



**Non-Technical Project Summary (less than one page):**

Funding in the amount of \$95,000 is requested to support a two-year project, directed by William Merrill (Curator of Anthropology, NMNH), to organize and analyze data relevant to understanding the factors that led to the widespread distribution of the Uto-Aztecan language family in western North America. Advocates of the Farming/Language Dispersal Hypothesis argue that population growth engendered by a shift from hunting-gathering to maize agriculture was the principal cause of the dispersal of Proto-Uto-Aztecan speakers from a homeland located in Mesoamerica, one of the world's nuclear areas of plant domestication. In the proposed project, this and alternative hypotheses will be evaluated in terms of linguistic, archaeological, biogeographical, and genetic data to develop a more profound understanding of Uto-Aztecan cultural history and the place of agriculture in it. The project also will create the intellectual foundation and infrastructure for developing a larger, multi-year project focused on Uto-Aztecan languages, cultural history, and ecological knowledge.

Because the proposed project represents the initial stage in the development of the larger project and involves only NMNH-based scholars, financial support at the required levels is available only from the Competitive Grants Program for Science. However, once the larger project is established, funding from external sources, primarily the National Science Foundation, as well as internal SI sources such as Grand Challenges, will be sought. Both the proposed project and the larger project engage issues central to three of the Smithsonian's Grand Challenges: Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures, and Understanding the American Experience.

# **The Farming/Language Hypothesis and Uto-Aztecan Cultural History: The Convergence of Linguistics, Archaeology, Biogeography, and Genetics**

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**A Note on Sources and Citations.** Hundreds of scholarly publications have been consulted to develop a concept and implementation plan for this project. In lieu of abbreviated in-text citations, an overview of the principal sources and full citations are presented in the "Bibliography."

## **Project Description**

**The Farming/Language Dispersal Hypothesis.** The Farming/Language Dispersal Hypothesis proposes that the broad geographic distribution of some of the world's major language families is the result of the expansion of agricultural populations out of nuclear areas of plant and animal domestication. The hypothesis is framed within the "Early Agriculturalist Population Diaspora Model," which postulates that a shift from hunting-gathering to agriculture resulted in more abundant and reliable food supplies that led to the growth of agricultural populations. These populations then expanded out of their homelands into other areas suitable for the kind of agriculture that they practiced, displacing or absorbing in the process the hunter-gatherer populations that lived there.

Since the 1980s, the Farming/Language Dispersal Hypothesis has stimulated considerable research and debate. Most studies have focused on evaluating whether the predictions of the Early Agriculturalist Population Diaspora Model are supported by empirical data from different parts of the world. Key questions asked include: Do discontinuities encountered in the archaeological and skeletal record coincide temporally with the earliest evidence of agriculture? Do genetic traces of population displacement or absorption exist in areas of purported agriculturalist expansion? Can agriculture-related vocabularies be reconstructed for the proto-languages of widely dispersed language families? In most cases, these studies have resulted in general agreement on the degree to which the migration of agriculturalist populations contributed to the dispersal of particular language families and the early diffusion of agriculture in both the Old and New Worlds. Such consensus has not emerged, however, with respect to the relationship between agriculture and the initial dispersal of the ancestors of speakers of Uto-Aztecan languages, nor the role that Uto-Aztecan speakers played in the diffusion of maize agriculture from Mesoamerica to the southwestern United States.

**The Uto-Aztecan Language Family.** The Uto-Aztecan (UA) language family comprises thirty documented languages, including Ute, Comanche, Hopi, Yaqui, Rarámuri, Huichol, and Nahuatl ("Aztec"), which are organized into two principal branches: Northern Uto-Aztecan (NUA) and Southern

Uto-Aztecan (SUA). At the time of initial European contacts, these languages were distributed from the Great Basin of western North America to Mesoamerica, with outliers as far south as Panama. Because UA-speaking farming societies extended between Mesoamerica and the southwestern United States, the Australian archaeologist Peter Bellwood proposed that the homeland of the ancestral Proto-Uto-Aztecan (PUA) speech community was located in northern Mesoamerica when its members first adopted maize agriculture, and then, as their population grew, they began spreading northward, eventually introducing maize agriculture to the American Southwest. The American linguist Jane Hill embraced Bellwood's perspective and, in a series of studies published between 2001 and 2012, presented a wealth of linguistic, archaeological, and ethnographic data that she interpreted as supporting his position.

Although many scholars regard the Bellwood-Hill scenario as neither proven nor disproven, it has been sharply criticized by historical linguists, archaeologists, and geneticists. In 2009, as part of a long-term project on early agriculture in the North American Southwest, archaeologist colleagues and I evaluated this hypothesis in terms of the available archaeological, linguistic, and genetic data from the Mesoamerica-to-Southwest region. We concluded that these data do not conform to the predictions of the Farming/Language Dispersal Hypothesis and the Bellwood-Hill perspective derived from it, proposing instead that group-to-group diffusion among hunter-gatherer populations, Uto-Aztecan or otherwise, was the most likely mechanism by which maize agriculture diffused from Mesoamerica to the southwestern United States. Hill responded to our position in 2010 and 2012 by offering additional evidence in support of her and Bellwood's perspective. At present, our debate continues.

**My Research, 2010–2012.** During the past three years, I compiled lists of names for wild plants and animals and words with agriculture-related meanings from all the UA languages. A preliminary analysis of this dataset, which now includes over 9000 words, indicates that an agricultural vocabulary cannot be reconstructed for Proto-Uto-Aztecan and that the members of the PUA speech community likely lived in a temperate, somewhat arid environment characterized by mountains, lakes, and streams. I also began an analysis of changes in the climate and the distributions of plant and animal species that have occurred in

western North America and Mesoamerica during the past 10,000 years. Based on this research, I developed the following model of early Uto-Aztecan cultural history and the place of agriculture in it:

During the early Holocene, PUA speakers were organized into small, mobile, hunter-gatherer bands living in the southwestern portions of the Great Basin. A decline in temperature for several centuries around 8000 years ago (the “8.2 k cold event”) motivated these bands to migrate southward, into an area along the eastern flanks of the southern Sierra Nevada mountain range. A subsequent 2.5 millennia interval of decreased effective moisture, ca. 7500-5000 B.P., resulted in the dessication of the vast lake systems of the region and the dispersal of the PUA bands. Around 5500 years ago, the ancestral PUA speech community split into northern and southern branches, and the southern bands, constituting the Proto-Southern Uto-Aztecan (PSUA) speech community, migrated southward into the Sonoran Desert and eastward across the Colorado River. They arrived in the borderlands of southeastern Arizona and northeastern Sonora sometime before 4100 years ago, when the practice of maize agriculture is first documented in the region. The members of the PSUA speech community gradually increased their reliance on agriculture and then began expanding in all directions from this homeland, across northwestern Mexico and adjacent areas of the American Southwest and southward toward Mesoamerica.

**The Proposed Project, 2013-2014.** The two-year project proposed here is intended to create the knowledge base and infrastructure required to begin testing the multitude of hypotheses entailed by my model of early UA cultural history and agriculture and, by extension, the Bellwood-Hill hypothesis. A primary objective is to convert a preliminary intellectual inquiry into a robust research and education endeavor. To pursue this goal, the project will be directed toward completing seven sets of activities:

- 1) Determine the relational database structure that is best suited for (a) managing the linguistic, biogeographical, and climatological data that I have compiled; (b) mapping, modeling, and analyzing these data; (c) integrating new data from external sources; and (d) drawing upon these data to produce web-based presentations on different aspects of UA linguistic and cultural history.

- 2) Upload my datasets, currently managed in non-relational databases, to the relational database and incorporate additional data collected during the project period into it.
- 3) Compile in EndNote a comprehensive, annotated bibliography of published and unpublished archaeological studies from sites located along the postulated routes of UA migrations that date to the 8000-4000 B.P. period and design a research project that will evaluate the degree of correspondence between the existing archaeological record and my UA migration scenario.
- 4) Plan a series of additional research projects to address specific aspects of the larger model and to test the applicability of phylogenetic, phylogeographic, and automated similarity judgment methodologies to the analysis and interpretation of UA linguistic and cultural historical data.
- 5) Identify potential funding sources for the core UA project and its sub-projects and prepare and submit grant proposals to these sources.
- 6) Establish partnerships with scholars in other NMNH departments, other SI units, and external institutions and organization who are engaged in similar projects.
- 7) Plan and begin implementing a strategy for diffusing knowledge about the project that will include developing an Internet presence through NMNH's and the Encyclopedia of Life's websites and the social media, presenting public lectures and papers at professional conferences and symposia, and preparing publications for both specialist and non-specialist audiences.

**Project Budget Items.** The total project budget over two years is \$95,000: \$75,000 to hire a project and database manager (half-time, temporary) and \$20,000 for consultant services to complete the archaeological bibliography and research project design. Additional in-kind support from NMNH staff is described in the "Other Support for the Project" section below.

**Permits.** No permits are required to undertake the proposed project.

**Significance of the Project.** If funded, the project proposed here will lead to the creation of a multi-year, interdisciplinary project that will draw upon the methods and perspectives of historical linguistics, archaeology, biogeography, and genetics to provide new insights into the linguistic, cultural, and

environmental history of western North America prior to the arrival of Europeans. The larger project also will contribute to addressing three of our four Grand Challenges: Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures, and Understanding the American Experience.

A variety of theoretical and topical issues of significance to diverse disciplines can be explored through an analysis of UA linguistic and cultural history. One obvious example is migration theory. Migrations of their ancestors figure prominently in the oral traditions of many contemporary UA societies, and I postulate that migrations of UA populations occurred throughout much of the history of the language family, motivated by both climatological factors and the demographic consequences of a growing reliance on food production. A project on UA migration could be linked to “Americans All: The Immigration/Migration Initiative,” a level two project of the Consortium for Understanding the American Experience.

Another example is Indigenous Natural History. Although the proposed project focuses on UA ethnobiological nomenclature, future research will be directed toward incorporating UA ecological knowledge in general. The first step in the process is underway, involving a collaborative project with Nahuatl communities in Mexico for which NSF funding is being sought (see “Other Support for the Project” below). This natural history of the UA research project will be relevant to other Consortia-funded projects, such as “IndiGEO: Long-term Monitoring of Cultural and Biological Diversity on Tribal Lands” and the Recovering Voices initiative, in which I am a participant.



## Proposal Budget/Budget Justification

**Item 1. Salary.** Project and database manager = \$75,000.

Justification: The person who will fill this position must have an advanced degree (Master's or Ph.D.) in archaeology or linguistics, expertise in biology, ethnobiology, or archaeobiology, fluency in English and Spanish (the relevant linguistic, archaeological, biogeographical, and climatological data and studies are in both languages), and a proven track record in database and program/ project management. Desired skills include expertise in quantitative methods, statistical analysis, and Geographical Information Systems applications and advanced competency in the software programs associated with the exercise of these skills. These qualifications warrant compensation at approximately a GS-12, Step 1 level. The current salary for GS-12-1 is \$74,872. Frozen at this level since 2010, this amount includes no benefits.

**Item 2. Consultant Services.** Archaeological bibliography and research project design = \$20,000.

Justification: I estimate that the completion of these two activities will require approximately 400 hours. One of my colleagues, an archaeobotanical consultant, indicated that she would charge \$50 per hour to complete a comparable project in her area of expertise. Thus, 400 hours @ \$50 / hour = \$20,000.

### Biographical Sketch – William L. Merrill

#### (a) Professional Preparation

University of North Carolina	Anthropology	A.B. (1972)
University of Michigan	Anthropology	M.A. (1975)
University of Michigan	Anthropology	Ph.D. (1981)

#### (b) Appointments

1980 – Present      Curator, Department of Anthropology, National Museum of Natural History,  
Smithsonian Institution

#### (c) Publications

##### (i) Publications most closely related to the proposed project:

Merrill, William L. 2013 [anticipated]. The Historical Linguistics of Uto-Aztecan Agriculture.  
*Anthropological Linguistics*, accepted for publication.

Merrill, William L. 2013 [anticipated]. The Genetic Unity of Southern Uto-Aztecan. *Language Dynamics and Change*, accepted for publication.

Merrill, William L., Robert J. Hard, Jonathan B. Mabry, Gayle J. Fritz, Karen R. Adams, John R. Roney, and A.C. MacWilliams. 2009. The Diffusion of Maize to the Southwestern United States and its Impact. *Proceedings of the National Academy of Sciences USA* 106: 21019-21026.

Merrill, William L., and Celia López González. 2007. Humans and Other Mammals in Prehispanic Chihuahua. In Eduardo Corona Martínez and Joaquín Arroyo-Cabrales, eds., *Human and Faunal Relationships Reviewed: An Archaeozoological Approach*, pp. 43-62. British Archaeological Reports International Series No. 1627. Oxford: Archaeopress.

Merrill, William L. 2007. La obra lingüística del padre Matthäus Steffel, S.J. In Karl Kohut y María Cristina Torales Pacheco, eds., *Desde los confines de los imperios ibéricos: Los jesuitas de habla alemana en las misiones americanas*, pp. 409-439. Frankfurt: Vervuert Verlag and Madrid: Iberoamericana.

Merrill, William L. 2002. Species Transformations in Northern Mexico: Explorations in Rarámuri Zoology. In William L. Merrill and Ives Goddard, eds., *Anthropology, History, and American Indians: Essays in Honor of William Curtis Sturtevant*, pp. 333-347. Smithsonian Contributions to Anthropology 44. Washington: Smithsonian Institution Press.

**(ii) Other significant publications:**

Merrill, William L. 2009. Indigenous Societies, Missions, and the Colonial System in Northern New Spain. In Clara Bargellini and Michael K. Komanecky, eds., *The Art of the Missions of Northern New Spain, 1600-1821*, pp. 122-153. Mexico City: Mandato Antiguo Colegio de San Ildefonso.

Hard, Robert J., A. C. MacWilliams, John R. Roney, Karen R. Adams, and William L. Merrill. 2006. Early Agriculture in Chihuahua, Mexico. In John E. Staller, Robert H. Tykot, and Bruce F. Benz, eds., *Histories of Maize: Multidisciplinary Approaches to the Prehistory, Biogeography, Domestication, and Evolution of Maize*, pp. 471-485. Burlington, MA: Elsevier Academic Press.

Merrill, William L. 1988. *Rarámuri Souls: Knowledge and Social Process in Northern Mexico*. Washington: Smithsonian Institution Press. [Spanish edition: 1992. *Almas Rarámuris*. Mexico City: Consejo Nacional para la Cultura and las Artes y Instituto Nacional Indigenista].

**(d) Synergistic Activities**

- 1) Exhibition Development Team. “Orchids of Latin America” (2011–Present). Scheduled to open at NMNH on January 26, 2013, this exhibition presents orchids from the Smithsonian Gardens Orchid Collection within the framework of Latin American cultural traditions, current research on orchid biology and evolution, and orchid conservation efforts underway in various Latin American countries. See: <http://www.si.edu/Exhibitions/Details/Orchids-of-Latin-America-4822>.
- 2) Project Development Team. Website “Edward Palmer Collections” (2010–2011). This website allows broad accessibility to the botanical and anthropological collections of Edward Palmer from the American Southwest and Mexico housed at the National Museum of Natural History. Available at: <http://botany.si.edu/colls/palmer>.

- 3) Undersecretary. Advisory Committee on Endangered Languages, Instituto Nacional de Lenguas Indígenas (INALI), Mexico (2005–2009). This committee, comprised primarily of native speakers, provided guidance on and evaluation of INALI’s programs directed toward the preservation and revitalization of Mexico’s Indigenous languages. See: <http://www.inali.gob.mx>.
- 4) Co-curator. Exhibition: “Mexican Cycles: Festival Images by George O. Jackson de Llano” (2007–Present). Featuring photographs by Mexican-American photographer Jackson de Llano, this bilingual (English-Spanish) exhibition explores the linguistic and cultural diversity of Mexico’s indigenous communities. Venues: Washington, D.C.: National Museum of Natural History (2007–2008). Mexico City: Museo Nacional de Antropología (2010), Museo Memoria y Tolerancia (2010), Instituto Politécnico Nacional (2012), Instituto Nacional del Derecho del Autor (2012). Associated webpage available at: [http://www.mnh.si.edu/exhibits/cycles/index\\_eng.html](http://www.mnh.si.edu/exhibits/cycles/index_eng.html). See also: [http://www.mexnor.org/documents/Comunicado%20a%20Medios%20XIV.%20Frente%20al%20esp\\_ejo.docx.pdf](http://www.mexnor.org/documents/Comunicado%20a%20Medios%20XIV.%20Frente%20al%20esp_ejo.docx.pdf) and <http://www.youtube.com/watch?v=GRVz37NEuIE>.
- 5) Project co-director. Website: “Textiles of the North American Southwest” (2000–Present). This bilingual (English-Spanish) website relies on textiles in the Smithsonian collections to demonstrate the creativity and dynamism of Indigenous and Hispanic cultures in the southwestern United States and northern Mexico. Available at: <http://www.smithsonianeducation.org/textiles>.

### **Other Support for the Project**

***In-Kind Support.*** Bruno Frohlich (Statistician, Department of Anthropology, NMNH) will provide guidance in selecting the relational database program or programs best suited for the project. Additional guidance will be provided by Dan Cole (Smithsonian GIS Coordinator, Geospatial Services Division, Web Branch, IT Office, NMNH), as well as by Jonathan Amith (Research Associate, Department of Anthropology, NMNH), who has created relational databases for the management of data very similar to mine. Dr. Jesús Maldonado (Geneticist, Department of Vertebrate Zoology, NMNH) has agreed to collaborate on the evaluation of the relevant human genetic data and analyses and to co-author research papers on UA cultural history that involve genetics. Once the project is underway, interns and volunteers will be invited to contribute to its completion.

***National Science Foundation.*** I am collaborating with Jonathan Amith (Research Associate, NMNH and Gettysburg College) and John Kress (NMNH Botany and Director, Understanding and Sustaining a Biodiverse Planet Consortium) on designing a five-year project titled “Synergizing Ethnobotanical and Botanical Research: Interdisciplinary Collaboration Among Anthropologists, Botanists, Linguists, and Indigenous Communities.” (A summary description of this project appears below, after the

“Bibliography”). On October 16, 2012, Drs. Amith and Kress met with the program officers of four NSF programs to determine if they would consider collectively funding this project. The response was quite positive, and a proposal will be submitted in early 2013 to NSF’s Crosscutting Awards Program. The total funding amount to be requested is \$984,064. If an award at the requested level is approved, NMNH will receive a subgrant of \$656,467.

**Additional Funding Possibilities for the Proposed Project.** I have been unable to identify any alternative sources of funding, internal or external, at the required funding levels to launch the proposed project. However, if CGPS supports the creation of this project, a number of funding opportunities exist. I anticipate that about six months of initial project work will be required before I can begin preparing additional grant proposals. Precisely when I will submit grant proposals to these funding sources depends upon whether and when a CGPS grant is awarded.

***SI Grand Challenges Awards.*** As noted in the Project Description, the longer-term project that will be established by the project proposed here will address three of our four Grand Challenges: Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures, and Understanding the American Experience. Funding for inter-unit, interdisciplinary sub-projects of the larger UA research project will be sought from the Grand Challenges Awards Program.

***National Science Foundation.*** The multi-disciplinary nature of the proposed project make it eligible for funding from the majority of NSF’s major program areas, including especially Social, Behavior & Economic Sciences, Biological Sciences, and Environmental Research and Education.

***Other Sources.*** In November, I will begin working with our Office of Sponsored Projects to identify additional potential funding sources for the larger UA research project.

## **Bibliography**

**Introduction.** The proposed project draws upon a vast literature. Part I of the Bibliography includes key references relevant to the main topics mentioned in the Project Description; the links between topics and references are summarized in this introduction. Part II of the Bibliography presents a sample of the more

significant recent studies relevant to the Farming/Language Dispersal Hypothesis, including those that apply phylogenetic, phylogeographic, and automated similarities judgment methodologies to reconstruct linguistic and cultural histories.

***The Farming/Language Dispersal Hypothesis (FLDH).*** The FLDH was originally proposed by Colin Renfrew and initially developed primarily by him and Peter Bellwood: Renfrew (1987, 1992); Renfrew, et al. (1988); Bellwood (2001, 2005); Diamond and Bellwood (2003); Bellwood and Oxenham (2008). Bellwood and Renfrew (2002) also edited a compilation of essays by comparative linguists, archaeologists, and geneticists that offer a range of perspectives, both positive and negative, on the FLDH. Shouse (2001) provides a summary of the conference that led to the published volume, which is reviewed by Smith (2004) and Andersen (2009).

***The Bellwood-Hill Hypothesis.*** Bellwood's perspective on the Uto-Aztecan is succinctly presented in Bellwood (2001, 2005), Diamond and Bellwood (2003), and Bellwood and Oxenham (2008). All of the studies by Jane Hill included in the Bibliography are contributions to the elaboration of the Bellwood-Hill Hypothesis. Studies that support this hypothesis are Matson (2002) and LeBlanc (2008). Critiques include Campbell (2002), Golla, et al. (2003), Mahli, et al. (2003), Kaufman and Justeson (2009), and Merrill, et al. (2009, 2010; cf. Hill 2010, 2012; Brown 2010). More neutral positions are taken by Carpenter, et al. (2002), Mabry (2005), Mabry, et al. (2008), Wichmann (2002), Wichmann, et al. (2010), and Caballero (2011).

***Uto-Aztecan Linguistic and Cultural History.*** Miller (1983b), Campbell (1997), Stubbs (2011), and Hill (2012) are the best overviews of the UA language family. The division of the Proto-Uto-Aztecan speech community into northern and southern branches is discussed in Merrill (2013b; cf. Fowler 1983, 1984; Miller 1984, 1994; and Cortina, et al. 2002). Merrill (2013a) provides an analysis of linguistic and biogeographical data that indicate that the Arizona-Sonora borderlands was the most likely location of the PSUA homeland. This area also is discussed as a possible location of the PSUA or PUA speech community by Romney (1957), Fowler (1972), Fowler (1983), Miller (1983), Carpenter, et al. (2002),

and Hill (2012). The evidence for early agriculture in this area is reviewed in Merrill, et al. (2009; cf. Piperno 2011). Studies relevant to UA migrations are Mason (1921), Smith (1984), Teague (1993), Spielman (1998), Fields and Zamudio-Taylor (2001), and Lyons (2003).

***Biogeography and Climate.*** Packrat midden deposits have proven key to reconstructing the climate and biogeography of the southwestern United States and adjacent areas of northern Mexico. An early overview of packrat midden research is Betancourt, et al. (1990). A major source of data derived from packrat midden studies is the USGS/NOAA North American Packrat Midden Database [<http://esp.cr.usgs.gov/data/midden>], which also provides complete citations of these studies. Overviews of the climatological history of the southwestern United States and Mexico during the Holocene include Brown (1984), Buckler, et al. (1998), Castiglia and Fawcett (2006), Curtis, et al. (1996), Davis and Shafer (1992), Enzel, et al. (2003), Holmgren, et al. (2003), Koehler and Anderson (1995), Lounejeva Baturina, et al. (2006), McAuliffe and Van Devender (1998), Metcalfe, et al. (1997), Metcalfe and Davies (2007), Ortega-Ramírez, et al. (1998), Palacios-Fest, et al. (2002), Piperno, et al. (2007), Polyak and Asmerom (2001), Stahle, et al. (2007), Thompson and Anderson (2000). Studies of the 8.2 k cold event are Alley and Ágústsdóttir (2005), Bird and Kirby (2006), Wurster, et al. (2008), and Cisneros-Dozal, et al. (2010). Dessication of the Pleistocene lakes in western North America is the focus of Bacon, et al. (2006), Benson, et al. (1990), Enzel, et al., eds. (2003), Gierlowski-Kordesch and Kelts, eds. (2000), Hershler, et al., eds. (2002), and Orme (2008).

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### **Other Support for the Project – NSF Project Summary**

“Synergizing Ethnobotanical and Botanical Research: Interdisciplinary Collaboration Among Anthropologists, Botanists, Linguists, and Indigenous Communities.” Principal Investigator: Jonathan Amith. Co-Principal Investigators: W. John Kress, William L. Merrill. Project Duration: 5 years. Total Budget: \$984,064. NMNH Subgrant: \$656,467. Status: Grant proposal being prepared.

## **Synergizing Ethnobotanical and Botanical Research: Interdisciplinary Collaboration Among Anthropologists, Botanists, Linguists, and Indigenous Communities**

This CREATIV project offers a highly synergistic partnership among anthropologists, botanists, linguists, molecular geneticists, and indigenous communities, each with multiple skills and resources, to pursue substantive and research goals that would be difficult for individuals working alone in these separate disciplines to achieve. The participants will contribute their expertise in novel ways to create a common resource---a multifaceted botanical, genetic and cultural reference library to facilitate the scientific determination of plant species---that will enable the completion of innovative multidisciplinary research.

**1. The resource:** The partners in this project will develop a multifaceted tool for regional (Sierra Norte de Puebla, Mexico) botanical, ethnobotanical, documentary linguistic, and ecological initiatives. First, a specimen-based floristic inventory for most of the state of Puebla (~4000 species) will be created. Specimens will then be genotyped at several DNA marker loci, including those standard for DNA barcodes, to enable accurate species-level identifications. As needed (probably under 10% of cases), additional tools required to discriminate among congeneric species in a restricted floristic environment will be employed: a morphological key valid for discriminating sterile specimens or the sequencing of clade-specific DNA markers (selected in consultation with experts on the taxon). The PI, Amith, has collaborated with over 100 botanists, experts in different families, to ensure a solid foundation for the reference tool: proper identification of the voucher specimens and expert support for the supplementary keys and clade-specific DNA region selection.

**2.a Anthropology: Comparative and historical ethnobotany:** The DNA-based reference library will facilitate efficient, comparative research on the nomenclature and classification of local flora in different communities, addressing two significant issues in cognitive anthropology and cultural history.

The first concerns the cognitive structure of classificatory systems of plants. Much ethnobotanical research relies on a few local consultants to construct models of nomenclature and classification considered representative of community ethnobotanical knowledge. The internal structure of the categories, the absence of clearly delimited category boundaries, the mechanisms used to extend classifications to new members, and variation in nomenclature and classification among different groups (men vs. women; neighboring communities of the same or different cultural-linguistic groups) are issues less commonly explored. Wide-ranging ethnobotanical work among a large set of native speaker consultants is a better way to research these issues. Rather than a consensus model, the goal is to explore variation and tension in nomenclature and classification. A resource that enables scientific determination of plant specimens in the absence of the flowering parts upon which traditional keys are based will significantly reduce the time required to complete such anthropological (and linguistic) research on local flora.

The second issue involves comparative ethnobiological research among cultural groups that share historical and linguistic roots to gain insights into their cultural history and the factors that affect the retention or loss of biological nomenclature and classificatory systems over time. First, comparison across genetically related language groups will permit the reconstruction of the terms and categories of biotaxa of an ancient protolanguage. These reconstructed data can be used to propose the ecological characteristics and perhaps physical location of the group's ancestral homeland. Second, a comparison of similarities and variation in the nomenclature and classificatory systems of genetically related languages can reveal the biological and linguistic variables most closely correlated with retention, loss, or extension of nomenclature and classification in the ethnobiological system.

**2.b Botany and Molecular Genetics:** The rapid development of a verified floristic inventory (leveraging indigenous ecological knowledge and collaboration) and DNA sequencing of voucher specimens will enable investigations of the interface between ethnobotany, linguistics, and phylogenetics. Studies will

include 1) the quantification of alpha and beta species diversity within and between communities and how this diversity may correlate with indigenous practices of land use; 2) the discovery of novel species and their local uses; and 3) biogeographic studies that explore the partitioning of biological diversity as a function of environment and indigenous communities. These areas of active research in the tropics are comparatively poorly studied in the central Mexican floras, despite their high levels of species endemism and environmental diversity. Finally, the integration of DNA and associated biogeographical data into a shared worldwide database will support broader-scale comparative biogeographic studies, as well as traditional phylogenetic analyses of local species in community assemblages.

Because different indigenous communities often use different names for the same species, linking standardized scientific names to the set of species recognized in each community will immediately enable comparative investigations into plant use and the effect of indigenous cultivation and settlement practices on plant species diversity. Similarly, it will be possible to quantify the range and distributions of the plant species used by local communities and test if these species represent a random subset of the available flora or if there are specific behaviors and choices that lead to a non-random selection of species by local cultures. Because of the improved taxonomy afforded by a combination of standard morphology and DNA analysis, we can partition the diversity phylogenetically (i.e., some families may be employed randomly, while selection of species from others may be strongly linked evolutionarily) and thereby enhance our understanding of the relationships between human behavior and biological diversity.

**2. c Linguistics:** A particularly challenging field of linguistic documentation is indigenous natural history, including the nomenclature and classification of regional flora. Approximately 15 percent of a language's lexicon references the natural environment. Inadequate attention to this domain leaves a significant lacuna in corpora, lexicons, and morphosyntax research (e.g., compounding). Moreover, the lexical richness of a language is revealed not only through an extensive terminology for biotaxa but in extended and metaphoric usage of such terms and in the rich vocabulary that references culturally specific technologies that transform local flora into material culture. Often, the semantics of indigenous terms for biotaxa may be opaque unless the referent is identified to scientific species, a goal attainable only through extensive field research and close collaboration with biologists.

The contribution of this project to linguistic research, particularly among endangered languages, is both substantive and transformative: it develops new strategies and techniques implemented by a multidisciplinary academic team collaborating with an indigenous cooperative. The innovative methodology will greatly facilitate study of important areas of cultural and linguistic endangerment (natural history and material culture) either insufficiently targeted or incompletely resolved in present language and cultural studies. The extensibility of this interdisciplinary approach will be tested with David Beck, a linguist working on Totonac spoken near Amith's Nahuatl research site. Beck has a list of over 300 Totonac plant terms, the majority not identified. The test will be to identify these to species in one month of fieldwork, utilizing the reference tool developed for identifying sterile specimens in the Sierra Norte.

**2.d Indigenous communities:** Tosepan Titataniske, an indigenous cooperative in the Sierra Norte de Puebla, will partner in this project. Dedicated to sustainable development, conservation, and grassroots education, it is celebrating its 35th year with over 18,000 members in over 22 municipalities. For five years Tosepan has worked with Amith on language documentation, including ethnobiological research and the creation of a 500-species botanical field guide that will be used in their school system and modified for public dissemination in English and Spanish through the Smithsonian's online presentations.

Collaboration with Tosepan will greatly expedite fieldwork across the 22 municipalities and facilitate wide-ranging floristic surveys with indigenous consultants. Often biodiversity studies focus on taxa richness or phylogenetic diversity. Relative species abundance and their biogeography is harder to determine. This project will rely on the ecological knowledge of native speakers to obtain a first approximation of these aspects of biodiversity in the Sierra Norte de Puebla.



**3. a Intellectual merit:** The multidisciplinary team is highly qualified to carry out this innovative and transformative research. The potential to advance goals in multiple fields is high. Strong institutional support (Smithsonian, National Autonomous University, Mexico) will establish a secure foundation for permanence and future expansion of the resource and its interdisciplinary methodology. The issues relevant to each major field of research (anthropology, botany, linguistics) are all pressing research concerns that can best be addressed in a multidisciplinary approach such as that here proposed.

**3.b Broader impacts:** This uniquely scalable project offers model collaboration among four major partners (anthropologists, botanists, linguists, and indigenous communities). It establishes a methodology and resource extensible to new partners and contiguous regions. It strengthens international networks, collaboration, and partnerships among a small liberal arts college, a Mexican indigenous collective, Mexico's National University and National Commission on Biodiversity, and the Smithsonian Institution. Two indigenous collaborators will be trained in botanical, linguistic, and anthropological research, and a Mexican post-doc collaborator will work for two years at the Smithsonian on DNA extraction, amplification, and sequencing for this project.

**3.c Transformative:** This project is transformative in its impact on the fields of anthropology (cognitive and ethnobiology), linguistics (documentation and lexico-semantics), and biology (ecology and biodiversity). Through new interdisciplinary methods, it will develop a creative synergy among partners that redefines disciplinary boundaries and provides a pathway to new ground-breaking collaborative research. The construction of a DNA based multi-faceted reference tool for (ethno)botanical research goes beyond a quantitative shift (more efficient research in multiple domains) to embrace a qualitative change in collaborative ventures and, most importantly, the ability to address transformative research goals otherwise difficult and extremely costly---in time, money and human effort---to attain.