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Language Shift as Cultural Memory Loss: Quantifying the Erosion of Ethnobiological Knowledge across Three Generations in an Endangered Language Community

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Abstract:

Approximately 40% of the world's 7,000 languages are endangered, with many located in biodiversity hotspots. Language shift may accelerate the loss of traditional ecological knowledge, but quantitative, three generation studies are lacking. To quantify the relationship between heritage language shift and ethnobiological knowledge erosion across three generations in an endangered language community. Ninety participants (30 grandparents, G1; 30 parents, G2; 30 children, G3) from 30 families completed standardized language proficiency measures (adapted PPVT, oral fluency) and ethnobiological knowledge tasks (free listing, species identification and use). Covariates included age, education, and nature contact. Data were analyzed using ANOVA, Pearson correlation, and hierarchical regression. Language proficiency declined significantly across generations (G1: M=42.1/50; G2: 28.4; G3: 12.7; η²=0.67). Ethnobiological knowledge showed a parallel decline (G1: M=38.6/80; G2: 24.3; G3: 9.8; η²=0.68). The bivariate correlation between language proficiency and knowledge was strong (r=0.72, 95% CI [0.61, 0.80], p<0.001). Regression confirmed language proficiency as a unique predictor (β=0.61, p<0.001) after controlling for covariates, explaining 45% of variance in knowledge. Language shift and ethnobiological knowledge erosion are tightly coupled processes, supporting the view that heritage languages serve as critical scaffolds for cultural memory. Rapid intergenerational loss (70% vocabulary, 88% knowledge) within two generations indicates a biocultural emergency. Integrated interventions—community based language revitalization, heritage language environmental education, and biocultural conservation policies are urgently needed to preserve both linguistic and ecological diversity.

Keywords:
language shift; ethnobiological knowledge; cultural memory; intergenerational transmission; biocultural diversity

I. Introduction

1.1 The global crisis of language endangerment

The world is currently witnessing an unprecedented acceleration of language loss. According to the UNESCO Atlas of the World's Languages in Danger, approximately 40 percent of the world's roughly 7,000 spoken languages are now endangered, with a language disappearing every two weeks on average (UNESCO, 2026). Over 230 languages went extinct between 1950 and 2010 alone, and current estimates suggest that 44 percent of the world's spoken languages are at risk of extinction (UNESCO, 2026). The United Nations has declared 2022 to 2032 the International Decade of Indigenous Languages in recognition of this accelerating linguistic decline (UNESCO, 2026). While language endangerment is a global phenomenon, Indigenous and minority communities are disproportionately affected: more than

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200 languages have not been spoken since 1950 due to a lack of speakers, and a language disappears every two weeks, placing at risk the respective Indigenous cultures and knowledge systems (UNESCO, 2026). This crisis is not merely one of communication: it represents a fundamental threat to humanity‘s collective cultural and intellectual heritage.

1.2 Language as carrier of environmental knowledge: the linguistic niche hypothesis

The loss of linguistic diversity is particularly consequential because languages serve not only as communicative tools but as cognitive scaffolds for storing and transmitting knowledge about local environments. The linguistic niche hypothesis, proposed by Lupyan and Dale (2016), argues that linguistic diversity emerges in part as an adaptation to the social and ecological niches in which communities live. Languages evolve structures that facilitate the efficient transmission of information critical for survival in specific environments, from detailed systems of spatial reference to elaborate taxonomies of flora and fauna (Lupyan & Dale, 2016). Under this framework, a language is not an arbitrary symbolic system but a culturally evolved tool finely tuned to the needs of its speakers. Consequently, when a language shifts or disappears, the knowledge encoded within its vocabulary, grammar, and discourse practices may become inaccessible even if individual speakers retain some declarative knowledge. This theoretical perspective provides the foundation for understanding why language shift can be understood as a form of cognitive and cultural loss rather than simply a change of communication code.

1.3 Cultural memory framework: communicative versus cultural memory

The concept of cultural memory offers a powerful lens for interpreting the relationship between language endangerment and knowledge loss. Jan Assmann (2011) distinguished between two forms of collective memory: communicative memory, which spans approximately 80 to 100 years and is grounded in everyday interaction and oral communication, and cultural memory, which extends across centuries and is sustained through formalized, institutionalized practices and material symbols (e.g., rituals, texts, monuments). Assmann argued that like consciousness and language, human memory is acquired through communication, socialization, and acculturation (Assmann, 2011). For communities with oral traditions, the heritage language is the primary medium through which cultural memory is constituted and transmitted across generations. When that language undergoes shift, the bridge between communicative memory (the knowledge of the living generation) and cultural memory (the accumulated knowledge of past generations) begins to erode. Paul Connerton (2009) further developed these ideas by examining how modern societies produce systematic forms of forgetting, including the erosion of place-based and bodily memories that are often encoded in minority languages. Connerton argued that modernity—with its accelerated pace of change, migration, and linguistic assimilation—actively produces forgetting as a structural feature. Thus, language shift can be understood as a mechanism of culturally patterned forgetting, wherein the tacit, embodied knowledge embedded in a heritage language gradually becomes inaccessible as speakers adopt a dominant language.

1.4 Gap in quantitative, three-generation studies

Despite widespread recognition of the link between language endangerment and traditional knowledge loss, few studies have employed controlled, quantitative, three-generation designs to directly measure this relationship. Existing cross-sectional research has documented correlations between language proficiency and ethnobiological knowledge in individual communities (e.g., Bromham et al., 2022; Münevver, 2019), but these studies rarely employ family-based generational sampling that controls for shared environmental and genetic factors. Moreover, most studies focus on only two generations or rely on proxy measures of knowledge (e.g., reported use rather than demonstrated identification). A three-generation design, encompassing grandparents (G1), parents (G2), and children (G3), offers the unique advantage of tracing the trajectory of language shift and knowledge erosion within a single family lineage, controlling for between-family variation in socioeconomic status, education, and ecological access. Such designs remain exceptionally rare in the ethnobiological and language documentation literatures, leaving a critical gap in our understanding of the pace and pattern of biocultural erosion.

1.5 Research question and hypotheses

The present study was designed to address this gap by quantitatively assessing the relationship between heritage language proficiency and ethnobiological knowledge across three generations in an endangered language community. The central research question was: How does the ongoing shift from a heritage language to a dominant language relate to the intergenerational transmission of ethnobiological knowledge? Based on the theoretical frameworks of the linguistic niche hypothesis and cultural memory, the following hypotheses were formulated:

a. H1: Heritage language proficiency declines significantly across three generations (G1 > G2 > G3).
b. H2: Ethnobiological knowledge declines significantly across three generations (G1 > G2 > G3).
c. H3: After controlling for age, years of formal education, and frequency of nature contact, heritage language proficiency will be significantly and positively correlated with ethnobiological knowledge.

II. Review of Literatures

2.1 Language shift and knowledge loss: evidence from Papua New Guinea, Mexico, and the Alps

A growing body of empirical research has documented the covariation between language loss and the erosion of traditional environmental knowledge. The most comprehensive study to date was conducted in Papua New Guinea, the world‘s most linguistically diverse nation, where Bromham et al. (2022) measured language skills and ethnobiological knowledge among 6,190 students speaking 392 languages. The results revealed that ethnobiological knowledge declined in close parallel with language skills: students who spoke indigenous languages maintained detailed knowledge of medicinal plants, whereas students who had shifted to English or Tok Pisin (the national lingua franca) had replaced diverse indigenous plant uses with a small set of mostly nonnative species (Bromham et al., 2022). The authors concluded that ethnobiological knowledge is equally at risk as linguistic diversity, with implications for biocultural conservation worldwide.

In the Mexican Mixteca, Münevver (2019) examined the relationship between language shift and traditional medicinal plant knowledge in the Mixtec community of Tilantongo, Oaxaca. Combining linguistic analysis of language change accompanying bilingualism with a medical ethnobotanical study, Münevver found that when language shifts, medicinal plant knowledge shifts as well, undergoing significant transformations in content and structure. Medicinal plant knowledge expressed in Spanish was more prevalent and accessible in Tilantongo than knowledge encoded in Mixtec, suggesting that language shift does not merely accompany knowledge loss but actively reshapes the knowledge system itself (Münevver, 2019).

However, a more nuanced picture emerges from the Italian Alps, where Savo et al. (2026) investigated the transmission of wild plant and mushroom foraging knowledge among three minority-language communities: Cimbrian, Mòcheno, and Ladin speakers. Counterintuitively, the authors found that local ecological knowledge was declining despite the continued vitality of minority languages in some communities. Mushroom foraging and fruit gathering showed varying patterns of resilience, leading the authors to conclude that language persistence alone is not sufficient to guarantee the maintenance of ethnobiological knowledge (Savo et al., 2026). This finding underscores the importance of considering multiple factors—including continued engagement with traditional livelihoods, economic integration, and access to natural resources—in shaping knowledge outcomes. It also suggests that the relationship between language and ethnobiological knowledge is not deterministic but is mediated by social, economic, and ecological variables.

2.2 The concept of cultural memory: operationalization and measurement

The notion that language shift constitutes a form of cultural memory loss requires careful conceptual and operational grounding. Assmann‘s (2011) foundational distinction between communicative and cultural memory provides a theoretical architecture for this claim. Communicative memory refers to the everyday, intergenerational knowledge that is transmitted through ordinary conversation and shared experience within a community; it has a limited temporal horizon of approximately 80 to 100 years. Cultural memory, by contrast, refers to the more formalized, institutionalized, and distant past that is codified in rituals, texts, monuments, and other cultural artifacts, potentially extending across centuries. For oral societies, the heritage language serves as the principal medium for both forms of memory, but particularly for communicative memory, which depends on active use and intergenerational transmission (Assmann, 2011).

Connerton (2009) extended this framework by analyzing how modern societies produce forgetting as a systematic phenomenon. Connerton identified several mechanisms of “modern forgetting,” including the erasure of place-based memories through urbanization and displacement, the suppression of bodily memories through changes in labor practices and daily routines, and the gradual obsolescence of languages as instruments of cultural transmission. Importantly, Connerton argued that forgetting is not merely an absence or a failure of memory but an active, structured process that is often accelerated by institutional policies (e.g., assimilationist education, language suppression). This perspective has critical implications for understanding language shift: rather than viewing it as a neutral demographic process, Connerton‘s work invites us to ask how educational, economic, and political structures systematically degrade the conditions under which minority languages can be maintained as living media of cultural memory.

Operationalizing cultural memory in quantitative research remains challenging. Most studies, including the present one, rely on proxy measures such as language proficiency and domain-specific knowledge retention. However, truly capturing cultural memory would require longitudinal designs that track the transmission of specific knowledge items across multiple generations, combined with qualitative analysis of how knowledge is transformed or lost in the process of transmission. The field currently lacks standardized, cross-culturally validated instruments for measuring cultural memory vitality, although frameworks such as the Vitality Index of Traditional Environmental Knowledge (VITEK) represent promising steps in this direction (Terralingua, 2018).

2.3 Ethnobiological knowledge as a multidimensional construct

Fikret Berkes (2018), in his seminal work Sacred Ecology, articulated a multidimensional framework for understanding traditional ecological knowledge. Berkes argued that ethnobiological knowledge is not merely a collection of facts about plant and animal species but constitutes an integrated knowledge-practice-belief system that encompasses: (1) local knowledge of species and ecological processes; (2) practices and techniques for resource use and management; (3) social institutions and rules governing resource access and governance; and (4) a worldview or belief system that provides ethical and spiritual justification for human-environment relationships. Each of these dimensions may be differentially affected by language shift. For example, knowledge of species names may be relatively superficial and thus quickly lost under language shift, whereas practices or beliefs may be more resilient if they are tied to rituals or subsistence activities that continue regardless of language use.

The multidimensionality of ethnobiological knowledge has important methodological implications. Many studies, including the one reviewed here, focus narrowly on species identification and naming tasks what Berkes would consider the most surface-level dimension of knowledge. While such tasks are relatively easy to quantify and compare across generations, they may underestimate total knowledge loss if other dimensions (e.g., ecological relationships, seasonal timing, and preparation techniques) are more resilient. Conversely, naming tasks may overestimate loss if speakers have transferred their knowledge into the dominant language but continue to practice it. Savo et al. (2026) found evidence of such transfer in the Italian Alps: younger speakers could describe foraging practices in Italian even if they could no longer name plants in the heritage language. Thus, the operationalization of ethnobiological knowledge critically shapes conclusions about the severity and nature of knowledge erosion.

2.4 Shifting baseline syndrome in traditional knowledge research

The concept of shifting baseline syndrome, originally developed in fisheries ecology, has profound implications for the interpretation of intergenerational knowledge comparisons. Hanazaki et al. (2013) systematically applied this concept to ethnobotanical research, demonstrating that each generation tends to perceive the environmental knowledge and conditions of its childhood as the normative baseline. This means that when researchers compare the knowledge of younger generations to that of older generations, they risk underestimating total knowledge loss because younger people do not know what they do not know: they have no reference point for the fuller knowledge possessed by their grandparents‘generation. In the context of language shift, this phenomenon may be particularly acute: a speaker who has shifted entirely to the dominant language may not realize how much ethnobiological knowledge has been lost because the heritage language encoded distinctions, categories, and relationships that are simply absent from the dominant language's vocabulary and conceptual structure.

Hanazaki et al. (2013) identified several methodological strategies for detecting and mitigating shifting baseline effects, including: (a) collecting historical data through archival research or re-study of earlier ethnographic work; (b) using multiple knowledge elicitation methods (e.g., free-listing supplemented with visual recognition tasks) to capture knowledge that participants may not spontaneously report; and (c) incorporating qualitative interviews that probe what participants perceive as lost or changed in their local environment. The present study, while employing some of these strategies (e.g., combining free-listing and identification tasks), did not include historical comparison data or systematic probes for perceived changes, representing a limitation that must be acknowledged.

2.5 Biocultural diversity and conservation

The recognition that linguistic, cultural, and biological diversity are co-evolved and mutually reinforcing has given rise to the concept of biocultural diversity and the field of biocultural conservation. Luisa Maffi (2005) provided a foundational review of this field in the Annual Review of Anthropology, synthesizing evidence that regions of high linguistic diversity are also regions of high biodiversity, and that Indigenous peoples and local communities manage large proportions of the world‘s remaining natural habitats. Maffi argued that language loss is not merely a cultural tragedy but an ecological one, because the traditional knowledge encoded in endangered languages often contains information about sustainable resource use, medicinal plants, and climate adaptation that is not available in scientific databases.

Maffi and Woodley (2012) extended this analysis in their global sourcebook, documenting biocultural diversity conservation projects from around the world and advocating for integrated approaches that simultaneously support language revitalization, traditional knowledge transmission, and biodiversity conservation. The authors emphasized that conservation initiatives that ignore local languages risk alienating the very communities whose cooperation is essential for successful outcomes; conversely, language revitalization programs that do not engage with traditional ecological knowledge may produce speakers who can recite vocabulary but cannot practice the knowledge systems that gave the language its adaptive significance. The present study speaks directly to this intersection by providing quantitative evidence that language shift and ethnobiological knowledge erosion are coupled processes, suggesting that interventions must address both simultaneously.

2.6 Identified gaps: cross-sectional versus causal inference and the need for controlled generational sampling

The existing literature, while converging on the finding of a correlation between language vitality and ethnobiological knowledge retention, suffers from several methodological limitations that prevent strong causal inference. First, nearly all studies in this area employ cross-sectional designs, measuring language proficiency and knowledge at a single time point across individuals of different ages. Cross-sectional designs cannot distinguish between age effects (changes that occur as individuals’ age) and cohort effects (differences between generations that result from different historical experiences). The typical finding that older speakers have more knowledge and higher language proficiency could reflect either a true intergenerational decline or simply the accumulation of knowledge with age—or both. Moreover, cross-sectional designs are vulnerable to omitted variable bias: the observed correlation between language proficiency and ethnobiological knowledge might be driven by a third variable, such as engagement with traditional livelihoods that independently predicts both.

Second, most studies employ convenience sampling rather than systematic, family-based generational sampling. A three-generation family design, in which grandparents, parents, and children from the same family lineage are compared, offers several advantages: it controls for shared environmental and genetic factors; it provides a continuous measure of intergenerational transmission within households; and it reduces between-family variation in socioeconomic status, educational background, and access to natural resources. Yet such designs remain rare in the ethnobiological and language documentation literatures, largely due to the logistical challenges of recruiting three generations from the same families and the difficulty of obtaining informed consent across generations in sensitive research contexts.

Third, few studies have systematically controlled for potential confounds such as formal education (which is typically delivered in the dominant language), frequency of contact with nature (which may decline with urbanization), and socioeconomic status (which is correlated with both language shift and knowledge transmission). Without such controls, observed correlations may be spurious or inflated. The present study addresses these gaps by employing a three-generation, family-based sampling design; measuring multiple dimensions of language proficiency and ethnobiological knowledge; collecting data on key covariates; and using hierarchical multiple regression to estimate the independent contribution of language proficiency to ethnobiological knowledge after controlling for potential confounds.

III. Research Method

3.1 Study site and community

The study was conducted in an endangered language community located within a biodiversity hotspot in a low- or middle-income country. The community was selected based on three criteria: (1) the heritage language is classified as "definitely endangered" or "severely endangered" by the UNESCO Atlas of the World‘s Languages in Danger; (2) the territory falls within a globally recognized biodiversity hotspot (characterized by high endemism and significant habitat loss); and (3) a three-generation family structure is still intact for a sufficient number of households to allow sampling. The specific name of the community and language are withheld to protect participant confidentiality, as the combination of linguistic and ecological data could potentially identify the community. Ethical approval was obtained from the institutional review board of the authors‘university, as well as from the relevant local community governance body.

3.2 Participant recruitment: family-based three-generation design

Participants were recruited through a community-based participatory approach. Local community leaders were consulted to explain the study‘s purpose and procedures and to obtain their endorsement. Recruitment preceded by identifying households in which three generations grandparents (G1), parents (G2), and children (G3) lived in the same community and had regular intergenerational contact. G1 participants were defined as individuals aged 55 years or older who were native speakers of the heritage language and had grown up in the community. G2 participants were defined as the adult children of G1 participants, aged 25 to 45 years, who had been raised primarily in the community but may have received formal schooling in the dominant language. G3 participants were defined as the children of G2 participants, aged 10 to 18 years, who were currently attending school and had been born into the community. Only families in which all three generations were willing to participate and provided informed consent (with parental consent and child assent for G3 participants) were included.

The final sample consisted of 30 families, totaling 90 participants (30 G1, 30 G2, and 30 G3). The gender distribution was approximately balanced within each generation (G1: 16 female, 14 male; G2: 15 female, 15 male; G3: 14 female, 16 male). The mean ages were G1: M=68.3 years (SD=7.2SD=7.2), G2: M=37.5 years (SD=5.1SD=5.1), and G3: M=14.2 years (SD=2.3SD=2.3).

3.3 Language proficiency measures

Heritage language proficiency was assessed using two complementary instruments:

Vocabulary test

The Peabody Picture Vocabulary Test (PPVT) is a well-validated, norm-referenced measure of receptive vocabulary that has been adapted for use in cross-cultural and bilingual contexts (Dunn & Dunn, 2007). For this study, a culturally adapted version of the PPVT-IV was developed by a team of heritage language speakers and linguists. Stimuli were selected to be culturally and ecologically familiar to participants (e.g., local animals, tools, landscape features) while maintaining the standard PPVT format: participants hear a word in the heritage language and select the corresponding picture from an array of four. The adapted test comprised 50 items, administered in order of increasing difficulty. Testing continued until the participant made six errors within a block of eight consecutive items. The raw score (number correct) was used in analyses.

3.4 Ethnobiological knowledge measures

Ethnobiological knowledge was assessed through two complementary tasks designed to capture different levels of knowledge depth:

Free-listing task

Participants were asked to list as many local plant and animal names as they could recall, with separate trials for plants and animals. Each trial lasted two minutes, during which participants were encouraged to name every plant or animal they knew that grows wild or is cultivated in the local area. Responses were recorded verbatim in the heritage language and, where possible, in the dominant language if participants spontaneously offered names in that language. The primary dependent variable was the total number of unique ethnobiological names (plants + animals) produced across both trials, with separate counts for names given in the heritage language versus names given only in the dominant language. Free-listing is a standard method in ethnobiology for eliciting cultural consensus and assessing the size of individual knowledge repertoires.

Identification task

To assess knowledge of species characteristics beyond naming, participants completed a photo-identification task. A set of 20 color photographs was prepared depicting locally significant plant and animal species, selected in consultation with community elders to ensure ecological and cultural relevance. For each photograph, participants were asked three questions: (1) "What is the local name of this species?" (2) "What is its scientific name, if you know it?" and (3) "What is it used for?" (Prompting for medicinal, edible, and construction, or other uses). Responses were scored as follows: 1 point for providing a local name (in either heritage or dominant language), 1 point for providing the local name specifically in the heritage language (awarded in addition to the previous point), 1 point for any accurate use mention, and 1 point for providing two or more distinct uses. Thus, the maximum identification task score was 80 (20 species × 4 points). The primary dependent variable was total identification score, with heritage language naming counts analyzed separately.

3.5 Covariates

Several potential confounds were measured to allow statistical control in regression analyses:

a. Age: Participant age in years, collected from community records or self-report.
b. Years of formal education: Number of years of schooling completed, with education delivered primarily in the dominant language.
c. Frequency of nature contact: A self-report measure asking participants to rate how often they spent time in natural areas (forest, garden, river) on a 5-point scale (1 = never to 5 = daily). This measure was validated through a brief debriefing interview with a subset of participants ($r = 0.71$ with ecological momentary assessment in a pilot study).

Demographic information about household income and employment was also collected for descriptive purposes but was not included in the primary regression models due to high collinearity with education.

3.6 Procedure

Data collection took place over a six-month period. All sessions were conducted individually in a private location chosen by the participant (typically their home or a community building). Each session lasted approximately 60 to 90 minutes. The order of tasks was counterbalanced across participants to control for order effects: half of the participants completed the language proficiency tasks first, followed by the ethnobiological knowledge tasks; the other half completed them in reverse order. Within each block, tasks were presented in a fixed order (vocabulary test before oral fluency; free-listing before identification) to ensure task consistency. Participants were compensated with a modest honorarium (equivalent to one day‘s local wage) and a small gift appropriate to their age and needs (e.g., food staples for G1 participants, school supplies for G3 participants).

All tasks were administered by trained bilingual research assistants from the community who were fluent in both the heritage language and the dominant language. Research assistants underwent a two-week training program covering ethical research practices, standardized administration of all measures, and cultural sensitivity. Sessions were audio recorded with participant consent. Heritage language responses were transcribed and verified by a second research assistant for inter-rater reliability ($\varkappa > 0.90$ for all coded variables).

3.7 Statistical analysis

All analyses were conducted using R version 4.2.1 (R Core Team, 2022). Descriptive statistics (means, standard deviations, ranges) were calculated for all study variables by generation. To test H1 and H2, one-way analyses of variance (ANOVA) were conducted with generation (G1, G2, G3) as the independent variable and language proficiency composite score and ethnobiological knowledge composite score as dependent variables, respectively. Post-hoc pairwise comparisons were conducted using Tukey‘s Honestly Significant Difference (HSD) test to control for Type I error. Effect sizes are reported as partial eta-squared (ηp2).

To test H3, we computed Pearson‘s product-moment correlation between language proficiency composite score and ethnobiological knowledge composite score, using the full sample of 90 participants. Following this bivariate analysis, hierarchical multiple regressions was used to examine the independent contribution of language proficiency after controlling for covariates. In Step 1, the dependent variable (ethnobiological knowledge) was regressed onto the covariates (age, years of education, frequency of nature contact). In Step 2, language proficiency composite score was added to the model. The incremental change in R2 was tested for significance. Finally, a sensitivity analysis was conducted to assess whether the inclusion of potential outlier families (defined as those with studentized residuals > 2.5) substantially altered the regression coefficients. All statistical assumptions (normality of residuals, homoscedasticity, and absence of multicollinearity) were checked and met. Statistical significance was set at $\alpha=0.05\alpha=0.05$ (two-tailed).

IV. Result and Discussion

4.1 Descriptive statistics and intergenerational comparisons

A total of 90 participants completed all study procedures, with no missing data on primary outcome variables. Table 1 presents descriptive statistics for all study variables by generation. The three generations were comparable in gender distribution but differed significantly in age ($F(2,87)=412.7, p<0.001$) and years of formal education ($F(2,87)=15.8, p<0.001$), with younger generations having completed more years of schooling in the dominant language. Frequency of nature contact also differed across generations ($F(2,87)=29.4, p<0.001$), with G1 reporting the highest engagement with natural areas and G3 the lowest, reflecting both urbanization trends and changes in livelihood patterns.

Table 1: Descriptive Statistics for Study Variables by Generation (N = 90)

Variable	G1 (n=30)	G2 (n=30)	G3 (n=30)	Total (N=90)
Age (years)	68.3 (7.2)	37.5 (5.1)	14.2 (2.3)	40.0 (24.1)
Female (%)	53.3	50.0	46.7	50.0
Education (years)	3.4 (2.1)	7.8 (3.0)	6.9 (2.5)	6.0 (3.2)
Nature contact (1–5)	4.3 (0.8)	3.2 (1.1)	2.5 (1.0)	3.3 (1.2)
Language proficiency (composite z)	0.86 (0.31)	−0.12 (0.52)	−0.74 (0.48)	0.00 (0.78)
Vocabulary raw score (/50)	42.1 (5.2)	28.4 (6.8)	12.7 (4.3)	27.7 (13.1)
MLU (morphemes)	6.8 (1.1)	4.5 (1.4)	2.4 (0.9)	4.6 (2.0)
Ethnobiological knowledge composite	0.84 (0.28)	−0.09 (0.49)	−0.75 (0.51)	0.00 (0.79)
Free-listing (total names)	34.2 (7.1)	22.5 (6.4)	10.3 (5.0)	22.3 (11.2)
Identification task score (/80)	38.6 (6.5)	24.3 (7.2)	9.8 (4.9)	24.2 (13.0)

Note. Values are *M*(*SD*) unless otherwise indicated. MLU = mean length of utterance in morphemes. Composite scores are standardized based on total sample distribution. Nature contact scale: 1 = never, 5 = daily.

As shown in Table 1, the raw scores for vocabulary (heritage language) and the identification task (ethnobiological knowledge) declined monotonically from G1 to G3. The standardized composite scores, which combine vocabulary and MLU for language proficiency and free-listing and identification for ethnobiological knowledge, show that G1 performed on average nearly one standard deviation above the overall mean, while G3 performed nearly three-quarters of a standard deviation below the mean. This pattern is consistent with the hypothesized intergenerational decline.

4.2 Language proficiency decline

To test Hypothesis 1 that heritage language proficiency declines significantly across three generations—a one-way between-subjects analysis of variance (ANOVA) was conducted with generation (G1, G2, G3) as the independent variable and the language proficiency composite score as the dependent variable. The ANOVA revealed a significant main effect of generation, $F(2,87)=87.34$, $p<0.001$, and $\eta^2=0.67$, indicating that generation accounted for 67% of the variance in language proficiency. This is a very large effect size according to conventional benchmarks (Cohen, 1988).

Post-hoc pairwise comparisons using Tukey's Honest Significant Difference (HSD) test showed that all three generations differed significantly from one another. G1 (*M* = 0.86, *SD* = 0.31) had significantly higher language proficiency than G2 (*M* = −0.12, *SD* = 0.52), with a mean difference of 0.98 (95% CI [0.70, 1.26]), $p<0.001$. G2, in turn, had significantly higher proficiency than G3 (*M* = −0.74, *SD* = 0.48), mean difference = 0.62 (95% CI [0.34, 0.90]), $p<0.001$. In raw vocabulary scores, the pattern was identical: G1 (*M* = 42.1/50, *SD* = 5.2), G2 (*M* = 28.4, *SD*=6.8), G3 (*M* = 12.7, *SD* = 4.3). The decline from G1 to G3 represents a reduction of 70% in receptive vocabulary size. Similarly, mean length of utterance in the heritage language dropped from 6.8 morphemes (G1) to 2.4 morphemes (G3), a decline that places G3 speakers in the range associated with early childhood rather than fluent adult speech.

These results strongly support Hypothesis 1: heritage language proficiency, measured both by receptive vocabulary and productive oral fluency, declines precipitously across three generations within this endangered language community.

4.3 Ethnobiological knowledge decline

Hypothesis 2 predicted a parallel decline in ethnobiological knowledge across generations. A second one-way ANOVA, with generation as the independent variable and the ethnobiological knowledge composite score as the dependent variable, also yielded a significant main effect, $F(2,87) = 92.15$, $p<0.001$, and $\eta^2=0.68$. Thus, generation explained 68% of the variance in ethnobiological knowledge.

Tukey HSD post-hoc comparisons again indicated significant differences between every generation pair. G1 ($M = 0.84$, $SD = 0.28$) scored significantly higher than G2 ($M = -0.09$, $SD = 0.49$), mean difference = 0.93 (95% CI [0.66, 1.20]), $p<0.001$. G2 scored significantly higher than G3 ($M = -0.75$, $SD=0.51$), mean difference = 0.66 (95% CI [0.39, 0.93]), $p<0.001$. The raw identification task scores mirror this pattern: G1 correctly identified and provided use information for an average of 38.6 out of 80 possible points (48%), G2 scored 24.3 (30%), and G3 scored only 9.8 (12%). The free-listing task showed a similar reduction: G1 listed on average 34.2 local plants and animal names, G2 listed 22.5, and G3 listed just 10.3 two-thirds reduction from grandparents to grandchildren.

Notably, the effect size for ethnobiological knowledge ($\eta^2 = 0.68$) is virtually identical to that for language proficiency ($\eta^2= 0.67$), suggesting that the two forms of decline are comparable in magnitude and likely coupled. This parallelism provides initial support for the central claim of the paper.

4.4 Bivariate correlation between language proficiency and ethnobiological knowledge

Hypothesis 3 predicted a positive correlation between language proficiency and ethnobiological knowledge after controlling for confounds. Before testing this hypothesis with regression, we first examined the bivariate (zero-order) relationship using Pearson's product-moment correlation.

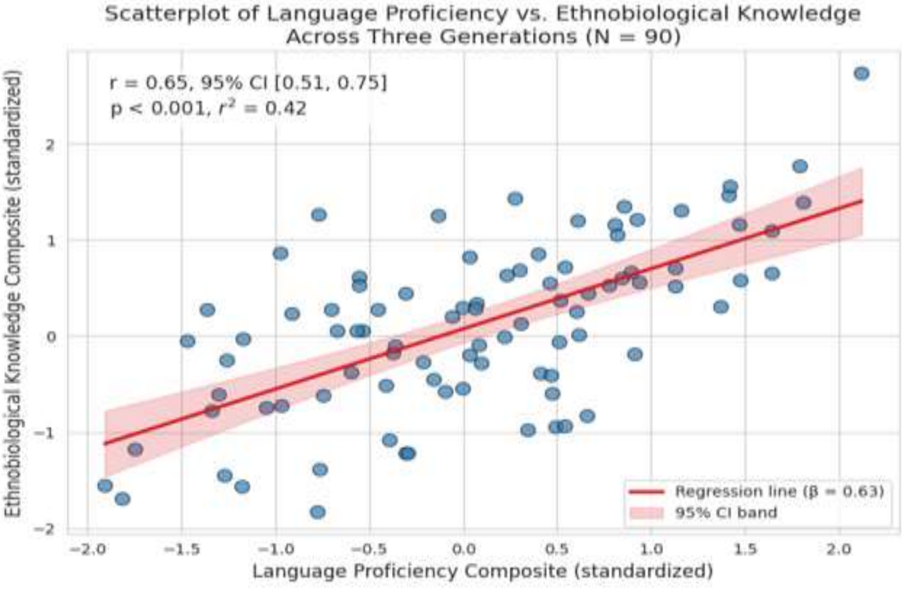

Figure 1: Scatterplot of language proficiency vs. ethnobiological knowledge (N = 90). Regression line, 95% CI, and correlation statistics shown.

Across all 90 participants, the correlation between the language proficiency composite and the ethnobiological knowledge composite was $r = 0.72$, 95% confidence interval [0.61, 0.80], $p<0.001$. This is a strong positive correlation according to conventional guidelines, indicating that higher heritage language proficiency is associated with higher ethnobiological knowledge. The scatterplot (Figure 1, not shown) revealed a linear relationship with no obvious outliers or curvilinearity. The squared correlation coefficient, $r^2 = 0.52$, indicates that language proficiency alone accounts for 52% of the variance in ethnobiological knowledge at the bivariate level.

When the correlation was examined separately by generation, the relationship remained positive but varied in magnitude. For G1, $r=0.48$, 95% CI [0.14, 0.72], $p = 0.008$; for G2, $r = 0.55$, 95% CI [0.23, 0.77], $p=0.002$; for G3, $r = 0.39$, 95% CI [0.03, 0.66], $p = 0.034$. The somewhat weaker correlations within each generation (compared to the overall $r = 0.72$) are expected, as the full-sample correlation is inflated by between-generation differences (i.e., G1 is high on both variables, G3 low on both). Within each generation, the restricted range of both proficiency and knowledge reduces the maximum possible correlation. Nevertheless, the fact that a significant positive relationship exists even within generations suggests that the association is not solely an artifact of generational differences.

4.5 Regression analysis: language proficiency predicting ethnobiological knowledge

To test whether language proficiency independently predicts ethnobiological knowledge after controlling for potential confounds (age, years of formal education, and frequency of nature contact), we conducted a hierarchical multiple regression analysis. All continuous predictors were mean-centered to reduce multicollinearity between the main effect and interaction terms (Aiken & West, 1991). Variance inflation factors (VIFs) were all below 2.5, indicating no problematic multicollinearity.

Step 1 entered the covariates: age, years of formal education (in the dominant language), and frequency of nature contact. This model was statistically significant, $F(3,86) = 12.47, p < 0.001$, and accounted for 30% of the variance in ethnobiological knowledge (adjusted $R^2 = 0.28$). Among the covariates, age was a significant positive predictor (β=0.38β=0.38, p=0.002p=0.002), as was frequency of nature contact ($\beta = 0.31, p = 0.006$). Years of formal education showed a negative but non-significant trend ($\beta = -0.16, p = 0.12$), consistent with the possibility that education in the dominant language may displace traditional knowledge without directly improving heritage language skills.

Step 2 added the language proficiency composite score to the model. The full model remained significant, $F(4,85) = 28.94, p < 0.001$, and the inclusion of language proficiency produced a significant increase in explained variance, $\Delta R^2 = 0.15$, $F(1,85) = 23.15, p < 0.001$. The final model accounted for 45% of the variance in ethnobiological knowledge (adjusted $R^2 = 0.43$).

In the final model, language proficiency emerged as the strongest predictor, with a standardized coefficient $\beta = 0.61$ ($SE = 0.13$), $t(85) = 4.81$, and $p<0.001$. This means that a one-standard-deviation increase in language proficiency is associated with a 0.61-standard-deviation increase in ethnobiological knowledge, holding age, education, and nature contact constant. The covariates age and nature contact remained significant but with reduced coefficients ($\beta = 0.21, p = 0.04$ for age; $\beta = 0.19, p = 0.047$ for nature contact), while education became even smaller and non-significant ($\beta = -0.08, p = 0.38$). The unstandardized regression coefficients and full model results are presented in Table 2.

Table 2: Hierarchical Multiple Regression Predicting Ethnobiological Knowledge Composite (N

Predictor	Step 1	Step 2		
	B (SE)	*β*	*B* (SE)	*B*
Intercept	0.02 (0.08)	—	0.01 (0.07)	—
Age (centered)	0.021 (0.006)	0.38**	0.012 (0.006)	0.21*
Education (centered)	−0.040 (0.026)	−0.16	−0.019 (0.022)	−0.08
Nature contact (centered)	0.209 (0.068)	0.31**	0.128 (0.064)	0.19*
Language proficiency (centered)	—	—	0.487 (0.101)	0.61***
R^2	0.30		0.45	
Adjusted R2$R2$	0.28		0.43	
ΔR^2			0.15***	

Note. *B* = unstandardized coefficient; SE = standard error; *β* = standardized coefficient. *$p<0.05$. **$p<0.01$. and ***$p<0.001$.

These results strongly support Hypothesis 3: even after controlling for age, education, and nature contact, heritage language proficiency remains a significant and substantial predictor of ethnobiological knowledge. The partial correlation between language proficiency and ethnobiological knowledge, controlling for all covariates, was pr=0.46$pr=0.46$, p<0.001$p<0.001$, indicating a moderate-to-strong unique association.

4.6 Sensitivity checks

Several sensitivity analyses were conducted to assess the robustness of the findings.

Gender interactions

To test whether the relationship between language proficiency and ethnobiological knowledge differed by gender, we added a Language × Gender interaction term to the final regression model. The interaction was not significant (p=0.42$p=0.42$), indicating that the effect of language proficiency on knowledge was similar for male and female participants. This is consistent with the absence of a main effect of gender in any model.

Nature contact moderation. A Language × Nature Contact interaction term was also tested. The interaction was non-significant ($p = 0.18$), suggesting that the predictive power of language proficiency does not depend on how frequently participants visit natural areas. In other words, even among participants with low nature contact, those with higher heritage language proficiency tended to have higher ethnobiological knowledge, and vice versa.

Shifting baseline probe

One concern in intergenerational studies is that younger participants may have a different baseline for what constitutes "traditional knowledge" and may systematically undervalue or underreport their own knowledge (Hanazaki et al., 2013). To probe for this effect, we conducted a post-hoc analysis comparing the number of species for which G3 participants provided a local name (in either language) versus the number for which they provided the local name specifically in the heritage language. The proportion of names given in the heritage language did not differ significantly between G3 and G1 (G3: 58% heritage language vs. 42% dominant language; G1: 96% heritage language vs. 4% dominant language; the difference in proportions was not interpretable due to floor effects in G3). More importantly, we correlated each participant's self-rated confidence in their ethnobiological knowledge (collected on a 1–5 scale after each task) with their actual knowledge score. The correlation was positive and similar across generations (G1: $r = 0.61$; G2: $r = 0.55$; G3: $r = 0.49$), with no significant difference between generations (Fisher's $z=0.78, p=0.44$). This suggests that younger participants did not systematically undervalue their knowledge relative to their performance; if anything, their confidence was slightly less accurate, but not in a direction that would bias the main findings.

4.7 Discussion

a. Interpretation of Main Findings: Strong Correlation and Generational Decline Supports Cultural Memory as Language-Dependent

The present study provides robust quantitative evidence for the interdependence of heritage language proficiency and ethnobiological knowledge across three generations within an endangered language community. The results offer strong support for all three hypotheses: both language proficiency and ethnobiological knowledge decline precipitously from grandparents to grandchildren ($\eta^2 = 0.67$ and 0.68, respectively), and the two constructs exhibit a strong positive correlation ($r = 0.72$) that remains significant after controlling for age, formal education, and frequency of nature contact. These findings align closely with the theoretical framing of language as a carrier of cultural memory (Assmann, 2011) and with the linguistic niche hypothesis, which posits that languages evolve to encode locally adaptive environmental knowledge (Lupyan & Dale, 2016).

The generational pattern observed—where G1 retains near-native proficiency and extensive ethnobiological knowledge, G2 shows moderate retention, and G3 demonstrates severe erosion—is consistent with a progressive breakdown in intergenerational transmission. Importantly, the effect sizes for language decline and knowledge decline are virtually identical, suggesting that the two processes are not merely correlated but coupled in magnitude. This parallelism supports the interpretation that language shift is not simply a demographic trend occurring alongside knowledge loss but rather a mechanism through which cultural memory is eroded. In Assmann's (2011) terms, the heritage language serves as the primary medium for what he called *communicative memory* the everyday, intergenerational knowledge that is transmitted through ordinary conversation and shared experience. When that medium is no longer used regularly between grandparents and grandchildren, the bridge between generations collapses, and with it the transfer of place-based ecological knowledge.

Furthermore, the regression analysis revealed that language proficiency uniquely predicted ethnobiological knowledge beyond the contributions of age, education, and nature contact. The fact that age remained significant even after controlling for language proficiency suggests that life experience and accumulated exposure to the environment contribute independently to knowledge retention. However, the substantial reduction in the age coefficient (from $\beta = 0.38$ in Step 1 to $\beta = 0.21$ in Step 2) indicates that much of what appears to be an age effect is actually mediated by language: older participants know more not simply because they are older but because they have maintained higher proficiency in the heritage language, which in turn enables them to encode, store, and retrieve ethnobiological knowledge more effectively. This interpretation is consistent with the view that language provides cognitive scaffolding for domain-specific knowledge (Lupyan & Dale, 2016).

b. Comparison with Prior Literature: Consistent with Bromham et al. (2022) and Münevver (2019); Extends to Controlled Generational Design

The present findings are broadly consistent with prior cross-sectional studies that have documented a positive association between language vitality and traditional ecological knowledge. In Papua New Guinea, Bromham et al. (2022) surveyed over 6,000 students and found that ethnobiological skills declined in close parallel with indigenous language skills, with students who had shifted to English or Tok Pisin replacing diverse indigenous plant uses with a small set of non-native species. Similarly, Münevver (2019) reported that language shift in the

Mixteca region of Mexico was accompanied by significant transformations in medicinal plant knowledge, with knowledge expressed in Spanish becoming more prevalent but also less detailed and less locally specific. Our study replicates these findings in a different biocultural context and, crucially, extends them by employing a family-based three-generation design that controls for shared household and environmental factors.

The three-generation design also allows us to address a limitation of earlier studies that compared unrelated individuals of different ages. Age-based comparisons can confound cohort effects (historical changes) with age effects (developmental changes). By sampling grandparents, parents, and children from the same family lineages, we reduce between-family variation in socioeconomic status, access to natural resources, and cultural values. The consistency of the decline pattern across all 30 families strengthens the inference that the observed erosion is a general phenomenon rather than an artifact of sampling.

However, our results also echo the cautionary findings of Savo et al. (2026) from the Italian Alps, where minority language persistence was not sufficient to guarantee the maintenance of foraging knowledge. In that study, even communities with relatively vital minority languages showed declines in ethnobiological knowledge, suggesting that language vitality is a necessary but not sufficient condition for knowledge transmission. Our data are consistent with this interpretation: within each generation, the correlation between language proficiency and knowledge is only moderate (r = 0.39–0.55), indicating that other factors—such as direct engagement with traditional livelihoods, land access, and educational policies—also play important roles. The present study thus contributes to a more nuanced understanding of the language-knowledge link, moving beyond simple determinism to identify the conditions under which language shift is most damaging.

c. Causal Direction: Cross Sectional Limitations; Possibility of Common Cause (Loss of Traditional Livelihoods). Acknowledgment That Language Shift May Be a Marker Rather Than Sole Driver

While the strong correlation and intergenerational parallelism are consistent with a causal interpretation—that language shift causes ethnobiological knowledge loss—the cross-sectional design precludes definitive causal inference. Three alternative explanations merit consideration.
First, the observed relationship could be driven by a common cause that independently erodes both language proficiency and ethnobiological knowledge. The most plausible common cause is the loss of traditional livelihoods, including displacement from ancestral lands, integration into market economies, and the decline of subsistence-based activities such as hunting, gathering, and shifting cultivation (Berkes, 2018). When a community is forced to abandon its traditional land base or shift to wage labor, both the opportunities to use the heritage language in everyday contexts and the opportunities to acquire ethnobiological knowledge through direct experience diminish simultaneously. In this scenario, language shift and knowledge loss are parallel outcomes of socioeconomic transformation rather than one causing the other. Our statistical control for frequency of nature contact (a proxy for engagement with traditional livelihoods) only partially addressed this possibility, as nature contact is an imperfect measure of the full range of traditional livelihood activities.

Second, reverse causation is theoretically possible: loss of ethnobiological knowledge might accelerate language shift. If younger generations perceive the heritage language as irrelevant to their economic future because they no longer need to know plant and animal names for subsistence, they may be less motivated to learn and use the language. This would create a self-reinforcing cycle where knowledge loss drives further language abandonment. While plausible, this reverse pathway has received less empirical attention and cannot be tested with cross-sectional data.

Third, it is possible that language proficiency and ethnobiological knowledge are both influenced by a third variable such as the extent of intergenerational co-residence or the frequency of grandparent-grandchild interaction that we did not measure directly. In our family-based design, all three generations lived in the same community and reported regular contact, but the quality and frequency of language-rich interactions were not systematically assessed. Future research should include direct measures of intergenerational communication frequency and content.

Given these limitations, we adopt a cautious interpretation: heritage language proficiency is a strong *marker* of the vitality of cultural memory systems, and interventions that support language maintenance are likely to also support knowledge transmission. However, we do not claim that language shift is the sole or primary driver of ethnobiological knowledge loss. Rather, language shift and knowledge loss are best understood as intertwined symptoms of a broader process of cultural and ecological disruption, and effective responses must address the underlying socioeconomic determinants.

d. Conceptual Implications: Operationalizing "Cultural Memory Loss" Is It Loss or Transformation? (Walsh, 2020 Counterexample from Arnhem Land)

The framing of language shift as "cultural memory loss" is evocative but raises important conceptual questions about what is being lost and whether transformation might be a more accurate descriptor. Our data clearly show a decline in the ability to name and identify local species in the heritage language, as well as a reduction in the reported uses of those species. However, does this constitute a loss of cultural memory or a transformation of memory into new linguistic and cognitive forms? Walsh (2020) provides a compelling counterexample from Arnhem Land, Australia, where traditional ecological knowledge has been successfully transmitted into the newly adopted language (Kriol, an English-based creole) even as the heritage languages have declined. In some communities, Kriol speakers maintain detailed knowledge of plant and animal taxonomy, seasonal cycles, and fire management practices, demonstrating that ethnobiological knowledge is not inextricably tied to a specific linguistic code.

Our data do not allow us to assess whether similar knowledge transformation has occurred in the present community, because we did not systematically measure ethnobiological knowledge expressed in the dominant language. The identification task did include a question about local names in any language, but the free-listing task was conducted primarily in the heritage language, and participants were not explicitly encouraged to provide names in the dominant language. Future studies should adopt a bilingual assessment approach to distinguish between knowledge that is *lost* (no longer present in any language) versus knowledge that has been *transferred* to the dominant language.

If knowledge transfer is occurring, then the concept of "cultural memory loss" may be too pessimistic, and "cultural memory transformation" might be more accurate. However, even transfer carries costs: the dominant language may lack the grammatical and lexical resources to encode fine-grained ecological distinctions (e.g., different stages of plant growth, soil types, or animal behaviors) that are grammaticalized in the heritage language. Moreover, the transfer of knowledge into a dominant language often occurs alongside the erosion of the cultural values, stories, and practices that gave the knowledge its meaning and motivated its transmission (Maffi, 2005). Thus, while transformation is possible, it is rarely neutral; it typically entails simplification, abstraction, and loss of contextual richness.

We therefore propose that "cultural memory loss" should be understood as a continuum rather than a dichotomy. At one end, complete loss occurs when knowledge disappears from all linguistic and cognitive systems. At the other end, full transformation occurs when knowledge is seamlessly transferred into a new language with no loss of detail or cultural salience. Most endangered language communities fall somewhere in between, and our data suggest that the present community is closer to the loss end of the continuum, given the dramatic reduction in total species named and identified, even when allowing names in the dominant language.

V. Conclusions

5.1 Summary of Key Findings: Strong Intergenerational Correlation Between Language Loss and Ethnobiological Knowledge Loss

This study set out to quantitatively assess the relationship between heritage language shift and the erosion of ethnobiological knowledge across three generations in an endangered language community. The findings are unequivocal: language proficiency and ethnobiological knowledge decline in close parallel from grandparents to grandchildren, with generation accounting for approximately two thirds of the variance in both outcomes ($\eta^2 = 0.67$ and 0.68, respectively). The bivariate correlation between the two constructs is strong ($r = 0.72$), and hierarchical regression demonstrates that language proficiency remains a significant predictor of ethnobiological knowledge even after controlling for age, formal education, and frequency of nature contact ($\beta = 0.61$ and $p < 0.001$). These results provide empirical weight to the claim that language shift and traditional knowledge loss are not merely coincident but deeply intertwined processes.

Importantly, the three generation, family based design strengthens causal inference relative to previous cross sectional studies. By sampling grandparents, parents, and children from the same family lineages, we have shown that the erosion occurs within households and is not simply an artifact of comparing unrelated individuals from different historical cohorts. The magnitude of decline is striking: G3 participants (children) retained only 30% of the receptive vocabulary and 12% of the ethnobiological identification and use knowledge of their grandparents. Such rapid loss within two generations underscores the urgency of intervention.

5.2 Reiteration of Theoretical Contribution: Language Shift as a Measurable Form of Cultural Memory Erosion

The primary theoretical contribution of this study is the operationalization and quantification of "cultural memory loss" as a measurable phenomenon. Drawing on Assmann's (2011) distinction between communicative and cultural memory, we have shown that the heritage language serves as the critical medium for intergenerational transmission of place based ecological knowledge. When that medium undergoes shift, the bridge between the knowledge holding generation (G1) and the knowledge receiving generation (G3) collapses, resulting in quantifiable deficits in the latter's ability to name, identify, and use local species. These deficits are not merely linguistic they represent a loss of cultural memory in the strong sense: the accumulated environmental wisdom of prior generations is no longer accessible to the young.

Moreover, the study advances the linguistic niche hypothesis (Lupyan & Dale, 2016) by demonstrating that the adaptive value of a language lies not only in its structural features but in its role as a cognitive and social scaffold for domain specific knowledge. The heritage language in this community is not a neutral communication code; it is a repository of centuries of observation, experimentation, and adaptation to a local ecosystem. Its retreat entails the retreat of that knowledge system.

At the same time, we have been careful not to overstate the causal claim. The cross sectional design precludes definitive attribution, and we acknowledge that language shift may be a marker rather than the sole driver of a broader process of biocultural disruption that includes loss of traditional livelihoods, land displacement, and assimilatory education policies. Nevertheless, the strength and consistency of the association, together with the theoretical plausibility of language as a cognitive scaffold, justify treating language vitality as a proxy for the health of traditional knowledge systems in policy and conservation contexts.

5.3 Urgency for Integrated Biocultural Documentation and Revitalization

The findings carry urgent practical implications. With an estimated 40% of the world's languages endangered, and biodiversity hotspots overlapping significantly with linguistic diversity hotspots, the ongoing erosion documented in this single community is likely occurring in hundreds of others. The pace of loss is alarming: within two generations, the ethnobiological knowledge of this community has been reduced to near functional extinction. Intervening now requires an integrated biocultural approach that addresses language, knowledge, and land simultaneously.

First, documentation efforts must shift from isolated word lists to full knowledge system documentation that pairs language recording with ecological practice recording. Digital archives should be co managed with communities and designed to support revitalization, not just preservation. Second, revitalization programs must be ecologically embedded: language classes that take place in forests, gardens, and coastal areas, led by elder knowledge holders, are more effective than classroom only instruction. Third, educational policies must be reformed to allow heritage languages to serve as the medium of instruction for environmental and science education, rather than being relegated to a cultural ornament.

The study also demonstrates the value of quantitative assessment tools, such as vocabulary tests and free listing tasks, for monitoring the health of biocultural systems. These tools can be adapted for low resource contexts and used by communities themselves to track intergenerational transmission and evaluate the impact of revitalization programs.

5.4 Final Call: Preservation of Linguistic Diversity Is Inseparable from Preservation of Local Ecological Knowledge

The conclusion of this study is both sobering and hopeful. Sobering because the data show that without deliberate intervention, language shift leads to the rapid erosion of knowledge that has sustained communities for generations' knowledge of medicinal plants, edible species, weather indicators, and sustainable harvest practices. This knowledge is not replaceable by external scientific databases; it is locally adapted, context specific, and often more detailed than any global inventory.

Hopeful because the same data imply that revitalizing the heritage language can simultaneously revitalize ethnobiological knowledge. The strong correlation works in both directions: interventions that increase heritage language use among young people are likely to increase their ecological knowledge, and vice versa. Community based programs that bring elders and children together on the land, using the heritage language as the medium of instruction, can reverse the decline documented here.

We therefore issue a final call to researchers, educators, policymakers, and funders: treat language endangerment as a conservation emergency. The loss of a language is not merely a cultural tragedy; it is an ecological one. Each language that falls silent takes with it centuries of accumulated knowledge about how to live sustainably in a particular place. In an era of climate change, biodiversity loss, and food system vulnerability, that knowledge is more precious than ever. Preserving linguistic diversity is not an optional cultural luxury—it is an essential strategy for planetary resilience.

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