivotal conversation, Polo Heredia, a respected Belizean lobster fisher of Maya descent whose father was among the founders of the Northern Fishermen's Cooperative Society Ltd., observed that lasting impact would not be achieved unless such educational materials were made accessible to all linguistic communities throughout Belize and across the wider Caribbean basin.

Although the critique was initially unexpected, subsequent reflection grounded in ecological insights into larval recruitment and regional fisheries connectivity (Cowen et al., 2006; Butler et al., 2010, 2018) confirmed its validity. The interconnectedness of Caribbean marine fisheries necessitated an equally interconnected educational strategy. Efforts to protect biodiversity and promote sustainable fisheries could not succeed unless ecological education transcended linguistic and cultural boundaries. What began as a local initiative therefore evolved into a broader mission: to support basin-wide biocultural diversity by integrating multiple languages and ecological knowledge systems into formal educational materials. To advance this mission, the nongovernmental organization *Marine Conservation Without Borders* (MCB) was established as a platform dedicated to promoting biocultural diversity and multilingual ecological education across the greater Caribbean basin and Mesoamerica.

Building on this new understanding, the pilot scope was narrowed to a specific, globally relevant theme: mangrove ecosystems. Mangroves were selected because of their widespread distribution across tropical latitudes and their critical role in marine conservation efforts (Spalding et al., 2010). They also provided an ideal ecological entry point for fostering collaboration across diverse Caribbean linguistic communities.

The mangrove chapter, originally developed within *Lillian the Lobster*, was subsequently translated into English, expanded both culturally and scientifically, and transformed into the first

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

STEM Plus prototype biocultural textbook. This process was carried out collaboratively in Colonia Kennedy, Tegucigalpa, Honduras, with marine biologists Grazzia Matamorás Erazo and, José Antonio Romero Durón whose experience working alongside Indigenous and Creole fishers informed the development (Thigpen et al., 2016).

These educational materials are referred to as STEM Plus because they encompass Science, Technology, Engineering, and Mathematics. However, unlike conventional STEM curricula, STEM Plus textbooks integrate concrete and tangible aspects of local flora, fauna, and thus local ecological knowledge, ensuring a more contextualized learning experience. Furthermore, they are delivered in the local language, enhancing accessibility and cultural relevance for young learners.

As introduced above, our mother-tongue ecological instruction builds on familiar linguistic and cultural frameworks to deepen ecological engagement. This principle is affirmed by multiple international and regional agreements. The *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP, 2007) and the *Charter on Language Policy and Language Rights in the Creole-Speaking Caribbean* (ICCLR, 2011) both advocate for the protection of Indigenous and Creole languages, the right to culturally relevant education, and the safeguarding of traditional ecological knowledge systems. These goals are further reinforced by the *Cartagena Convention* (United Nations Environment Programme [UNEP], 1983), a regional legal framework for the protection of the marine environment in the greater Caribbean basin and emphasizes ecological cooperation and habitat conservation. By embedding STEM education within these linguistic and ecological contexts, the mangrove prototype operationalized these commitments at the community level.

The mangrove prototype consisted of brief chapters approximately half a page, each featuring two reading comprehension questions and two hands-on classroom activities. It also included an outdoor activity focused on mangrove gardening techniques and a glossary detailing scientific terms and descriptions of local flora and fauna. Although initially developed for research purposes, the prototype was subsequently tested in Kriol and Mopán [Maya] classrooms in Belize, and

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Yucatec Maya classrooms in Quintana Roo, México where students and teachers alike praised its cultural resonance and accessibility.

While this project began as a multilingual translation effort, it also created the conditions for what this paper terms ecological translanguaging, the emergent practice of using multiple languages fluidly to express ecological knowledge across cultural and epistemological boundaries. In this framework, local languages do not merely convey translated scientific content but actively shape how ecological concepts are taught, understood, and adapted within their communities. This approach mirrors Aikenhead's (1997) model of the teacher as a "culture broker," a guide who helps learners navigate between the epistemologies of Western science and those rooted in Indigenous cosmologies.

Results

The bilingual Mangrove prototype STEM Plus books authored in Kriol (Thigpen et al., 2018), Mopán (Thigpen et al. 2021) and Yucatec Maya (Thigpen & Poot Cahun 2018) encapsulate traditional ecological knowledge that aligns closely with empirical ecological research. Observations such as birds nesting in mangroves, the role of mangroves as nurseries for juvenile fish, and the prevention of coastal erosion are all substantiated by ecological studies (e.g., Ravaoarinorotsihoarana et al., 2023; Longepée et al., 2021; McKee et al., 2021). This congruence affirms the scientific legitimacy of community-derived ecological claims and underscores the value of integrating diverse ecological knowledge systems into conservation education.

Student enthusiasm across Kriol, Mopán, and Maya classrooms revealed the powerful impact of culturally grounded language in science instruction, validating both the relevance of the content and the emotional connection to place and identity. The following reflections illustrate the reception, validation, and cross-cultural relevance of the mangrove prototype.

At Buttonwood Bay Nazarene Primary School in Belize City, teacher Yaricel Castillo shared: "I had the opportunity to write a Creole biology book with Robby, which I integrated into my classroom. The experience was rewarding as my students were excited to read the Creole and felt

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

a deep connection to the science and culture it represents. Seeing their enthusiasm and engagement with the material reaffirmed the importance of integrating diverse literature into education, fostering a sense of inclusivity and appreciation for linguistic diversity among young learners." – Yaricel Castillo

In San Jose Village, teacher Richard Peck reflected: "I am thankful you gave the San Jose RC School biology books written in Mopán. Since Mopán is our language, it was greatly appreciated by my students. As an educator, I consider the book to be student-centered and user-friendly. Furthermore, the book aligns with the Belize National Competency Based Curriculum, which calls for the implementation of hands-on activities for our students, including reading and writing in our Mopán language. More books like this will benefit our students and the future of our Mopán communities and nation in understanding the importance of conservation and ways of combating climate change." – Richard Peck.

At Gonzalo Aguirre Beltrán Indigenous Primary School in X-Hazil Norte, Quintana Roo, México teacher Hilario Poot Cahun shared: "I am very proud of this work for two reasons. The first is that Robby's aim was to combine different systems of knowledge: scientific and local. The topic of mangroves is being brought to Indigenous communities through his ethno-translation methods makes science more relevant and accessible to Maya communities. The second reason is that our language is reaching new places, disciplines, and educational levels. Many people believe that Indigenous languages are only useful at home, in the milpa [cornfield], or among friends. However, with this project, our language is expanding its reach and gaining new value. Also, my students were learning about science in their mother tongue for the first time. They loved the book because of the images and the text. They saw that their language was not just for the market, they could see their language being used to teach science." -Hilario Poot Cahun

Following this positive reception, the mangrove prototype was shared across the Caribbean and Mesoamerican regions and beyond, where it was adapted for fourteen seafaring linguistic communities [see Table 1]. In each case, community members recognized aspects of their own ecological knowledge within the content, affirming the cross-cultural relevance of the curriculum

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

and validating the existence of biocultural constants. Moreover, professional biologists and educators who reviewed the prototype consistently found the content indistinguishable from modern biology curricula, affirming the scientific rigor of the materials. One such educator, Dr. Glen Aikenhead, a foundational scholar in Indigenous science education, described the mangrove books as "showcases of what can be accomplished for high school biology instruction located in ocean-front school jurisdictions" and praised them as "superior templates for other Western science courses to draw on" (G. Aikenhead, personal communication, 05 August, 2020). This convergence where both local communities and scientific experts independently validated the material's accuracy and relevance strongly supports the concept of biocultural constants. It demonstrates that Indigenous and Creole ecological knowledge systems often encode empirical environmental observations that align closely with contemporary scientific understandings.

This cross-cultural validation was further reinforced by a formal study conducted in México.

Hilario Poot Cahun's (2025) thesis, conducted in Maya-speaking Indigenous primary schools of Quintana Roo, evaluated fourth- and fifth-grade multiple chapter STEM Plus textbooks whose themes were originally developed for use in other countries, including locations as distant as the Azuero Peninsula in Panamá. One such theme focused on primate ecology and conservation, was developed by Dr. Pedro G. Méndez-Carvajal, a Panamanian primatologist, and his graduate student, Karol Gutiérrez, affiliated with the University of Panamá. Despite their external origin, the materials functioned effectively in a new cultural and linguistic context, demonstrating the portability of the STEM Plus model and offering strong empirical support for the existence of biocultural constants. These findings revealed that students not only gained ecological knowledge but also felt a stronger connection to their cultural identity, reinforcing the core proposition of this paper: that hybridized ecological knowledge systems, when delivered in the mother tongue, can transcend geographic boundaries while remaining culturally resonant and scientifically rigorous.

The concept of biocultural constants arises from the recognition that certain ecological understandings are consistently present across different cultural and linguistic communities inhabiting the same or similar ecoregions (Berkes et al., 2000; Toledo & Barrera-Bassols, 2009).

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Biocultural constants are observed when geographically dispersed communities independently arrive at parallel understandings of ecological phenomena.

One example involves the ecological role of the howler monkey (*Alouatta spp*.) in seed dispersal and forest regeneration. Despite geographic, linguistic and cultural separation in Latin America, many Indigenous groups recognize the importance of these primate's in maintaining forest ecosystems (Baniwa & Schwartzman, 2005; Cortés-Ortiz et al., 2015; Estrada et al., 2022; Gilmore & Vriesendorp, 2021; Rajashekarappa, 2023). Additionally, the jaguar (*Panthera onca*) is admired both as a traveler between worlds and for its ecological role as an apex predator and for helping maintain ecosystems balance (Ceballos et al., 2007; Colchero et al., 2011; Ripple et al., 2014).

Biocultural constants suggest that ecological knowledge systems, while culturally mediated, are also profoundly empirical. They evolve through sustained environmental engagement and are validated by practical outcomes, such as the success of agroforestry practices, the sustainability of hunting traditions, or the resilience of agricultural systems (Alayco et al, 2007; Garnatje, Vallès, & Parada, 2014; Schulz et al., 1994). Recognizing biocultural constants will allow resource managers and policymakers to identify commonality between Indigenous, Creole, and Western ecological systems. Biocultural constants have the potential to facilitate collaborative approaches to environmental management.

Moreover, the identification of biocultural constants challenges misconceptions that Indigenous and Creole ecological knowledge systems are static or outdated. Instead, these knowledge systems are revealed as dynamic, adaptive frameworks capable of responding to environmental changes over time. By validating and integrating biocultural constants, these naturally hybridized ecological knowledge systems can promote resilience, adaptability, and sustainability in conservation strategies.

The mangrove curriculum case study offers direct empirical support for the existence of biocultural constants. Geographically separated communities from different linguistic backgrounds consistently recognized their ecological knowledge in the materials. This cross-cultural recognition, coupled with validation by professional biologists, demonstrates that biocultural

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

constants are not theoretical abstractions but observable certainties that can guide conservation and education efforts.

Languages are instrumental for sharing, the preservation of and even the evolution of ecological knowledge in Indigenous communities (Maffi, 2001; Reyes-García et al., 2016). These minority languages contain intricate relationships concerning flora and fauna, and ecological reciprocity that are encoded, shared and advanced across generations (Kimmerer, 2002; Berkes, 2012, UNESCO, 2021).

Indigenous and Creole languages often contain specialized terms for flora, fauna and habitat types that may not have direct counterparts in colonial languages. These distinctions offer insights into the understandings local communities possess about their own environments. For example, many Indigenous languages distinguish between stages of plant growth or animal behaviors. These observations are critical for successful agriculture, hunting, fishing or conservation practices (Lantz & Turner, 2003; Asif et al., 2023; Ramos, 2021).

The erosion of linguistic diversity, therefore, represents not merely a cultural loss but an ecological one (Maffi, 2005; Harmon & Loh, 2010). As languages disappear, so does the ecological knowledge embedded within them, diminishing our collective capacity to manage and sustain ecosystems. Numerous studies have shown that areas of high biodiversity often correspond with regions of high linguistic diversity, suggesting that biocultural diversity is integral to ecosystem resilience (Gorenflo et al., 2012; Maffi, 2005; Harmon & Loh, 2010)

Furthermore, the use of mother-tongue ecological education promotes cultural pride and identity, countering centuries of marginalization and validating the importance of local ways of knowing (Poot Cahun, 2025; McCarty & Lee, 2014; UNESCO, 2011). It positions Indigenous and Creole ecological knowledge systems as equally legitimate sources of empirical environmental understanding, alongside Western scientific paradigms.

Incorporating local languages into ecological education is not simply an act of translation but a process of epistemological integration. It enables a dialogue between ecological knowledge

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

systems, preserving the richness of traditional ecological insights while fostering scientific literacy. By embedding ecological education within the linguistic and cultural contexts of communities, conservation efforts can achieve greater relevance, inclusivity, and long-term sustainability.

Thus, the role of language in ecological knowledge transmission is foundational to the success of hybridized ecological knowledge systems. Protecting and revitalizing Indigenous and Creole languages is not only a matter of cultural preservation but an essential strategy for maintaining the ecological knowledge necessary for resilient and adaptive environmental management.

The Hybridization Hypothesis of Ecological Knowledge Systems offers practical applications for environmental management, conservation education, and community resilience initiatives. By integrating Indigenous, Creole, and Western scientific perspectives, hybridized ecological knowledge systems create flexible, context-sensitive frameworks that are more likely to achieve long-term ecological sustainability.

One primary application is the development of educational materials that are both scientifically rigorous and culturally resonant. As demonstrated by the mangrove prototypes, delivering ecological content in the local language and incorporating local ecological knowledge fosters deeper engagement among students and communities. Such materials can be adapted for use in formal education systems, community workshops, and conservation training programs, ensuring that ecological literacy is rooted in cultural identity and lived experience.

In conservation practice, hybridized ecological knowledge can inform more adaptive and community-centered management strategies. Traditional ecological practices, such as rotational farming, seasonal harvesting, and sacred site protection, offer time-tested models of sustainable resource use. When combined with contemporary scientific monitoring and analysis, these

practices can enhance ecosystem management by blending empirical observation with cultural stewardship.

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Furthermore, hybridized ecological knowledge systems can strengthen community resilience in the face of environmental change. Indigenous and Creole communities have long histories of adapting to ecological variability through diversified livelihood strategies, risk management practices, and social networks (Fernandez-Gimenez, 2000; Turner & Clifton, 2009; McCarty & Lee, 2014). Recognizing and incorporating these adaptive strategies into contemporary conservation and development planning can improve the robustness and sustainability of such initiatives.

The practical application of the Hybridization Hypothesis of Ecological Knowledge Systems also extends to policy development. Policymakers can draw on biocultural constants to craft regulations and programs that resonate across cultural boundaries, promoting broad-based support for conservation initiatives. Such approaches are consistent with international commitments outlined in *the Charter on Language Policy and Language Rights in the Creole-Speaking Caribbean* (ICCLR, 2011) and the *United Nations Declaration on the Rights of Indigenous Peoples* (United Nations, 2007), both of which advocate for the protection of linguistic diversity and traditional ecological knowledge in education and policy.

Ultimately, the practical application of hybridized ecological knowledge systems holds transformative potential. The Hybridization Hypothesis enables the co-creation of solutions that are scientifically informed, culturally meaningful, and ecologically sustainable, paving the way for a future in which environmental stewardship is collaborative and inclusive.

Environmental stewardship is deeply rooted in the worldviews and practices of Indigenous and Creole communities, where reciprocal relationships between people and nature are foundational to cultural identity and ecosystem management (Kimmerer, 2013; Turner & Berkes, 2006; Posey, 1999). The Hybridization Hypothesis of Ecological Knowledge Systems offers a powerful means of revitalizing and strengthening these stewardship traditions, while simultaneously integrating contemporary scientific insights.

Hybrid ecological frameworks recognize that stewardship is not solely a technical process but a cultural and ethical one. Traditional ecological knowledge systems are often embedded with

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

principles of reciprocity, responsibility, and respect for the natural world. For example, many Indigenous communities view humans as part of a larger ecological community rather than separate from it, emphasizing the need for sustainable interactions with natural systems (Kimmerer, 2013; Turner & Berkes, 2006; Posey, 1999).

By integrating these principles with empirical scientific knowledge, hybrid ecological systems promote stewardship practices that are both culturally resonant and ecologically effective. Such integration helps communities reclaim traditional management roles, strengthening local leadership in conservation initiatives. It also fosters a sense of ownership and pride, motivating long-term commitment to ecosystem protection and restoration efforts.

Educational initiatives based on the Hybridization Hypothesis of Ecological Knowledge Systems further reinforce stewardship values among younger generations. When students learn about local ecosystems through the lens of both their cultural traditions and scientific inquiry, they are more likely to develop a personal and collective sense of responsibility for environmental protection (Poot Cahun, 2025: Ritchie & Eames, 2010; Acharibasam & McVittie, 2023). This dual engagement can cultivate a new generation of stewards equipped with the knowledge, skills, and ethical foundations necessary to navigate complex environmental challenges.

Moreover, hybridized ecological knowledge systems encourage intergenerational dialogue and knowledge transmission. Elders, community leaders, scientists, and educators can collaborate to share and co-create knowledge, ensuring that stewardship practices evolve in response to contemporary needs while remaining grounded in cultural heritage.

Ultimately, fostering environmental stewardship through hybrid ecological knowledge systems not only enhances ecological outcomes but also strengthens cultural resilience. It creates pathways for communities to assert their ecological sovereignty, advocate for their rights to manage traditional territories, and contribute meaningfully to global conservation efforts. In doing so, hybrid ecological frameworks support a vision of environmental stewardship that is inclusive, adaptive, and deeply rooted in the interconnectedness of linguistic, cultural and biological diversity.

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2

Nov. 2025– Abr 2026

p. 111-140

Table 1.

Premiere Community-Based Adaptations of the Mangrove Prototype by Language and Region.

		Language	*Title*	*ISO 639-1*	*Country*	*Speakers*
01		Bahasa	Bakau	id	Indonesia	>200,000,000
02		Burmese	ဒိစ စ ေ◌◌ာမ ေ◌◌ာ◌်◌း	my	Myanmar	~33,000,000
		English	The Mangroves	en		
		French	Les Mangroves			
03		Garifuna	Budunudagei	cab	Belize, Guatemala, Honduras, Nicaragua, St Vincent	~190,000
04		Kreyòl Ayisyen	Mangwòv yo	ht	Haiti	~11,000,000
05		Kriol	Di Mangro Dehn	bzj	Belize	20,000-40,000
06		Iyasa	Beilé bá kɔ́ngɔ́kɔ	yko	Cameroon	~3,000
07		Maya Mopán	Okok Ha'il K'ak'naab	mop	Belize, Guatemala	3,00-4,000
08		Maya Yucateco	Le Chukte'obo'	yua	Belize, México	~800,000
09		Miskito	Laulu pâwi pliska nani ba	miq	Honduras, Nicaragua	~150,000
10		Papiamentu	Palu di mangel	pap	Bonaire, Curaçao	~350,000
		Português	Os Manguezais			
11		Q'eqchi' Maya	Eb' li che Mankl	kek	Belize, Guatemala	~1,300,000
		Spanish	Los Manglares			
12		Trinidad English Creole	De Mangro Dehn	trf	Trinidad	~1,000,000
13		Ulwa	Pauluh balna	ulw	Nicaragua	<300
14		Wayuu	Tü wunu´ulia Junna münakat	guc	Colombia, Venezuela	~400,000

Note: Speaker estimates are based on the best available data, but may not reflect recent demographic changes.

Discussion

This study supports the Hybridization Hypothesis of Ecological Knowledge Systems as a viable framework for fostering sustainable and inclusive environmental resource management. The independent recognition of ecological knowledge across multiple linguistic communities, coupled with the scientific validation of the mangrove prototype, demonstrates that biocultural constants are not abstract constructs but observable realities embedded in both traditional and scientific ecological systems.

Recognizing biocultural constants allows conservationists, educators, and policymakers to identify foundational ecological principles that transcend cultural and linguistic boundaries. These constants offer a powerful entry point for building hybrid ecological knowledge systems that are both scientifically robust, linguistically sound and culturally resonant. Rather than treating

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Indigenous and Creole ecological knowledge as supplemental to Western science, the Hybridization Hypothesis positions these ecological knowledge systems as empirical, adaptive, and essential for ecological resilience.

The findings also highlight the critical role of language in the preservation and transmission of ecological knowledge. Language loss poses a significant threat to biocultural diversity and ecological stewardship. Integrating mother-tongue education into conservation initiatives enhances the accessibility, relevance, and sustainability of ecological knowledge, while simultaneously revitalizing linguistic and cultural identities. These qualitative reflections suggest that mother-tongue ecological instruction significantly enhances student engagement and perceived relevance, affirming the importance of linguistic inclusion in science education. This conclusion is further supported by empirical data collected by Poot Cahun (2025) in Indigenous primary schools in La Zona Maya, Quintana Roo, México.

Hybridized ecological knowledge systems provide practical, adaptable solutions for contemporary conservation challenges. By combining traditional stewardship ethics with scientific methodologies, hybrid frameworks create strategies that are locally grounded yet globally informed. These strategies foster deeper community engagement, greater ecological literacy, and more resilient socioecological systems.

Furthermore, the hybridization process must be approached with ethical sensitivity. Knowledge integration should prioritize equitable collaboration, mutual respect, and the protection of intellectual sovereignty. Effective hybridization depends on recognizing the value of diverse epistemologies and ensuring that Indigenous and Creole communities maintain agency over how

their knowledge is represented and utilized. Aikenhead (2001) similarly cautions against the assimilationist tendencies of conventional science education, advocating instead for culturally sustaining pedagogies that respect Indigenous ontologies and support epistemological pluralism. These principles align closely with Articles 31 and 32 of the United Nations Declaration on the Rights of Indigenous Peoples (United Nations, 2007), which affirm Indigenous peoples' rights to

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

control, protect, and develop their traditional knowledge, cultural heritage, and intellectual property.

Importantly, while hybridized ecological frameworks integrate Indigenous, Creole, and Western scientific perspectives, this process must occur without imposing Western ideological frameworks onto Indigenous knowledge systems. The goal is not assimilation but genuine epistemological integration, where local ontologies, ethics, and worldviews retain their centrality in shaping environmental stewardship. Protecting the intellectual sovereignty of Indigenous and Creole communities ensures that ecological hybridization enriches, rather than erodes, biocultural diversity.

This work directly addresses persistent assumptions that Indigenous languages lack scientific utility, offering compelling counterexamples that showcase their relevance in both theory and classroom practice. This project challenges that limitation by demonstrating that these languages can convey scientifically rigorous ecological content across all educational levels (Poot Cahun, 2025), potentially including university-level biology. This perspective was echoed by Dr. Glen Aikenhead, who characterized this work as reaching "the pinnacle of the 'different but equal' philosophy of cross-cultural science teaching," further affirming that the project embodies the pedagogical ideals he pioneered (G. Aikenhead, personal communication, 05 August, 2020). By embedding ecological education within Indigenous and Creole linguistic frameworks, this work repositions these languages not as cultural artifacts, but as powerful instruments for scientific inquiry and environmental stewardship.

As Nicholas (2009) notes in her study of Hopi youth, cultural identity and ecological sensibilities may persist even in the absence of full linguistic fluency. However, this perceived disconnection can also generate feelings of loss or cultural incompleteness. Her work highlights the importance of revitalization strategies that are not limited to grammar and vocabulary but that reintegrate language, culture, and place-based knowledge. This affirms the hybrid approach proposed here: one that bridges affective enculturation with epistemological access through ecological translanguaging and transknowledging.

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Beyond breaking the disciplinary boundary between cultural studies and science education, this work reaffirms that Indigenous and Creole languages are not only capable of describing the past, they are equally vital for shaping the future. By demonstrating that these languages can be used contemporaneously to teach science at all levels, this project repositions them as modern, strategic tools for navigating ecological challenges, engaging with environmental policy, and participating in global scientific discourse. In doing so, it disrupts the assumption that these languages are frozen in history and instead affirms their enduring relevance in contemporary and future knowledge systems.

A key long-term goal of this work is to foster ecological translanguaging and transknowledging as sustained pedagogical practices. By validating and integrating multiple languages in science education, ecological translanguaging equips Indigenous and Creole learners to engage ecological topics using their own linguistic and conceptual frameworks (García & Kleyn, 2016; Wei, 2018). At the same time, this multilingual flexibility improves their ability to communicate ecological insights to external actors such as resource managers, scientists, and government officials in a manner that these institutions can clearly comprehend. This communicative bridge is strengthened further through transknowledging, as defined by Nyblade et al. (2024), which allows learners to navigate and integrate multiple knowledge systems. Together, these approaches advance the broader aim of decolonizing science education while enhancing local capacity for environmental governance.

Importantly, while the primary focus of this framework is on restoring and amplifying Indigenous and Creole ecological knowledge systems, the resulting materials serve a broader public good. In multilingual and multicultural regions such as Mesoamerica, the Caribbean, or North America many dominant-language speakers also lack access to contextualized environmental education. This new class of educational materials thus support the scientific literacy of all learners who depend on and interact with the same ecosystems, regardless of cultural background.

In the end, this study affirms that hybrid ecological knowledge systems, anchored by biocultural constants and transmitted through culturally relevant languages, offer a promising pathway for

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

decolonizing conservation practices and fostering an inclusive environmental stewardship. Future research should continue to explore the mechanisms by which hybrid ecological knowledge systems can enhance ecological resilience, support cultural and linguistic revitalization, and inform adaptive governance models responsive to the complexities of the Anthropocene.

Conclusion

The Hybridization Hypothesis of Ecological Knowledge Systems presents a robust framework for fostering resilient, inclusive, and culturally grounded environmental stewardship. Through the identification of biocultural constants, the study demonstrates that diverse communities possess deeply rooted ecological knowledge that is not only compatible with modern scientific frameworks but essential for addressing contemporary conservation challenges.

The experiences gained from the development and application of the mangrove STEM Plus prototype illustrate that Indigenous and Creole ecological knowledge systems offer empirical, adaptive understandings of the environment. Their integration into educational materials and conservation strategies strengthens ecological literacy, revitalizes cultural identities, and enhances community engagement.

Recognizing and validating the ecological knowledge embedded within multiple languages reinforces the critical connection between linguistic diversity and biodiversity conservation. Language, as a vessel of ecological knowledge, must be preserved and promoted to sustain the depth and breadth of humanity's environmental understanding. UNESCO (2003) outlines this connection clearly, emphasizing that multilingual education supports intergenerational cultural transmission, equity, and the cognitive development necessary for ecological literacy.

The integration of Indigenous and Creole languages into science education represents a paradigm shift. These languages are often siloed within cultural studies; in this framework, they are reclaimed as tools for delivering rigorous scientific knowledge. This not only empowers local learners but also affirms the capacity of these languages to support advanced ecological literacy including instruction at the university level.

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Conservation efforts are increasingly seeking inclusive, adaptive, and community-centered approaches. Educational materials developed using hybridized ecological knowledge systems grounded in biocultural constants offer a persuasive path forward. The framework responds directly to calls made by global and regional frameworks for culturally grounded, multilingual, and ecosystem-based education. It operationalizes the cultural and linguistic rights affirmed in the *United Nations Declaration on the Rights of Indigenous Peoples* (United Nations, 2007) and the *Charter on Language Policy and Language Rights in the Creole-Speaking Caribbean* (ICCLR, 2011), while also advancing the ecological goals of the *Cartagena Convention* (UNEP, 1983), which provides a legal foundation for coordinated marine protection and sustainable management throughout the greater Caribbean basin.

Future work should prioritize ethical collaboration, ensure the protection of Indigenous intellectual sovereignty, and continue to explore the role of Hybridization Hypothesis of Ecological Knowledge Systems in shaping adaptive governance models. These findings are further supported by Hilario Poot Cahun's (2025) evaluation of STEM Plus materials in Quintana Roo, where even themes developed in distant contexts, such as primate conservation materials authored by University of Panamá researchers proved effective and culturally resonant in Maya communities in México. By embracing the insights and stewardship traditions of diverse cultural communities, conservation science can move toward an inclusive and resilient future; one where ecological knowledge is celebrated in all its forms and where the interconnectedness of cultural and biological diversity is honored and protected.

This contribution has been recognized by leading scholars in the field, who note that the project "goes significantly beyond what has been done" in prior initiatives and "sets a very high bar" for culturally responsive science curricula (G. Aikenhead, personal communication, August 16, 2020).

While the early implementation of the Hybridization Hypothesis yielded promising results, it is important to acknowledge that the initial sample size was limited and the prototype materials were intentionally designed to prioritize linguistic accessibility and robust ecological content. Future research should expand the model to larger, more diverse communities and explore the

Revista Científica Especializada en Educación y Ambiente
ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

development of increasingly sophisticated scientific materials that maintain cultural and linguistic relevance. Such work would further validate the adaptability of Indigenous and Creole languages for teaching complex scientific concepts at advanced educational levels.

In sum, the Hybridization Hypothesis provides a scalable, community-driven model for transforming science education. By treating Indigenous and Creole languages not as relics, but as living tools for ecological insight and stewardship, this approach bridges traditions and modern science. It affirms these languages as powerful, enduring platforms for knowledge, vital to a sustainable future

Acknowledgments

Many people offered encouragement along the way, but I want to especially acknowledge three: Ms. Myrna Manzanares, who immediately saw the value of this work; Maria Josefa Epiayu, whose dictated words carried me through the darkest moments; and R. Leroy Creswell, who recognized the potential early on and gave unwavering support. I also need to thank my Aunt Ima Lee for helping me catch my first fish and dad, Bobby Thigpen and all the other folks who continued my local ecology education teaching me to respect these other ways of understanding the environment. I know y'all are receiving the rest of the just, but I truly wish you could see what your encouragement has accomplished. I also want to thank Francis Staine, the Northern Fisherman's Cooperative, Polo and the other Belizean fishermen who taught me what their grandfathers taught them and for the family of Mercedes Castillo who taught me how to understand the fishery by teaching me to understand Kriol the right way. We all speak many languages, but we are one family.

Bibliographic References

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*(1), 1–52. https://doi.org/10.1080/03057269608560077

Aikenhead, G. S. (1997). Toward a First Nations cross-cultural science and technology curriculum. *Science Education, 81*(2), 217–238. https://doi.org/10.1002/(SICI)1098-237X(199704)81:2<217::AID-SCE6>3.0.CO;2-I

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Aikenhead, G. S. (2001). Integrating Western and Aboriginal sciences: Cross-cultural science teaching. *Research in Science Education, 31*(3), 337–355. https://doi.org/10.1023/A:1013153222472

Alayco, M., Bergeron, M., & Michaud, A. (2007). Inuit elders and their traditional knowledge: Beluga hunting and sustainable practices. Pêches et Océans. Canada.

Acharibasam, J. B., & McVittie, J. (2023). Connecting children to nature through the integration of Indigenous ecological knowledge into early childhood environmental education. *Australian Journal of Environmental Education, 39*(1), 24–37. https://doi.org/10.1017/aee.2023.7

Asif, M., Kazmi, J. H., & Tariq, A. (2023). Traditional ecological knowledge-based indicators for monitoring rangeland conditions in Thal and Cholistan Desert, Pakistan. *Environmental Challenges*, 13, 100754. https://doi.org/10.1016/j.envc.2023.100754

Baniwa, G., & Schwartzman, S. (2005). The Zo'é perspective on what scientists call "forest management." Ecology and Society, 10(1), 18.

Berkes, F. (2009). *Sacred ecology: Traditional ecological knowledge and resource management* (2nd ed.). Routledge.

Berkes, F. (2012). Sacred Ecology (3rd ed.). Routledge. https://www.routledge.com/Sacred-Ecology/Berkes/p/book/9780415517324

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications, 10*(5), 1251–1262. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Berkes, F., & Turner, N. J. (2006). Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology, 34*(4), 479–494. https://doi.org/10.1007/s10745-006-9008-2

Butler, M. J. IV, Mojica, A. M., Sosa-Cordero, E., Millet, M., Sanchez-Navarro, P., Maldonado, M. A., Posada, J., Rodriguez, B., Rivas, C. M., Oviedo, A., Arrone, M., Prada, M., Bach, N., Jimenez, N., Garcia-Rivas, M. del C., Forman, K., Behringer, D. C., Matthews, T., Paris, C., & Cowen, R. (2010). Patterns of spiny lobster (*Panulirus argus*) postlarval recruitment in the Caribbean: A CRTR project. Proceedings of the Gulf and Caribbean Fisheries Institute, 62, 360–369. https://digitalcommons.odu.edu/biology_fac_pubs/79

Butler, M. J., Mojica, A. M., Sosa-Cordero, E., Millet, M., Sanchez-Navarro, P., Maldonado, M. A., Posada, J., Rodriguez, B., Rivas, C. M., Oviedo, A., Arrone, M., Prada, M., Bach, N., Jimenez, N., Garcia-Rivas, M. del C., Forman, K., Behringer, D. C., Matthews, T., Paris, C., & Cowen, R. (2018). Patterns of spiny lobster (*Panulirus argus*) postlarval recruitment in the Caribbean: A CRTR Project (SEDAR57-RD-12). Southeast Data, Assessment, and Review (SEDAR). https://sedarweb.org/docs/wsupp/S57_RD_12.pdf

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Ceballos, G., Chávez, C., Rivera, A., & Manterola, C. (2007). Conserving jaguars in the Sierra Madre Occidental. In R. Woodroffe, S. Thirgood, & A. Rabinowitz (Eds.), People and Wildlife: Conflict or Coexistence? (pp. 283–299). Cambridge University Press.

Cajete, G. (2000). *Native science: Natural laws of interdependence*. Clear Light Publishers.

Colchero, F., Conde, D. A., Manterola, C., Chávez, C., Rivera, A., & Ceballos, G. (2011). Jaguars on the move: Modeling movement to mitigate fragmentation from road expansion in the Mayan Forest. Animal Conservation, 14(2), 158–166. https://doi.org/10.1111/j.1469-1795.2010.00406.x

Cortés-Ortiz, L., Bermingham, E., Porter, C. A., Gutiérrez-Espeleta, G. A., Veà, J. M., & Quinn, J. S. (2015). Genetic differentiation and phylogeography of Central American howler monkeys (*Alouatta palliata*). Molecular Phylogenetics and Evolution, 82, 53–63. https://doi.org/10.1016/j.ympev.2014.08.016

Estrada, A., Garber, P. A., Chaudhary, A., & Stoner, K. E. (2022). Global importance of Indigenous Peoples, their lands, and knowledge systems for saving the world's primates from extinction. Science Advances, 8(33), eabn2927. https://resourceafrica.net/wp-content/uploads/2022/08/sciadv.abn2927.pdf

Fernandez-Gimenez, M. E. (2000). *The Role of Mongolian Nomadic Pastoralists' Ecological Knowledge in Rangeland Management. Ecological Applications, 10*(5), 1318–1326.

Fine, Caitlin G. (2016): Translanguaging with multilingual students: Learning from classroom moments, García, O., & Kleyn, T. (Eds.), Bilingual Research Journal. https://doi.org/10.1080/15235882.2018.1468365

Garnatje, T., Vallès, J., & Parada, M. (2014). Resilience of traditional knowledge systems: The case of agricultural knowledge in home gardens of the Iberian Peninsula. Digital CSIC

González, J. A., & Gómez-Baggethun, E. (2011). Ecología y saberes indígenas: ¿Un modelo para la gestión ambiental? *Revista Latinoamericana de Ciencias Sociales, 9*(1), 103–119.

Gómez-Baggethun, E., E. Corbera, and V. Reyes-García. 2013. Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and Society* 18(4): 72. http://dx.doi.org/10.5751/ES-06288-180472

Gómez-Baggethun, E., Reyes-García, V. Reinterpreting Change in Traditional Ecological Knowledge. *Hum Ecol* 41, 643–647 (2013). https://doi.org/10.1007/s10745-013-9577-9

Gorenflo, L. J., Romaine, S., Mittermeier, R. A., & Walker-Painemilla, K. (2012). Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. *Proceedings of the National Academy of Sciences, 109*(21), 8032–8037. https://doi.org/10.1073/pnas.1117511109

Harmon, D., & Loh, J. (2010). *The Index of Linguistic Diversity: A new quantitative measure of trends in the status of the world's languages. Language Documentation & Conservation, 4*, 97–151.

latindex catálogo 2.0 Dialnet

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981
Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Haugen, E. (1972). *The ecology of language*. Stanford University Press.

Hornberger, N. H. (2008). *Can schools save Indigenous languages? Policy and practice on four continents*. Palgrave Macmillan.

International Centre for Caribbean Language Research (ICCLR). (2011). *Charter on language policy and language rights in the Creole-speaking Caribbean*. https://caribbeanlanguagepolicy.weebly.com/uploads/5/3/9/0/5390818/charter_on_language_policy_and_language_rights_in.docx2.pdf

Kimmerer, R. W. (2002). Weaving traditional ecological knowledge into biological education: A call to action. BioScience, 52(5), 432–438. https://doi.org/10.1641/0006-3568(2002)052[0432:WTEKIB]2.0.CO;2

Kimmerer, R. W. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants.* Milkweed Editions.

Lantz, T. C., & Turner, N. J. (2003). Traditional phenological knowledge of Aboriginal peoples in British Columbia. *Journal of Ethnobiology*, 23(2), 263–286.

Lewis, G., Jones, B., & Baker, C. (2012). Translanguaging: Developing its conceptualization and contextualization. *Educational Research and Evaluation, 18*(7), 655–670. https://doi.org/10.1080/13803611.2012.718490

Wei, L. (2018). Translanguaging as a practical theory of language. *Applied Linguistics, 39*(1), 9–30. https://doi.org/10.1093/applin/amx039

Longepée, L., Le Corre, M., & Cuq, F. (2021). Local ecological knowledge on mangroves in Mayotte Island (Indian Ocean) and influencing factors. Forests, 12(1), 53. https://doi.org/10.3390/f12010053

Maffi, L. (1998). Language: A resource for nature. *Nature and Resources, 34*(4), 12–21.

Maffi, L. (2001). *On biocultural diversity: Linking language, knowledge, and the environment*. Smithsonian Institution Press.

Maffi, L. (2005). *Linguistic, cultural, and biological diversity. Annual Review of Anthropology, 34*, 599–617. https://doi.org/10.1146/annurev.anthro.34.081804.120437

McCarty, T. L. (2003). Revitalizing Indigenous languages in homogenizing times. *Comparative Education, 39*(2), 147–163.

McCarty, T. L., & Lee, T. S. (2014). *Critical culturally sustaining/revitalizing pedagogy and Indigenous education sovereignty. Harvard Educational Review, 84*(1), 101–124.

McKee, S. L., Thorne, T., Koslouski, J. B., Chafouleas, S. M., & Schwartz, M. B. (2021). Assessing district policy alignment with the Whole School, Whole Community, Whole Child model in Connecticut, 2019 to 2020. Journal of School Health, 92(6), 594–604. https://doi.org/10.1111/josh.13183

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Nabhan, G. P. (1997). *Cultures of habitat: On nature, culture, and story*. Counterpoint.

Nicholas, S. E. (2009). "I live Hopi, I just don't speak it": The critical intersection of language, culture, and identity in the lives of contemporary Hopi youth. *Journal of Language, Identity, and Education*, 8(5), 321–334. https://doi.org/10.1080/15348450903305114

Nyblade, M. L., Smith, S. J., & Sumida Huaman, E. (2024). "The heavy burden": Indigenous knowledge systems, biocultural diversity, and transknowledging in sciences education. Cultural Studies of Science Education, 19(4), 779–792. https://doi.org/10.1007/s11422-024-10236-0

Poot Cahun, H. (2025). *Educación ambiental intercultural: Desarrollo y pilotaje de libros en lengua maya para niños de primaria indígena en Quintana Roo* [Master's thesis, Universidad Intercultural Maya de Quintana Roo]. https://marinefrontiers.org/wp-content/uploads/2025/07/Tesis-MEI_Hilario-Poot-Cahun-15-07-2025.pdf

Posey, D. A. (Ed.). (1999). *Cultural and Spiritual Values of Biodiversity.* United Nations Environment Programme.

Rajashekarappa, M. (2023). *The monkey hunters of Vanarmare tribe: Guardians of the forest*. International Journal for Multidisciplinary Research, 5(5), 1–4. https://doi.org/10.36948/ijfmr.2023.v05i05.6237

Ramos, S. C. (2021). *Understanding Yurok traditional ecological knowledge and wildlife management*. The Journal of Wildlife Management, 86(1), e22140. https://doi.org/10.1002/jwmg.22140

Ravaoarinorotsihoarana, L. A., Maltby, J., Glass, L., Oates, J., Rakotomahazo, C., Randrianandrasaziky, D. A., Ranivoarivelo, L. N., & Lavitra, T. (2023). *Lessons for ensuring continued community participation in a mangrove blue carbon conservation and restoration project in Madagascar*. Western Indian Ocean Journal of Marine Science, 22(2), 43–60. https://doi.org/10.4314/wiojms.v22i2.4

Reyes-García, V., Broesch, J., Calvet-Mir, L., McDade, T., Tanner, S., Huanca, T., Leonard, W. R., Vadez, V., Pérez-Llorente, M., Paneque-Gálvez, J., Luz, A. C., Gueze, M., & Pino, J. (2016). Cultural transmission of traditional ecological knowledge and methods for measuring it. Ecology and Society, 21(2), Article 25. https://doi.org/10.5751/ES-08413-210225

Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M. P., Schmitz, O. J., Smith, D. W., Wallach, A. D., & Wirsing, A. J. (2014). *Status and ecological effects of the world's largest carnivores. Science*, 343(6167), 1241484. https://doi.org/10.1126/science.1241484

Ritchie, J., & Eames, C. (2010). *Connecting children to nature through the integration of Indigenous ecological knowledge into early childhood environmental education. Australian Journal of Environmental Education, 26*, 30–39.

Soto, S., Rangel-Landa, S., Saucedo-Gudiño, María; Guzmán-Gómez, Erandi; Salazar-Ramirez, Maria, Blanco, Arnulfo; Caldera-Cano, Delia, Carbajal-Navarro, Aglaen; Caro-Gómez, Rosendo; Ponce-

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

Rangel, Andrea; Texta-Hernández, José; Madrigal-Sánchez, Xavier. (2017). Traditional ecological knowledge and biodiversity conservation: Lessons from Mexico. *Ecology and Society, 22*(2), Article 23. http://dx.doi.org/10.1007/978-3-030-99357-3_11

Schulz, J., Becker, M., & Goetsch, E. (1994). *Indigenous knowledge in a 'modern' sustainable agroforestry system*. Naturefund.

Spalding, M., Kainuma, M., & Collins, L. (2010). *World atlas of mangroves*. Earthscan. https://doi.org/10.4324/9781849776608

Thigpen, R., Romero Durón, J. A., & Matamoros Erazo, G. M. (2016). *Los manglares / The Mangroves: A bilingual STEM Plus curriculum prototype*. Sáasil Uj Publishing LLC. https://marinefrontiers.org/digital-library/

Thigpen, R., Castillo, C., Castillo, Y., & Majil, Z. (2018). *Di Mangro Dehn*: Bilingual Kriol-English Edition for (S. Udz & M. Manzanares, Eds.). Sáasil Uj Publishing LLC. https://marinefrontiers.org/wp-content/uploads/2019/10/Mangro-Kriol-NORFICOOP-Robby-Thigpen-Celeste-Castillo-Yarisel-Castillo-Zaida-Majil-Myrna-Manzanares-Belize-National-Kriol-Council.pdf

Thigpen, R. C., & Poot Cahun, H. (2018). *Chukte'ob: The Mangroves, Treasures of the Caribbean (Maya Edition)*. Sáasil Uj Publishing LLC. https://marinefrontiers.org/wp-content/uploads/2018/06/Yucatec-Mangrove-Chukte%E2%80%99ob-Robby-Thigpen-Hillario-Poot-Cahun-Felicita-Cantun-Madison-Heltzel.pdf

Thigpen, R., Ico, J., & Peck, R. (2021). *Okok Ha'il K'ak'naab'*: The Mangroves (Maya Mopán Edition). Sáasil Uj Publishing LLC. https://marinefrontiers.org/wp-content/uploads/2021/03/Mangrove_Master_Mopan.pdf

Turner, N. J., & Clifton, H. (2009). *"It's so different today": Climate Change and Indigenous Lifeways in British Columbia, Canada. Global Environmental Change, 19*(2), 180–190.

UNESCO. (2003). *Education in a multilingual world* (Education Position Paper). Paris: UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000129728

UNESCO. (2016). *If you don't understand, how can you learn?* (Policy Paper 24). Global Education Monitoring Report. https://unesdoc.unesco.org/ark:/48223/pf0000243713

UNESCO. (2021). Indigenous Peoples and UNESCO. United Nations.

UNESCO. (2011). *Enhancing learning of children from diverse language backgrounds: Mother tongue-based bilingual or multilingual education in the early years.*

United Nations. (2007). *United Nations Declaration on the Rights of Indigenous Peoples*. United Nations. https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

Revista Científica Especializada en Educación y Ambiente

ISSN L 2953-2981

Vol. 4, Núm. 2
Nov. 2025– Abr 2026
p. 111-140

United Nations Environment Programme (UNEP). (1983). Cartagena Convention: Convention for the protection and development of the marine environment of the wider Caribbean region. Retrieved from https://www.unep.org/cep/cartagena-convention