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Cynthia Twyford Fowler
Wofford College

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Abstract

To explore the process through which people develop knowledge about socioecological change, this article describes a mixed-methods toolkit containing a technique for making maps in real time while moving through landscapes. The quantitative component of the toolkit is grounded in ethnobiologists' embeddedness in place-based communities and harnesses the power of global positioning systems (GPS). As GPS-wielding ethnobiologists engage in participatory mapping by moving through landscapes with their research collaborators, we can use handheld devices and simultaneously communicate with satellites in outer space to produce maps in real time. Within the existing, large inventory of ethnobiological methods, using handheld GPS devices can be combined with other types of data-collecting techniques to enhance studies of interactions in more-than-human landscapes. Moreover, mapmaking implements movement trace, a tactic for interpreting space-time cultures and documenting grounded experiences with socioecological change. By bringing together interests in the disciplines of ethnobiology and qualitative geographic information systems (GIS), this article describes methods that make it possible to explain the space-time culture that guides people to move through their homelands and to communicate about their experiences even as they work toward integrating and directing the changing circumstances of their lives.

Keywords

Southeast Asia, environmental change, qualitative GIS, methodology, fieldwork

Foreword

Recognizing Dr. Justin Nolan by dedicating a special issue of the *Journal of Ethnobiology* to the subject of research methods suits his legacy. Justin was not only an expert in ethnobiology's textbook methods but was also a creative collector and analyzer of data. A notable moment in my memories of Justin comes from the presentation he delivered at the University North Texas about the ethnoecology of Cherokee communities in the Ozarks (Nolan et al. 2012). Dr. Cassandra Quave recorded Justin's talk and archived it on her YouTube Channel, "Teaching Ethnobotany," making it possible to rewatch his talk and share it with other students of ethnobiology. As I attended Justin's presentation live, I have a first-hand recollection of Justin standing in front of the auditorium in Denton with a map of river cane distribution as his backdrop while he wove together lessons about mapping, knowledge, language, and ecology. These are issues that I am also interested in and therefore work through here as I write about the ways people perceive social and ecological changes. In offering this article for you to read, I drop my chin and bend my knee in a curtsy towards Justin. Thank you, Justin, for sharing your brilliance with us. I honor with respect the many gifts you gave to the world.

Introduction: Ephemeral Transmissions

Much of the transformative worldmaking humans do happens as we move through the universe while interacting with diverse living organisms. We enact change in the assemblages that constitute culture by accumulating, interpreting, sharing, interacting with, modifying, moving, creating, and recreating tangible and intangible components of the whole. The ephemeral space-time cultures that social groups construct through these machinations are "temporary collections of socially transmitted information…[and] cultural items" (Durham 2002, 193–196). As human groups and landscapes are together combined in dynamic assemblages, the members of social collectives similarly curate their homelands through "socio-natural enactments…[and] multispecies coordinations" (Tsing 2015, 7). Where these collectives are Indigenous to a place, traces of their curations are embedded in their homelands in forms that reflect their

Department of Sociology and Anthropology, Wofford College, Spartanburg, SC, USA

Corresponding Author:
Cynthia Twyford Fowler, Department of Sociology and Anthropology, Wofford College, 429 North Church Street, Spartanburg, SC 29303, USA.
Email: cynthiafowler@gmail.com

lifeways, and they change over time in response to internal and external influences.

To the extent that humans recognize cultural and ecological change, we learn how to sense it and how to interpret our sensations from one another through shared involvements with and communication about space-time. Through being immersed in our own communities, we acquire the epistemologies, ontologies, and methodologies for sensing, perceiving, and knowing change (Springer 2017). The sensory, cognitive, and social processes at play when we move through landscapes shape our symbolic lives and also emerge out of those experiences. Among the interactions that occur when people move through space-time are communicative exchanges during which thoughts, meanings, and language are shaped and emerge. Interactions—between people and their environments as well as between individual humans—lead to the development of thoughts and also guide people's movements through space-time and communications about them (Brown 2002; Ellen 2016).

Movements (Ingold 2011) and communication (Wassman and Dasen 2000)—together with the interactions (Brown 2002) that occur during these endeavors—generate cultural orientations to space and time. This article brings together these three processes by focusing on two specific subsets of space-time culture: Illustrations of iconic movements through landscapes in the form of foot travel followed by communication about movements through landscapes in the form of key concepts related to going on walkabouts. As you will see through learning about practices and concepts related to walkabouts, Kodi People's spatial and temporal involvements are evident in the traces they have inscribed in their homelands.

The toolkit that I used to bring forth this evidence consists of geospatial tools and ethnographic techniques. My use of these mixed methods is situated within the academic arena of qualitative geographic information systems (GIS) studies (Hawthorne et al. 2015) and spatial analyses of subsistence activities (Smith 2003) in agropastoralists' landscapes (Hearn 2021). Researchers have used global positioning systems (GPS) tracking with interlocutors who narrate their experiences as they move together through landscapes in combination with interpretive techniques to evaluate multiple questions related to space, movement, perception, community well-being, and additional concerns (Hand et al. 2017). Among the labels associated with these mixed-methods projects are walking through spaces, go-along interviews, and walking interviews (Aw et al. 2021; Botfield et al. 2019; Carpiano 2009; Castrodale 2018; Clark and Emmel 2010; Garcia et al. 2012; Jones et al. 2008; Kusenbach 2003; Springgay and Truman 2018). Methodological approaches that blend qualitative spatial analytical techniques with ethnography (e.g., Hearn 2021) and ethnobiology (e.g., Gilmore and Young 2012) have been used by researchers to document culturally valuable assets, to empower communities, and to conserve biocultural diversity. In reviewing the results from "walking through spaces" and allied methods in previous research projects, Aw et al. (2021, 4) found they are "most effective [for researchers who seek] to inspire and verify perceptions in context through exploring and directly confronting the environment."

Tracing Space-Time Culture

As I work to generate a better understanding of space-time culture and how it is constituted through a combination of moving through landscapes, communicating about it, and people's perceptions and interpretations of change, I employ the tactic of "movement trace" (Carter 2008, 2010). Movement trace is a useful focal concept for interpreting people's activities as they move through space, as they interact with their landscapes and other components of their landscapes, and as they talk about their experiences moving through landscapes. The movement trace tactic can be operationalized through mapmaking with handheld GPS devices in combination with other methods (such as discourse analyses, species identifications, interviewing) and is best performed in conjunction with research interlocutors (i.e., participatory mapping).

Participatory mapping in Southeast Asia (Vandergeest and Peluso 1995) and Indonesia (Peluso 1995) documenting details about tenure regimes has been instrumental in providing evidence of the historical depth of communities' presence in their homelands. On Sumba, spatial analysis has been utilized in participatory and nonparticipatory styles. Regarding the latter, satellite imagery has been tapped to characterize fire regimes (Fisher et al. 2006) and to comment on Islanders' management of natural resources. Participatory community mapping (Hardiono et al. 2005) and countermapping (Pramono 2005) projects on Sumba have discovered that spatial analyses may be constrained by external funding needs; on-site obstacles with equipment availability; personnel challenges, such as staff training and staff retention; and community interest, which may be low when practical benefits are unclear.

Working with Kodi collaborators, I have used GPS devices in combination with a variety of ethnographic methods to create visual representations and narrate illustrations of the paths, or "pattern of traces" (Carter 2008, page 228) that we have together made in southwestern Sumba's landscapes, specifically in the homelands of the people who identify ethnically and linguistically as Kodi, Karendi, and Bukambero. As a means of providing a more general portrait of the local space-time culture, the illustrations we created of the patterns of our traces are matched with spatial-temporal language-in-use (where the languages are Kodi, Bukambero, and Indonesian) that were recorded during social interactions within Kodi communities. Employing geospatial tools in tandem with ethnographic analyses enabled me as a fieldworker to map Kodi People's movements through the landscape and to comment on the relationships between daily activities, communication, and space-time culture.

The ways people move through and talk about their territories contribute to constructing perceptual and conceptual links between space and time, which is the reason why information related to movements and expressions are part of this mixed-

methods study. Combining qualitative data (mainly linguistic information and interpretations of narratives) with quantitative data (specifically, GPS maps and the information contained therein) leads to the discernment of patterns constructed through the typical ways people move on foot through their landscapes. The methods described in this article were utilized during fieldwork that I conducted in Kodi in 1997–98, 2007, 2008, 2013, 2014, and 2022 and generated both textual and graphic results; including records of ecological knowledge, oral histories, stories about life experiences, and voicings about needs and desires. Fieldnotes have been compiled and sorted to identify themes and to include a range of diverse positionings internal to the Kodi community. These are records for individual Kodi persons, family groups, clans, and the collective ethnolinguistic group to use as they wish whenever they are ready.

Reckoning While Going

Moving through space by moving one's own body involves "reckoning where one is—one's internal geographical map—navigating and route finding, giving route directions, indicating where to find things one is looking for, tracking locations and travels in a narrative, spatial reasoning, and much more" (Brown 2002, page 170). Walking is a key type of space-time involvement (Middleton 2009) during which Kodi People imprint their lifeways upon the landscape. Similar to what Lye witnessed with the Batek of Malaysia, "…the movement creates the path" (Lye 2003, page 23). Ingold expresses a similar understanding when he writes, "…paths and tracks 'impose a habitual pattern on the movement of people" (Ingold 1993, page 167). As an endeavor that is socially constructed and that also influences the construction of the environment, walking is instrumental for navigating through landscapes as well as sensing, perceiving, and knowing them. Walking is also a setting for negotiating identities of Self and Others relative to landscapes, and communicating about one's experiences within changing landscapes. "If walking creates the path," writes Lye (2003, page 26), "and if walking itself is an act of sociality, then can the path have any meaning without the stories of people using it?" While learning to walk and teaching others about walking, people deploy, make, and reshape space-time involvements.

The construction of space-time culture including the homelands where culture is embedded involves many complex processes, and here in this article I focus on walking as one of these because it is an interesting activity where ethnobiologists can see how spatial and temporal dimensions overlap where people simultaneously take and leave, absorb and embed their individual selves and their collective cultures in their environments. Ethnobiologists can do this by collecting and analyzing information using geospatial tools. Indeed, walking interviews (Botfield et al. 2019; Evans and Jones 2011; Jones et al. 2008) are well-suited to ethnobiological research—having been referred to by ethnobiologists as "plant walks" (Balik and O'Brien 2004;

Martin 1995) and "plant trail interviews" (Zarger and Stepp 2004). Environmental anthropologists (Kearney 2004) and medical anthropologists (King and Woodroffe 2019) have also effectively used walking interviews in their research. Evaluating the ways people cognize and talk about space-time can be facilitated by looking for insights in the realm of people's walking endeavors.

As an ethnographer and ethnobiologist, I have personally spent many hours accompanying Kodi as they walk through their territory, which they mostly do on foot (*witi* in Kodi) and (also increasingly by motorcycles, minivans, and cars when traveling longer distances to gatherings, marketplaces, and towns). During these walks, I observed and listened to my companions and I also recorded our walks using handheld Garmin and GPS tracking tools on mobile devices. GPS tracking—meaning using a GPS device while mapping to collect quantitative data and create illustrations en route, in situ—effectively shows how walks are "subjective, embodied" (Hong 2016, page 46) experiences situated in places and intersectional identities (Crenshaw 1991; Harvey 1993; Valentine 2007). In addition to generating location data for salient places (e.g., settlements, water reservoirs, gardens, historic sites), the GPS mapping yielded information about distances traveled, time expended, rate of travel, topographic gradient, and altitude, which, in turn, generated data related to cultural geography as well as time invested in particular endeavors.

Subsequent to recording the GPS data, GPS waypoints and routes were stitched to aerial and satellite photography. The waypoints marking significant places served to ground truth remotely sensed images. Using ArcGIS and Google Earth Pro, maps were digitally attached to the qualitative information that were gathered during field work in Kodi, including linguistic information, narratives, and audiovisuals. Analyses of the maps and models have led to a better understanding of the significance of space, place, and landscape in Kodi.

Results 1: Sensing First-Person While Walking Through the Landscape

To provide a view of the results produced by mapping using handheld GPS devices, a sample of three walks are described here. In line with the mixed-methods approach, quantitative GIS data are provided in Table 1, while qualitative data in the form of narrative interpretations are provided in this section and the subsequent section of this article. The three walks presented here are typical kinds of outings for Kodi women and girls. By focusing on women and girl's daily lives, feminist qualitative GIS scholars have gained insights into the gendered dimensions of spaces, societies, and economies (Kwan 2002; Pavlovskaya 2002). Indeed, for the three females whose walks are featured here, focusing on aspects of their everyday geospatial routines reveal intersectional (gender, age, ethnic, class, marital status) aspects of their labor in a triad subsistence-exchange-market economy that may not be visibilized by the methods of

Table 1. Data Generated From Real-Time Mapping With GPS Devices.

Map #	Speed	Distance	Elevation change
1	7.32 kmph	0.90 km one-way, 1.80 km round trip	12.08 m
2	4.75 kmph	0.56 km one-way, 1.12 km round trip	4.27 m
3	4.36 kmph	0.27 km one-way, 0.54 km round trip	3.96 m

masculinist researchers. All three walks are related to Kodi's triad agropastoral society in that they involve farming, accessing water, acquiring fire for cooking, and collecting plants. The routine excursions that I mapped together with Kodi women and girls that serve as examples in this paper are: (a) The route Ripka, a young mother, takes from her garden where she grows maize, rice, and other crops and where the nearest source of freshwater is located to her house; (b) the route Nona, a teenage girl, takes from her garden to the edge of a forest patch to gather wild plants; and (c) the route Lati, a little girl, takes from her garden hut to another neighboring hut to ask for a burning stick to use as a fire brand.

Otu la monggo (go to the garden) is a common pattern of trace for Kodi women and girls, a type of trip taken nearly every day. Mothers, grandmothers, and children walk to their gardens nearly every morning and sometimes in the evenings as well. They spend portions of their days planting, weeding, harvesting, and processing their crops while guarding against pests (birds, pigs, monkeys, and locusts) and managing water supplies while their children play. Grain gardens are set up so farmers can take shelter from the rain or sun underneath the roofs of small huts. Open hearths on the huts' floors are used to prepare snacks and meals.

Ripka is a young mother whose daily life fits this routine. The distance from Ripka's house to her garden hut is 0.90 km one-way (Map 1), meaning that she walked 1.80 kilometers round trip nearly every day. This is the distance she covered if she went to and from her garden only once per day, but sometimes she went back and forth more than once per day. At a pace of 7.32 kilometers per hour, it takes Ripka 12–13 min one-way to walk to her garden. Her path rises and falls along the way for a total of 12.80 of elevation change.

In the course of cultivating their crops, Kodi People attend to various other routine tasks that afford them the opportunity to know the environment. An example is when a teenage girl, Nona, went to harvest a handful of betel leaves (*Piper betle* L. Piperaceae) that were growing on vines up trees in the ecotone between fallow fields and a forest patch (Map 2). Her mother and aunts asked Nona to *otu la deke ro uta* (go get betel leaves). Married women chew betel leaves as an ingredient in *hamama* quids that also include areca nuts (*Areca catechu* L. Arecaceae) and powdered limestone. Nona walked 0.56 km one-way or 1.12 km round trip at an average pace of 4.75 kilometers per hour. She climbed 4.27 meters of elevation on her gathering excursion.

Another example is when seven-year-old Lati *otu la deke api* (went to fetch fire) from the hearth of a neighbor's garden hut (Map 3). Lati returned to her garden hut where her grandmother used the burning stick to reignite the fire in their own hearth that had gone cold overnight. The fires in the garden huts are essential for not only cooking but also warming bodies and fumigating insects. Lati walked 0.27 km one-way or 0.54 km round trip with 3.96 meters of elevation change. Close to Nona's speed, Lati walked at an average pace of 4.36 kilometers per hour. That same day, Lati also walked 1.9 km round trip with her mother between their house their garden. Thus, in two walks that day—from her house to her garden and back home, and from her garden to fetch fire and back to her garden—Lati covered 2.44 km. Some days Lati covers longer distances because she walks back and forth to school and other places.

While completing subsistence activities, Kodi women and girls are exposed to the full textures of their surroundings as they move along the particular tracts mapped here. Their total immersion on a day-to-day basis over temporal periods of varying lengths affords them opportunities to observe socioecological changes over time. One lesson generated from this geospatial data is that Kodi sense, perceive, and know their homelands through being fully immersed in the environment as they walk through it. A second lesson is that being immersed in a space over a period of time privileges individuals to understand socioecological change (cf., Pavlovskaya and Martin 2007). Moving at relatively low speeds and with a ground-level vantage point, Kodi are well-positioned to directly interact with many landscape components, including a wide variety of human and more-than-human entities ranging from vine leaves on field-forest ecotones, to tree fruits in agroforests, to domestic animals pastured in fields, wild mammals browsing through the brush, reptiles, amphibians, and insects, as well as soils, rocks, water, the weather, and the ancestors' spirits (Fowler 2003). The inventory of things Kodinese sense and perceive as they move through their homelands expands over time to form a compendium of personal experiences with socioecological change. Combining the information presented in this section of the article and the following section reviewing related qualitative ethnolinguistic data, we see how expressions about and interpretations of spatial and temporal change connected to routes traveled on foot provide insights into conceptualizations of socioecological change.

Results 2: Ethnolinguistic Expressions About Motion and Change

In the Kodi conceptualization of space-time, change over time co-occurs with movement in space (Hoskins 1994). Kodi People know their territory because they spend their lives moving within it. Casual verbal and nonverbal expressions

about moving contain evidence about the roles of movement in constructing conceptualizations of socioecological change. Words, phrases, and concepts related to movement are plentiful in Kodi. A few vivid examples serve the purpose of illustrating Kodi ways of sharing information about their space-time movements.

First, consider two common greetings as examples revealing that concepts of motion through space and time contribute to the cognitive underpinnings of mental maps; though, for sure, many more concepts about time-space progression exist. The two most common greetings exchanged between people who encounter each other when they are walking through their homelands are: "*Gep plu mu* (Where are you going)?" and "*Gep wali mu* (Where are you coming from)?" Women who pass one another as they travel between their homes, water sources, and gardens—such as those in the mapping examples above—regularly ask each other, "*Gep plu mu*?" and "*Gep wali mu*?" The frequency with which these greetings are used reveal a compelling drive to know about fellow community members' space-time movements. In using these greetings, Kodi speakers recognize the other person as moving towards some place and moving away from some place. The centrality of movement in the ways people relate to one another is implied in each of these greetings. As Kodi speakers move their own selves through the landscape, they first seek information about their companions passing through space-time. This happens at the beginning of encounters because it is one of the ways Kodi People share their space-time culture with each other.

Another vivid concept that provides intriguing insights into the Kodi cosmovision is *haloko*. In its variety of uses *haloko* can be a noun or verb, can refer to the present or past, and to the actions or activities of living people or dead relatives. In all of its forms, *haloko* contains information about conceptualizations of humans' location in space-time relative to the natural and spiritual domains, and relative to the Earth and to spaces beyond Earth. It thereby expresses how Kodi envision humans in the cosmos.

In its verb form, *haloko* means to travel around, to go somewhere, or to arrive somewhere. *Haloko* can be used to describe a living person walking through the landscape in the contemporary era. An example of the use of *haloko* in a sentence is when a person is going somewhere alone, an observer might say, "*Haloko kaneheng*" to mean "Come alone" or "Go by yourself." Another example of the word in a phrase is when a person refers to a mode of travel they might say, "*Haloko witi*" or "*Haloko la witi*" meaning "To go by foot." When reduplicated (Ate 2021), *haloko-loko* means to wander around leisurely. The verb means "returning home" when stylized as *hla-loko*.

Haloko may be used to point out changes over time, such as when comparing how historically everyone in Kodi *haloko witi* (walked) to their gardens and to water sources—as was the case with the women in the mapping examples above—and nowadays many young folks *haloko la motoro* (ride motorbikes) when they *otu la mongo* (go to the garden) and *otu la hoke*

waiyo (go to fetch water) for their mothers, aunts, and grandmothers.

When describing an activity during which people are deeply invested in moving through space-time, the speaker elongates the second "o" in *haloko* to emphasize the experience. After being gone all day on a long walking expedition through the coastal plains of the North Kodi subdistrict, Nyila Kali's wife, Kali Wonggo, asked him, "*Gep wali mu* (Where are you coming from)?"

Nyila Kali answered, "*Halooooooooookona*" ("I've returned from a long journey that started here [where we are now], extended far afield, and eventually returned back to here").

As he spoke, Nyila Kali motioned with an outstretched arm, which he used to outline the general shape of his route and to imply how substantive it was. Nyila Kali elaborated by saying that he spoke with many people along the way; he stopped to drink coffee, eat snacks, and have lunch with kin and allies; he passed through several of the tiny hamlets and went by numerous lone garden huts that are dispersed within the savannas and thorn forests covering the coastal plains; at the farthest point on his expedition, he burned the grass growing on the cliffs overlooking the Sumba Strait; as he moved along his route, he occasionally paused just long enough to light the woody shrubs and grasses so they would burn behind him, easing passage for people who journey along these paths after him. "Walkabout" might be an apt translation of the type of movement through space-time described by Nyila Kali in that dialogue. Walkabouts in Kodi, similar to those in Aboriginal Australian communities (Liberman 1999; Strang 2010), are walking expeditions covering many kilometers over the course of an entire day during which people expend much energy. Walkabouts are socially and ecologically productive excursions.

Other speakers use *haloko* in referring to space in similar ways as Nyila Kali's use in the dialogue above, but that refer to a different time: The ancient past rather than the recent past. When suffixed with "ni," *haloko ni* refers to the longer-distance journey of a famous ancestor in the ancient past. "Ni" is a verb affix, and functions as a third person singular object pronoun, also known in this case as a pronominal object clitic (Ate 2021). "Journey" is an apt translation for *haloko ni* here, meaning memorable historic events; most notably the ancient trips of the first settlers who, according to oral histories, were hunter gatherers who disembarked on the island's northern coast at Cape Sasar after an epic ocean journey, and traversed the island until settling in their new territory of Kodi. *Haloko ni* also refers to the journey into the afterlife, the one people take when they die and will not return to the world of the living.

Walking along, a long walking expedition, a walkabout, the historic event, death, and the afterlife all illustrate the "irreversible" quality of *halokona ni* (Hoskins 1994). The concept describes the completion of an action or activity where people brought about change in space-time. When people use the concept, they express their ideas about not only the structure

of the Kodi cosmovision but also the mechanism through which it functions. *Halokona ni, haloko ni, hla-loko, haloko-loko*, and *haloko* refer to change through a particular kind of movement through space-time. The kind of changes *haloko* refers to require human energy and are a type of human action or activity. Moreover, the ways people change as they perform these actions or activities occur in relation to multiple species, relative to specific places, during particular temporal intervals. As people *haloko*, space and time pass. People cause this passing and these changes in space-time. By pointing to humans as causal agents, Kodi recognize the agency of humans who are still alive as well as the ancestors who are no longer alive.

In the Kodi cosmovision living humans as well as the souls of the dead live within the Earthly realm. The ancestors' souls are Earth-bound because they inhabit rocks, caves, water reservoirs, pythons, crocodiles, rice, maize, lightning, thunder, rain, and other natural vessels. The exceptions are the souls of people who died young or whose deaths were due to accidents or violence. Their souls flee to the Sun and Moon until priests in Kodi's Marapu religion call them back to the Earth. The spirits of the ancestors too move within the Kodi territory: the ancient fathers are in the rivers (*Bapa Mangu Loko*, Father Who Owns the Rivers) and the ancient mothers are with the land (*Inya Mangu Tana*, Mother Who Owns the Lands). This brief reference to Marapu serves to illustrate that Kodi People think about transformations in their surroundings in terms of the activities of members of their social group and their environment. Kodi People express their cosmovision in concepts about motion by living people, the spirits of the dead, and more-than-human entities through socionatural and mythological landscapes. Words to reference walking, walkabouting, journeying, coming, and going are heuristic tools for gaining insight into Kodi space-time culture. These words refer to actions and activities that involve people moving through landscapes, changing them as they go and as time passes.

Discussion: Mixed Methods Yields Results and Leads to Further Inquiries

Data generated by real-time mapping with GPS devices provide information that could potentially inform a myriad of research problems. The data could show, for example, where water reservoirs are located and the distances traveled to access water. Maps could make visible the location of houses and villages relative to one another, showing the distribution of members of subclans and clans as well as the outline of their territories. The quantitative data attached to maps could reveal the placement of gardens, orchards, and fields relative to dwellings, water sources, forests, and other features. Data could be used to assess energy expenditure, to document tenure, and to show settlement patterns. Data could capture changes through time as well. For instance, mapping on multiple occasions over time could show seasonal variations in pasturing livestock or collecting water. Differences throughout a person's life history may become apparent as well

such as those due to shifts from unmarried to married, from being childless to having children, from menstruating to postmenopausal, or other status changes.

Having created maps using GPS devices, new research questions may appear to researchers and their interlocutors. Questions related to geographical boundaries around settlements and group territories may emerge. Vegetative patterns may become visible when the landscape is viewed from the satellite perspective. For example, gallery forests along river banks, green buffer zones around settlements, burned versus unburned areas, forest fragmentation, or afforestation may come into view. Questions may be generated from "seeing" these patterns about, for example, landscape management practices, fire regimes, protective mechanisms, and ecosystem types and their meanings.

The GPS maps generated by handheld devices can become props for novel data collection techniques. The maps in their digital format or as color prints can be used as prompts in interviews with individuals or small groups (Aw et al. 2021). The maps created by the GPS devices are layered with satellite imagery and can be viewed at a range of resolutions. Having conversations about the maps and the satellite imagery they are layered upon is an effective technique for gathering local knowledge of land use and land cover as well as changes in them over time and across space. Local knowledge gathered in this way has the ability to enhance geodata by serving as a means for ground truthing satellite imagery. Ground truthing may be added to a project's agenda when questions emerge from studying the maps, such as whether the forests are anthropogenic or nonanthropogenic. Combining ethnographic information about an Indigenous community's perceptions of space could advance social theory by presenting alternative ways of interpreting satellite imagery and lifting up Indigenous space-time cultures.

Spatial modeling using GPS handheld devices produce insights from the ground in the form of geographic data on actual routes traversed. Therefore, using handheld GPS devices improves ethnobiological methods for understanding the ways people perceive and interact with changing landscapes. Combining the GPS data with longitudinal ethnolinguistic data leads to better understandings of people's use of space over time and conceptualizations of space and time (Jones and Evans 2012). In addition to learning more about how people acquire and express experiences with planetary change, we also have assessments of distances, elevation, and pace of travel as well as illustrations of routes and portraits of environments traversed. Using these mixed methods, ethnobiologists can apply analyses of the combination of quantitative and qualitative data to describing and interpreting the ways people move within and communicate about their space-time involvements.

Conclusion: Culture's Interventions in Planetary Change

In the Kodi case, using real-time GPS mapping in combination with ethnolinguistic interviewing shows how Kodinese absorb

information and discern spatial and temporal changes in their landscape using epistemologies (i.e., ways of knowing) and interpretations of knowledge accumulated typical to their social collective. Space-time culture is embedded in the social collective and conditions which technologies mediate individuals' observations and how as well as interpretations of change; because of this, Kodi have been conditioned to notice change in situ through a lifetime of being fully, sensorially immersed via their experiences moving on-foot within their homelands. Through specific forms of movement and modes of circulating symbols, Kodi individuals play major roles in constructing their own homelands. The data from Kodi shows individuals see the various spaces in their territory and observe changes in those places in routes whose designs are driven by the social contexts shaping their lives as farmers, pastoralists, hunters, gatherers, and fishers, connected through extended human and more-than-human relatives (cf., Fowler 2016).

The members of the Kodi social collective have shared experiences of moving through space-time, and thus also have shared perceptions of change in spaces over time. However, variations occur within the collective because individual's worldmaking practices as well as the spatial and temporal resolutions of their viewings of the world are shaped by many external and internal factors, including seasonality, weather and climate, the ritual calendar, market activities, health events, and relationship dynamics. In addition, gender, age, class, marital station, health status, and the positionality and geolocations of kin and allies among other factors lead to variations in the spaces individuals visit and their activities in those spaces. By looking at the ways that Kodinese express themselves in moving through their world, we have seen how they construct patterns of trace by walking through their homelands and also how they understand change in the course of complex interactions between moving and conceptualizing space-time conditioned by socioecological contexts. In Kodi, change over time co-occurs with movement in space (Hoskins 1994). Cultural values related to space-time motion are expressed in words and phrases. Great weight is given to tracking changes in people's space-time movements, in alignment with Brown's explanation of how people construct culture through "shifts back and forth between individual mind and collective representations, between universals and particulars" (Brown 2002, page 169).

Individual Kodi materialize their learned space-time orientations when they engage directly in social activities, including those that involve practical, everyday things. Whereas their orientations are dynamic and hybridizing, Kodinese involvements with space and time are mostly territorial. They produce this territoriality through a dynamic interplay between their social relationships, "sensory engagement[s]," and "bodily movement[s]" (Ashmore 2015, page 294) in combination with their symbolic life as evident in spoken words. Meanwhile, they are continuously reshaping land cover and inscribing particular patterns of traces on their landscapes. In sum, these symbolic, cognitive, and biophysical traces they make through their territory are drawn in their interactions with their nonhuman companions and the ecosystems within which they live as they move through their homelands and communicate about their experiences.

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