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Yellowknives Dene and Gwich'in Stellar Wayfinding in Large-Scale Subarctic Landscapes

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ABSTRACT. Indigenous systems of stellar wayfinding are rarely described or robustly attested outside of maritime contexts, with few examples reported among peoples of the high Arctic and some desert regions. However, like other large-scale environments that exhibit a low legibility of landmarks, the barrenlands of the Northwest Territories and the Yukon Flats of Alaska generally lack views of prominent or distinguishing topography for using classic route-based navigation. When travelling off trails and waterways in these respective inland subarctic environments, the Yellowknives Dene and the Alaskan Gwich'in utilize drastically different stellar wayfinding approaches from one another while essentially sharing the same view of the sky. However, in both systems the use of celestial schemata is suspended in favor of route-based navigation when the traveller intersects a familiar geographical feature or trail near their target destination, suggesting strong preference for orienting by landmarks when available. A comparison of both wayfinding systems suggests that large-scale environments that lack a readily discernible ground pattern may be more conducive to the development and implementation of a celestial wayfinding schema when combined with other influential factors such as culture, individual experience, and travel behavior. These are likely the first stellar wayfinding systems described in detail for any inland subarctic culture.

Key words: stellar wayfinding; Indigenous navigation; Yellowknives Dene; Gwich'in; landscape legibility; Northern Dene astronomy; Yukon Flats; barrenlands; dead reckoning; Big Dipper

RÉSUMÉ. Les systèmes autochtones de repérage grâce aux étoiles sont rarement décrits ou font rarement l'objet d'une attestation valable en dehors des contextes maritimes. Il existe quelques exemples de ces systèmes chez les peuples de l'Extrême-Arctique et certains autres exemples émanant des régions désertiques. Cependant, à l'instar d'autres environnements spacieux où la lisibilité des points de repère est faible, les landes des Territoires du Nord-Ouest et les Yukon Flats de l'Alaska sont généralement dépourvus d'éléments topographiques proéminents ou particuliers permettant d'utiliser la navigation classique par routes. Dans ces environnements subarctiques intérieurs respectifs, quand les Dénés Yellowknives et les Gwich'in de l'Alaska se déplacent en dehors des sentiers et des voies navigables, ils emploient des méthodes de repérage grâce aux étoiles radicalement différentes l'une de l'autre même s'ils ont essentiellement la même vue du ciel. Toutefois, dans les deux systèmes, l'utilisation de schémas conceptuels célestes est laissée pour compte en faveur de la navigation par routes quand le voyageur croise un élément géographique ou un sentier familier à proximité de sa destination cible, ce qui laisse entrevoir une forte préférence pour l'orientation à l'aide de points de repère lorsque ceux-ci existent. La comparaison des deux systèmes de repérage suggère que les environnements spacieux dépourvus de configurations terrestres facilement perceptibles pourraient être plus propices à l'élaboration et à la mise en œuvre d'un schéma de repérage céleste lorsque jumelés à d'autres facteurs d'influence, comme la culture, l'expérience individuelle et le comportement de déplacement. Il s'agit probablement des premiers systèmes de repérage grâce aux étoiles à être décrits en détail pour n'importe quelle culture subarctique intérieure.

Mots clés : repérage grâce aux étoiles; navigation autochtone; Dénés Yellowknives; Gwich'in; lisibilité du paysage; astronomie des Dénés du Nord; Yukon Flats; landes; navigation à l'estime; Grande Casserole

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INTRODUCTION

To the best of our knowledge, a stellar wayfinding system has never been robustly attested or described in Northern Dene studies or in the literature pertaining to any other inland subarctic culture. In contrast to studies conducted in psychology and geography, cultural anthropology has made limited contributions to research on human wayfinding in large-scale environments (Levinson, 2003). In a review of anthropological theories on human spatial orientation, Istomin and Dwyer (2009:41) call for additional ethnographic examples of "how different peoples perceive their environment and navigate around it." Given the relative dependence of wayfinding systems on sociocultural factors (Golledge, 2003) it is surprising that more ethnologists have not engaged in delimiting the range of strategies and methods employed in finding one's way across a landscape. On this matter Levinson (2003:217) states:

> Still, I think it must be conceded that in many ways we know much less about navigation in our own species than amongst birds, bees, and ants. Apart from the efforts of the geographers, there are simply relatively few examples of how humans actually find their way around real novel environments, or calculate angle and distance and current location in moving around on a scale larger than the psychological laboratory. One might have expected anthropologists to have had a keen interest in wayfinding amongst, especially, hunter-gatherer groups. But, on the whole, the information available is extremely disappointing.

When narrowing the literature to studies concerning Indigenous stellar wayfinding systems, the research is nearly exclusive to maritime contexts, particularly among societies in Oceania (e.g., Makemson, 1938, 1941; Goodenough, 1953; Best, 1954, 1955; Åkerblom, 1968; Gladwin, 1970; Lewis, 1972, 1978; Riesenberg, 1972; Kursh and Kreps, 1974; Johnson and Mahelona, 1975; Finney, 1998; Moyle, 2003; Osmond, 2007), but with some detailed coverage of those systems utilized by peoples of the high Arctic (Lewis and George, 1991; MacDonald, 1998; Bradley, 2002). In reference to external aides that assist spatial cognition in wayfinding, Golledge (2003:26) states: "While hard-copy or digital cartographic maps are the supplement of choice, in earlier times travellers used knowledge of star patterns, sun angles, wind or wave direction, terrain visualizations, or other environmental features as those supplements." He continues: "There has been much speculation on whether these former abilities are still extent in humans despite radical changes in information technology."

We describe two Northern Dene stellar wayfinding systems utilized in two different subarctic environments, the barrenlands (Taiga Shield High Subarctic) of the Northwest Territories for the Yellowknives Dene and the boreal forest of the Yukon Flats (Continental Subarctic) in interior Alaska for the Gwich'in. In both cases the landscape, culture, and individual experience and travel behavior factor into the development and efficacy of these wayfinding systems.

The Yellowknives Dene system described below is based on the lead author's conversations and outdoor observations of the night sky with Fred Sangris of Ndılǫ, Northwest Territories, whereas the description of the Alaskan Gwich'in systems is based on his conversations and travels with Paul Herbert of Fort Yukon. Both mentors actively use their Indigenous knowledge of the stars for reckoning time and direction in particular contexts and scenarios. Fred uses stellar wayfinding to reach a hunting area in the barrenlands any time after there is sufficient snowfall for travel and before early spring. Paul uses stars for orientation from about September through March when stars are visible in interior Alaska, and only if he loses his bearing and no recognizable landmarks or distinguishing topography are in view.

Although the wayfinding systems described in this paper are significantly different from one another, both utilize dead reckoning in conjunction with a celestial schema when travellling off established trails and waterways in large monotonous landscapes that lack views of prominent landmarks and distinguishing geography. Dead reckoning, also called path integration, is "the ability of an agent to update the distance and direction travelled from a starting point," which "requires storing either a minimal homing vector or a more complete record of the path traversed" (Foo et al., 2005:195). In these contexts, we use the term "schema" to refer to an external representation that "compensate[s] for the lack of [landscape] information beyond the immediate perceptual domain" (Golledge, 2003:29). However, use of these celestial schemata are suspended in favor of route-based navigation when the traveller intersects a familiar geographical feature or trail near the final destination, suggesting preference for the latter wayfinding strategy when available. Route-based navigation relies on "remembering specific sequences of positions, which may be defined as sequences of landmarks, junctions, vistas, homing vectors, turns, and so on" (Foo et al., 2005:195).

Like oceans, the Arctic plain, and some deserts, the barrenlands and Yukon Flats are monotonous landscapes that have a low legibility of landmarks (Lynch, 1960). In the geographical sciences, landscape legibility refers to "the degree of distinctiveness that enables viewers to comprehend their surroundings" and examine them for "coherent structure" (Golledge, 2003:34). Although difficult to measure, highly legible landscapes are those that have a recognizable pattern composed of distinguishing landmarks and topographical relief, whereas flat, heavily vegetated, or otherwise monotonous landscapes tend to exhibit low legibility and are more difficult to navigate and memorize (Kelly, 2003). Monotonous landscapes may either contain too many features, such as thousands of lakes

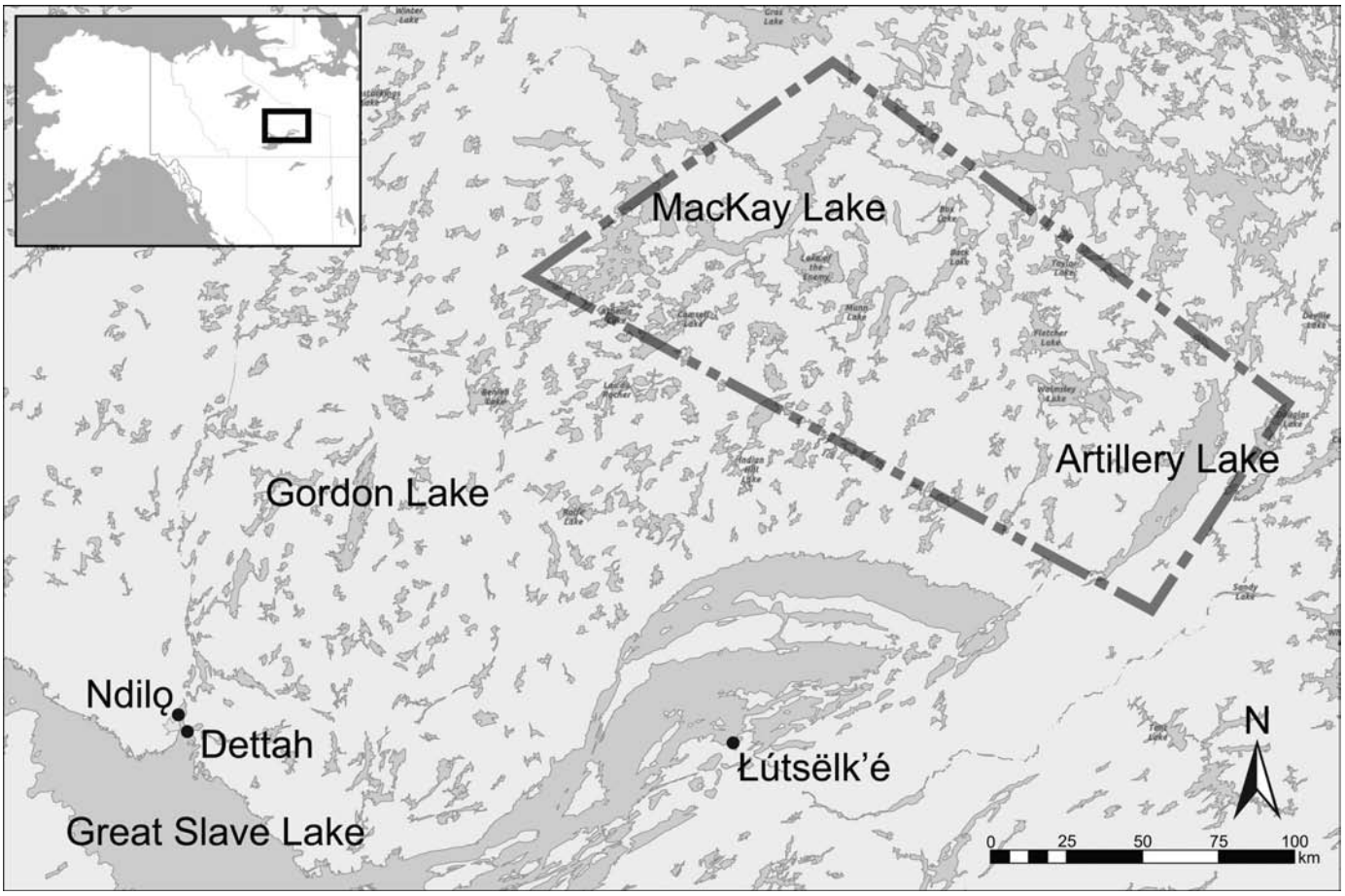

FIG. 1. The area (dashed polygon) between MacKay Lake and Artillery Lake in the Northwest Territories where Fred Sangris describes using traditional stellar wayfinding methods after travelling from Ndılǫ via a route that passes Gordon Lake.

or an extensive region of similarly sized hills or summits, or they may be characterized by a perceived lack of features, such as the open ocean or a vast snow-covered plain (cf. Kelly, 2003). Different weather and light conditions may, of course, also change the perceived legibility of any given landscape.

Aside from the physical aspects of a landscape and their spatial relationships, landscape legibility is also dependent on personal experience, travel behavior, and sociocultural constructions, such as mnemonic devices or significant and sacred places which may impart greater significance to a landscape for different people and peoples (Golledge, 2003). For these reasons, landscape legibility is dependent on: 1) physical landscape characteristics and their spatial relationships, 2) sociocultural factors, and 3) individual travel behavior and experiences (Golledge, 2003). Each of these factors are considered in the following case studies and may have relevance to the development, selection, or implementation of a celestial schema for wayfinding in some parts of the Northern Dene region and not in others. In addition, these examples integrate with time-reckoning methods and concepts to demonstrate how the sun and stars are utilized as both a clock and compass.

YELLOWKNIVES DENE STELLAR WAYFINDING

The traditional estate of the Yellowknives Dene extends from Great Slave Lake, north to the Coppermine River and east to the vicinity of the Thelon River. However, journeys as far north and east as the Coronation Gulf and Hudson Bay respectively were not uncommon in earlier times (Weledeh Yellowknives Dene, 1997). The entirety of this estate is broadly classified as the Taiga Shield ecozone and contains approximately 200,000 lakes (Ecosystem Classification Group, 2008). Waters in the Taiga Shield feed into Great Slave Lake and Great Bear Lake, eventually reaching the Arctic Ocean via the Mackenzie River, or else they drain to Hudson Bay via the Thelon and Dubawnt River systems. Permafrost is discontinuous to continuous and vegetation ranges from slow-growing mixed-wood forests to lichen-dominated tundra (Ecosystem Classification Group, 2008).

The specific area relevant to this study is the region between Gordon Lake, MacKay Lake, Artillery Lake, and Ndılǫ and Dettah, which are the two principal Yellowknives Dene communities located on the north arm of Great Slave Lake (Fig. 1). This area is approximately bounded between 62˚25′ and 64˚18′ N and 114˚21′ and 107˚33′ W.

The region around Artillery Lake or *ʔehdaàcho tì* (big point lake) has cultural and subsistence value of great importance to the Yellowknives Dene and the Dëne Sųlıné of Łútsëlk'é and contains the landscape type known colloquially as the barrenlands or *hoezìı* (the area which is smooth), otherwise classified as the Taiga Shield High Subarctic. The topography of this ecozone consists of a "complex of glacial till and Precambrian bedrock outcrops" that is quite rugged in places (Ecosystem Classification Group, 2008:25). Lakes cover nearly one -quarter of the total land area and elevations range between approximately 200–500 m, although local variations rarely exceed 100 m. The landscape is largely treeless. Frost is common in all months except July and August with mean annual temperatures between –4˚C and –9˚C (Ecosystem Classification Group, 2008). January is the coldest month with a mean temperature that ranges from –27˚C to –30˚C, whereas July is the warmest month with a mean temperature between 13˚C and 16˚C. Mean annual precipitation ranges from 27 to 39 cm (Ecosystem Classification Group, 2008).

The barrenlands around Artillery Lake are a valued muskoxen and caribou hunting territory (Weledeh Yellowknives Dene, 1997) and contain numerous sacred places tied to ancient events and the transformation of the world. In traditional times, trips made from treeline to basecamp destinations in the barrenlands were conducted at night by setting a bearing to a sequence of low altitude stars rising from the eastern horizon. During the generation of Fred Sangris's grandfather, *Hotethk'aáldhër* (portage boss, born in 1890), the hunters broke trail on snowshoes, travellling with their dog teams at night while the women and children followed behind on the packed trail in the morning with the remainder of the family's possessions. Fred explained:

> My grandfather, they used to travel from Lac de Gras going to the [caribou] calving grounds. In order for them to travel that kind of distance they would have to travel at night. All night they will break trail and continue following certain stars to another star, to another star, to get to an area where they want to go. Once they arrive there, daylight will come around. And then the women and children who were left behind, miles behind, by morning they would be packing up and would be following the same snowshoe trail in the daytime to where the harvesters were.

Family groups maintained this travel itinerary until reaching a basecamp destination where they resumed a daytime schedule.

Today, Fred Sangris is among few Yellowknives Dene who still occasionally use a traditional stellar wayfinding system. To reach the barrenlands to hunt caribou, Fred travels approximately northeast to Gordon Lake and then continues to MacKay Lake where he takes a southeast bearing to the vicinity of Artillery Lake. Fred begins a typical trip right from his home in Yellowknife Bay in Ndılǫ and then travels approximately 90 km to Gordon Lake. This segment of the journey is made during the day or night and follows a series of established trails through open canopy forest punctuated by numerous lakes and hills of mantled bedrock. However, a portion of these trails now overlap with the winter road that connects the Ingraham Trail road east of Yellowknife to the Diavik and Ekati Diamond mines at Lac de Gras north of MacKay Lake. If a night schedule is selected for this leg of the journey, then Fred departs around dusk. For a daytime trip, Fred departs just before dawn, usually reaching Gordon Lake by late evening of the same day.

Fred observes Arcturus (α Boo), known as *Wezhìı Nàgede* (they go inside), as a traditional time-referent used to determine his departure times near dawn or *k'òmba*. The Big Dipper points directly to this star as it rises from the east-northeast horizon at morning twilight from about mid-October to early December. Regarding the use of this star Fred said:

> You got to get the early start in the morning. By the time *k'òmba* comes around you should be gone on the trail. So, it was one of those teachings that they say that you have to be up and there's no time to waste to sleep in and take your time. You only have so many hours during the day to do so much things… Another thing, I drink lots of tea because I have a hard time waking up. So, when I drink tea, about four in the morning I'm getting up. I go to the washroom. So, when I go out, I could see the stars. I look at the stars if the sky is clear. It'll tell me that it's still in the evening. It's still not quite morning. So that's when I go back to sleep and then later on I will get up again and look at the star. When I see that big finger [Big Dipper] there's a star that should be coming up [Arcturus]. And if I see that star, then I'm one hour away from daylight. That's the time I get up. So, it's right after that [star], *k'òmba* comes up. So that's the big star [Arcturus]. When it comes up, I got an hour to prepare my food, get my gear ready, get my sled dogs ready, ready to travel. So, by the time I start travellling on the lake [Great Slave Lake] it's still little bit dark, but I get a head start and I move ahead… If we leave here right after *k'òmba* then we get there [Gordon Lake] at night.

This segment of the journey utilizes classic route-based navigation and may be conducted any time after there is sufficient snow for travel, from late autumn to the end of winter.

After sleeping and resting at Gordon Lake, Fred continues northeast to MacKay Lake. At this point Fred transitions to a nighttime travel itinerary and begins using a celestial schema to maintain his southeast bearing across the Taiga Shield to the barrenlands near Artillery Lake, approximately 175 km away as the crow flies. Before departing MacKay Lake, Fred obtains an approximate southeast bearing by placing two sticks vertically in the snow about 12 m apart aligned to the rising sun. After

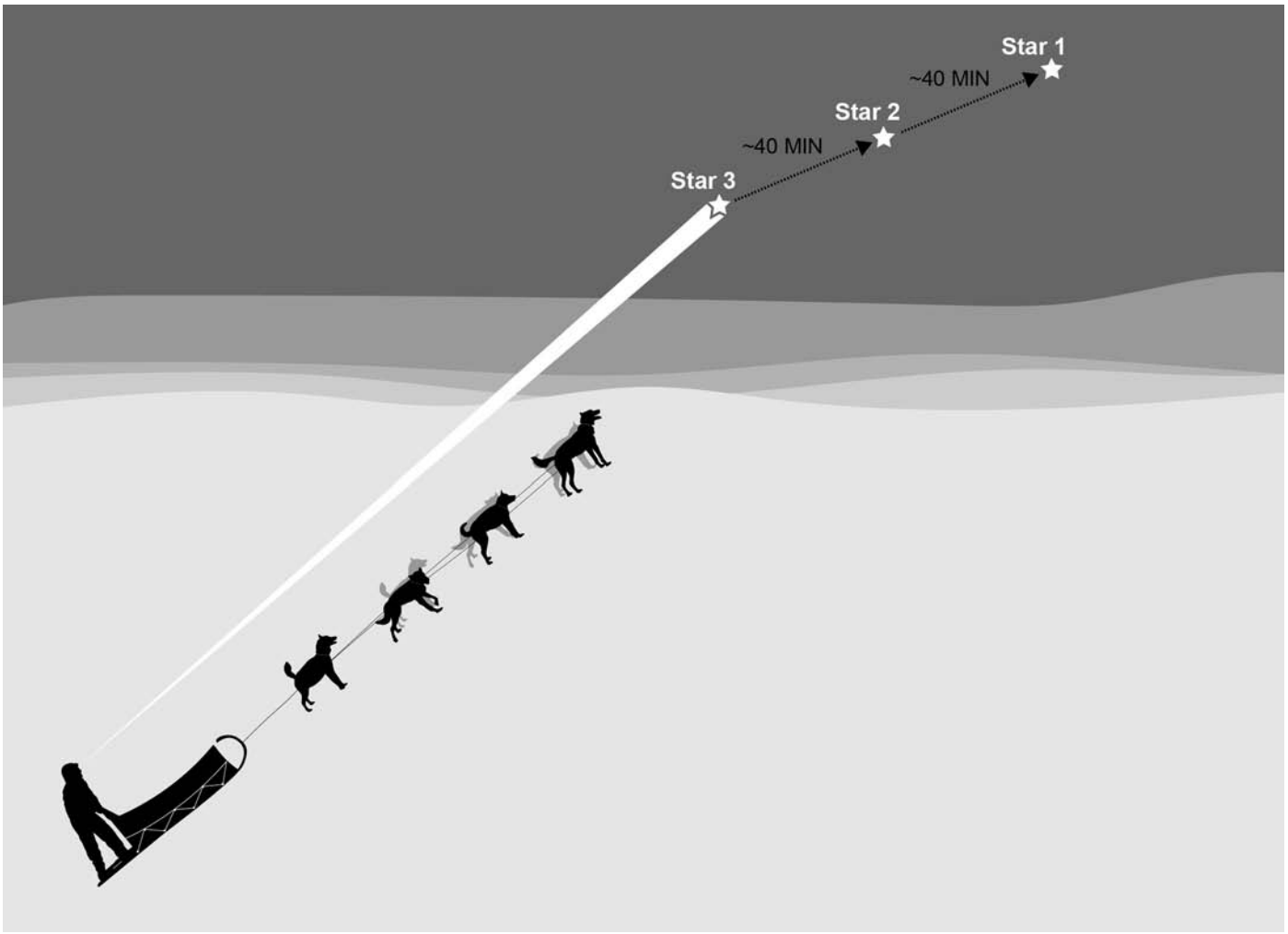

FIG. 2. Yellowknives Dene method of picking up and tracking a new star at about 40-minute intervals as each rises from the southeastern horizon in the barrenlands of the Northwest Territories.

marking this southeast-northwest axis at dawn, Fred goes to sleep until late afternoon when he wakes up to begin packing up his camp in preparation for nighttime travel (cf. Pike, 1892).

When the first stars begin to appear just after dusk, Fred waits with his dog team or skidoo until any conspicuous star rising near the southeastern horizon aligns with his southeast-northwest oriented sticks. After an alignment is made, Fred pulls his sticks and sets out following the target star. Because stars appear to rotate through the sky at 15˚ per hour, a new star must be picked up near the original place of the proceeding star at about 40-minute intervals. This homing process also involves tracking somewhat behind or to the left of the target star, which appears to move across the sky from east to west, rising at an oblique angle to the horizon. Fred described this process (Fig. 2):

> In front of my teepee on the barrenlands I have two poles. Maybe one form here to the next house, which is about 40 feet. I have one pole here and then I watch the sun, where the sun come up. I put another pole there. And that way during the day I always know where the east is… So, in the barrenlands it's dangerous kind of to travel during the daytime, especially if it's whiteout. You have no idea where you're at. But if the stars come out and the sky is clear and you're travelling, that's the safest. For me that's the safest way to travel because I've done it many times. And then I watch the east sun, or the star from the east [i.e., southeast]. I would pick that. I would pick that star. There's lots of stars. Remember, lots of stars in the sky, eh. But I pick the unusual star and I keep my eye on that star. And I keep travelling, travelling a great distance. And then it comes right up like that. Just like that. Just like that, and then I would find another star over here not too far from that and I would pick on that one. I'll pick on that one for a little while. I'll keep going, eh. After a while I'll stop and [then] I'll pick another one here [to the left of the previous star]. And that's how I get from one end to the other end.

Fred repeats this process (following a new star at approximately 40-minute intervals) until the Pleaides known as *Łą Wedzà* (they sit together) or *Wetseè Dzà* (its

tail measure) has ascended to a very generalized high position in the sky indicating that it is late at night and time to rest the dogs again. Fred said:

> Late in the evening there will be some star coming up too. If you look towards the east, you will see a star [Pleiades] that will come up that will look like a high noon. And that star will tell you that it's about 11 o'clock to about 12 o'clock at night. So, when you look at the star over to the east, that star will tell you that it's late at night. Time to rest the dogs and time to go to sleep. And if you don't pay attention to the stars you may travel all night and your dogs will get worn out. You'll have no idea what time it is, and you'll really lose track of time. So, if you pay attention, you'll keep track of the skies as you travel, and you always know where you are and the distance you need to go.
>
> So, for me when I travel late at night with sled dogs in the past, I can see that big star [Pleaides] going up pretty high; high noon, like. To me it's 11 o'clock at night. And that's when I usually set up my camp for the night and I go to bed. So, probably around four in the morning … but if I keep going and the star's way over here [towards the south or southwest] then I know I'm beyond the time; going late at night, which is not good. So that's the one we watch.

After Fred makes his way across the barrenlands by repeating the procedures described above for two or three days, he transitions to a route-based approach when intersecting a trail or other familiar geographical feature near his final destination. In this respect, a trail or large familiar geographical feature, such as Artillery Lake, has efficacy in expanding the size of Fred's target destination, just as a Polynesian navigator at sea might expand the target size of small distant island or atoll by looking for distinctive V-shaped land clouds or certain species of birds (Lewis, 1971). Because trails and certain lakes are relatively large targets, it does not matter so much where they are intersected, so long as the traveller reaches them at some point. After arriving at the general target (e.g., trail or lake), the traveller recognizes the familiar landscape and knows which course to travel to reach a more specific destination, such as a particular bay or esker near Artillery Lake. After Fred has reached his destination in the barrenlands, he adjusts back to a daytime itinerary to hunt and carry on life in the bush as normal from a basecamp location.

To return to Ndılǫ from the barrenlands, Fred again reverts to a nighttime itinerary and repeats the process followed during the outbound leg, but in the opposite direction following target stars that are setting on the northwest horizon. Again, when intersecting a familiar landmark, such as the ice road or MacKay Lake, Fred will turn southwest and switch to a route-based wayfinding approach to continue towards Gordon Lake and beyond to Ndılǫ following established trails.

Although a celestial schema offers great utility for traversing the barrenlands when covered in snow, Fred emphasizes the importance of always paying attention to landscape features in case of inclement weather. Fred stresses that when the weather is cloudy, memorization of the landscape must be used to "bring you back." In addition, landscape features are sometimes used in conjunction with the star-based method. For example, if a distant hill is aligned beneath a target star, the traveller may choose to fix on the hill instead of the moving star. As the traveller approaches the hill, he will look for a new low-altitude star approximately aligned with his bearing to the hill and then continue by following that star.

Another strategy used by travellers is to mark well-travelled routes with stone cairns, or piles of rocks called *kwe daı̨la* (rocks were piled up). Apparently, certain paths, such as portions of a route from Łútsëlk'é to the Thelon River, are already marked with stone cairns aligned to an east-west course set by following stars. These cairns also have utility when travelling in summer between portages when no stars are visible. Fred explained that travellers sometimes carry several boulders with them in their dogsleds or skidoos to place after the last pile of stones, thereby gradually extending the marked portion of the route during the winter. In this respect, Fred stated:

> The markers were placed long before, following the stars. Long before me. They're out there yet, and some of the hunters still use them to this day. We go from Łútsëlk'é to Thelon. There are markers along the Thelon already; rocks… If I'm travelling, we'll say the three of us are travelling, we just left the fresh ground, with unmarked ground, eh. Nothing there, and we know where the sun comes out. So, we'll keep going to that direction and as we move, we'll put boulders out. So, we'll keep going to that direction and as we move, we'll put boulders up, boulders up, boulder up. Boulder up like that [i.e., building rock piles]. So, pretty soon you don't have to pay attention to the stars. You just watch the boulders, the rocks. It's been placed already… And if you go to another new ground, you know, unmarked; well, then that's when you got to be careful. You got to know your way around.

Another route-marking strategy used by Dene peoples throughout the Northwest Territories is to mark a winter route with a series of sticks placed in the snow at an angle pointed towards the home destination. In this way, the traveller knows which way to return even in a whiteout. This method is not only used in the barrenlands by the Yellowknives Dene, but also by the Sahtúot'ı̨nę when traversing Great Bear Lake. If caught in overcast weather, travellers will often estimate their bearing against the direction of sastrugi or wind-crusted snow called *tsı̨łkëné* (snow road) or *tàhtsıì* (snowdrift) until they are able to camp and wait for better travel conditions. Because the windblown drifts orient in the same direction, travellers

can maintain their approximate bearing by feeling how their skidoo or dog team rides with or across the drifted snow. With respect to orienting by the wind and snowdrifts, a Dëne Sųłiné speaker from Łútsëlk'é explained:

> Yeah, those snowdrifts were indicators, I guess, for travelling across long distance on the lake, especially in the whiteouts when there's just heavy snow falling. So, you can't see nothing. There's no other land you can see or landmarks. So basically, you'll just look at the snow, what direction they're going. And if the snowdrifts are facing one direction, they'll try to keep their skidoo or their dog team in that direction to where their destination is, I guess. So that was an indicator for people to travel a long distance on the lake without any [other] indicators and stuff like that … when you go out, when you're off you could tell. And the same with the wind too. The wind, that's basically on skidoo; the wind direction. Because on a skidoo you can't feel these *tsı̨łkëné* sometime because you're going so fast. But you can feel the wind on one side of your face. And all of a sudden the wind's in your face. That tells you you're in the wrong direction.

In addition, Fred noted that he and other travellers formerly marked the shadow of a stick with a rock or chunk of ice to estimate the passage of time. However, Fred also emphasized that barrenland travellers all have their own slightly different techniques for finding their way and estimating time.

Finally, it is worth noting that until at least several decades ago, Yellowknives Dene trappers commonly spent the duration of the trapping season in the barrenlands before returning home in the early spring. Fred explained that the distinctive "dancing" appearance of the sun caused by refracted light in March or April is a telltale sign to return from the barrenlands before spring breakup. This was an important temporal marker given that the spring thaw in the tundra lags breakup in Ndılǫ at Great Slave Lake. Fred explained:

> March is the long sun. And then right after the long sun is *sa datłǫ* [sun is dancing]. The sun started to dance in April, eh. You can't look at it, it's too bright; *sa datłǫ*. Then you know you have to leave the barrenlands before *sa datłǫ*. Because if you don't leave the barrenlands [by] *sa datłǫ*, about 50, 60 miles out there'll be no snow. You'll be coming back from the tundra, you'll be going through water. There'll be ducks swimming around. Yeah, then you'll be in trouble. So, you get back by the time the long sun and before the dancing sun; *sa datłǫ*.

Fred's collective wayfinding knowledge was not only honed by years of personal experience, but it was also passed on to him by his grandfather and father who confiscated his wristwatch and paper calendar when he was a teenager to stress the importance of learning to read the land and sky. With respect to learning to tell time by the moon, sun, and stars, Fred explained:

> In 1976 I was 18 years old. I went to the Arctic tundra in the treeline around MacKay Lake. And my father helped me with sled dogs for the first load; setting up my camp. And he noticed I had this big watch. Big military watch that I just bought that summer and also with the cardboard. I made a calendar with a pencil and cardboard. And he said, "Give me your watch." He said, "You don't need a watch. Where you are right here, you don't need a watch. Your watch tells you when to sleep and when to get up, but you should really pay attention to your surroundings, listen to your body, listen to your surroundings, and look at the stars at night. And every time a moon goes by, a full moon, keep track of it. And every time the sun goes down, the stars will come up. And try getting up early in the morning and you'll see. You'll see a big star called, we call it the finger [Big Dipper]," he said. "At the tip of the finger there'll be another big bright star [Arcturus as the Morning Star—referring here to Altair not Venus] that will come up, maybe about one hour before the daylight. That star is the important star. And if you pay attention to it that star will tell you that it's in the morning time."

Finally, Fred commented on the status of Yellowknives Dene stellar wayfinding and time-reckoning knowledge and practices:

> Today there are still hunters with the community who still use the stars. My family, brother and sister, we still travel at night here. Within the next week or two we'll be travelling up north of here and I think we'll be travelling at night. So, that's how we get to our hunting ground… So, stars are very important to our life. It not only tells us how to navigate, but it also tells us how to tell time. Time is very important, and in olden days we didn't have watch. We had to navigate. We didn't have Tim Hortons and all the good stuff, but we had to look into the sky. As my grandfather said, "It's all written in the skies."

GWICH'IN STELLAR WAYFINDING

The Gwichyaa Gwich'in (residents of a broad area) and Draanjik Gwich'in (platform cache river residents) estates that compose much of the Yukon Flats district of Alaska is a vast floodplain of the Yukon River and its tributaries covering roughly 35,500 km^2 (Williams, 1962). The region is approximately bounded between 65˚45′ and 67˚30′ N and 142˚30′ and 150˚00′ W (Williams, 1962). The topography is markedly flat with few low-lying hills and thousands of shallow lakes, sloughs, and streams. The braided Yukon River meanders through the Flats, dropping just 61 m over a distance of roughly 435 km as the river flows (U.S. Fish

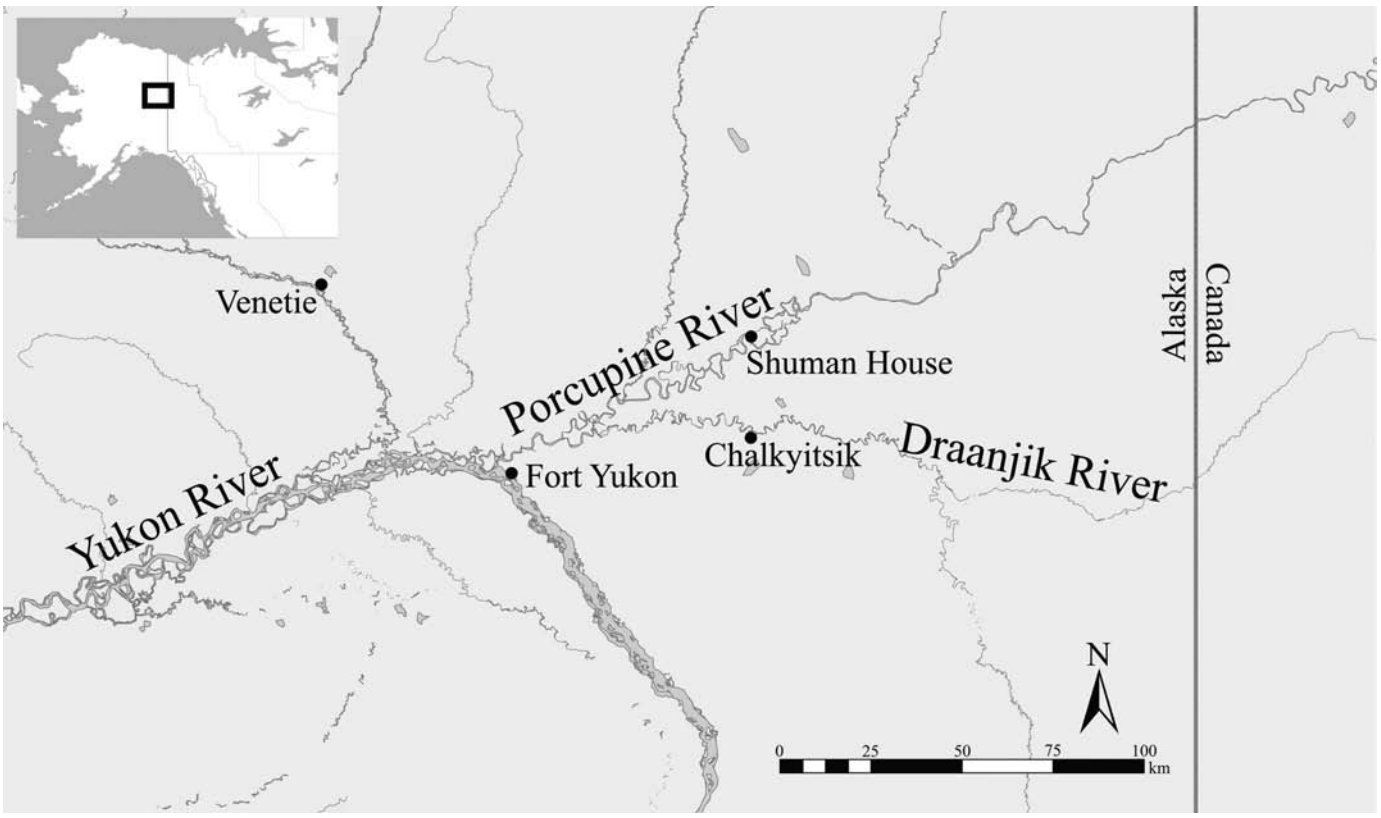

FIG. 3. The Yukon Flats and Porcupine Plateau in Alaska where Paul Herbert uses the Gwich'in constellation, *Yahdii*, for wayfinding.

and Wildlife Service, 2022). Two other major rivers, the Porcupine (*Ch'oonjik*, quill river) and *Draanjik* (platform cache river), feed into the Yukon River near the Gwich'in community of Fort Yukon or *Gwichyaa Zhee*. These three rivers and their tributaries provide a matrix of routes for winter and summer travel. To the north and east, the Yukon Flats transitions to the Porcupine Plateau, an upland area that extends to Canada with numerous hills and rounded mountains reaching 1067 m (Todd, 1978a) (Fig. 3).

The climate of the Yukon Flats is classified as Continental Subarctic and is noted for relatively low rainfall (17.8 to 25.4 cm annually) and extreme temperatures (Todd, 1978b). For example, from 1928 to 1958 Fort Yukon registered a mean annual temperature of –6.3˚C, whereas maximum and minimum temperatures were 36.1˚C and –57.2˚C, respectively (Johnson and Vogel, 1966). The mean number of days with freezing temperatures for the same period is 215 (Johnson and Vogel, 1966). Black and white spruce, birch, larch, alder, and various species of willow account for thick forest vegetation. When combined with the region's relatively flat topography, the landscape affords few vantage points for orienting by prominent geography and distant landmarks, particularly when travelling off waterways and established trails. Nonetheless, the Yukon Flats offers expansive views of the sky filled with reliable orientation markers for those who have learned to read them.

Although the Gwichyaa and Draanjik Gwich'in of the Yukon Flats also utilize a celestial wayfinding schema in an environment that has a low legibility of landmarks, it is completely different than the one employed by the Yellowknives Dene. These differences may be related to the fact that the Yellowknives Dene utilize a celestial schema designed for tracking target stars over relatively long distances in open country, whereas the Gwich'in schema primarily facilitates orientation during short trips into thickly vegetated forests after departing familiar trails and waterways. The Gwich'in schema is unique in that it projects human anatomy and its bilateral symmetry into the sky as a uniquely adapted whole-sky constellation that serves as a mnemonic device for remembering the spatial relationships of key stars (Cannon and Holton, 2014). This whole-sky constellation, known as *Yahdii*, integrates with the landscape and the Gwich'in riverine directional system to facilitate orientation when prominent geography and landmarks are not visible.

Although travel in the Yukon Flats is largely conducted on watercourses and established trails, numerous circumstances require travel off these paths into dense vegetation where maintaining one's directional orientation can be challenging. In this region, views of a trail or river are often obscured by thick vegetation after just a few dozen paces into the forest or brush. In situations that require longer detours off a primary route, such as when tracking a wounded animal, the landscape can become truly disorienting if no external sky-based schema is utilized.

Except in the summer, the Gwich'in observed the positions of stars to determine the timing of the day's first

activities around morning twilight. From early October to early December, for example, *Yahdii*'s tail or *vitsì'* (Big Dipper) points to three morning stars called *vành oozhrii* (it is naming the morning) or *yeedàak gahàajil* (they rose far up) and variants thereof, which rise in sequence from the northeast horizon between the time from morning darkness to the first light of dawn. These stars, δ Boo (Thiba), ε Boo (Izar), α Boo (Arcturus), are evenly spaced, each signaling an activity in the morning routine, particularly in hunting or subsistence contexts. When the first star appeared, people woke up to begin their day. When the second star came into view, one should have finished eating breakfast and be dressed to head outside. When the third and final star appeared around the first glow of dawn, hunters should already be out on the trail lest they miss their opportunities for the day. Gwich'in Elder, Paul Herbert explained:

> Say four o'clock, the first one come up over the horizon, that's four o'clock. Next one is five, and then six. And then after that there's daylight. You see? So, when you're hunting that's how people a long time ago, all they did was hunt, eh. Go hunting for food. I mean long, long time ago. They have to go hunting to survive. Okay so they go by the stars for the direction, for their time. So, when in early in the morning when you get up and you go outdoors. You go outside and you look. You see the stars start just peeking over the horizon, you know it's four o'clock [by the appearance of the first star, δ Boo]. So then by the second one [ε Boo] you've already drank, drank something, you ate and you're going. You're on your way because you got ready. Like if we're going to go tomorrow, we're ready to go tonight. Okay, we got everything ready. All you've got to do is jump into your warm clothes and you're going. You're gone, by the second star. And by the third star (α Boo), you're one hour out that way.

In his native language, Paul summarized:

> *Tr'ohkìt vành oozhrii gahàa'aįį izhit khèekee'aįį.*
> She or he got out of bed when the first morning star rose.
>
> *Gwats'aįį vành oozhrii khànee'aįį ts'ą̀' neech'in'àl.*
> We ate something when the next morning star rose.
>
> *Gwats'an tik vành oozhrii gineehòo'aįį gwizhit hàazhii.*
> She or he went from there [to go hunting] when the third morning star rose.

The morning stars are regarded as three spirits rising directly towards *Yahdii* and are a metaphor and reminder to follow protocols and live correctly to keep one's own spirit light and untethered from the emotions and baggage of this world. Early dawn is also an important time for spiritual exchange, which underscores the significance of the relationship between waking up with these stars, the dawn period, and hunting (Fig. 4). As described in a previous paper (Cannon et al., 2019), the whole-sky constellation, *Yahdii,* is the incarnated spirit of a Dene Traveller figure who went around the world in ancient time to instill balance and order while transforming Earth into its present form.

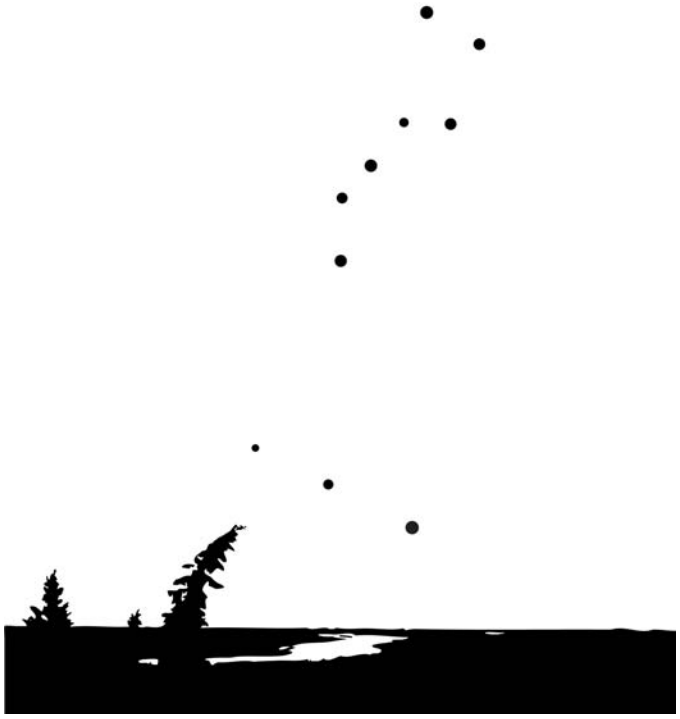

FIG. 4. The Big Dipper or *vitsì'* (his tail) pointing to a Gwich'in constellation of three morning stars called *vành oozhrii* (it is naming the morning) or *yeedàak gahàajil* (they rose far up) and variants thereof on 1 November at 6:30 AM local time in interior Alaska.

After a pre-dawn departure, although not always the case, travel is largely conducted along a trail or watercourse during daylight hours when no stars are visible. If a situation requires venturing off the trail or river, such as when following a wounded animal or searching for a fishing lake, the sun and wind are used as primary referents for orientation. In these situations, Paul maintains his bearing by noting the direction of the wind or the position of the sun relative to the trail or watercourse where he parked his transportation before setting out on foot into the brush or forest. For example, if the sun is in the downstream direction on the Porcupine River (e.g., to Paul's right side when headed east-southeast into the forest), he will keep it in the same relative position to his body when travelling outbound, or he simply notes that the sun is to the right side of his body (downstream direction) when departing the river. Paul also pays close attention to the landscape and occasionally counts lakes or ponds that he passes to estimate distance. To return, Paul simply reverses course by maintaining the sun or wind on the opposite side of his body (e.g., to his left) until he intersects the trail or river near where he parked his boat, skidoo, ATV, or dog team. Paul explained:

TABLE 1. Identification of asterisms in the Gwich'in whole-sky constellation, *Yahdii,* the three morning stars, and Polaris.

Asterism	Translation	Stars[1]
1. vitsì'	his tail	The Big Dipper
2. tł'o̱hts'ą́į́ vanlì'	his left hand	o Leo (Subra), α Leo (Regulus)
3. shreets'ą́į́ vanlì'	his right hand	γ And (Almaak), β Tri
4. tł'o̱hts'ą́į́ vatth'àn	his left leg	a general region of stars
5. shreets'ą́į́ vatth'àn	his right leg	a general region of stars
6. tł'o̱hts'ą́į́ vidzèe	his left ear	α Gem (Castor), β Gem (Pollux)
7. shreets'ą́į́ vidzèe	his right ear	α Aur (Capella), β Aur (Menkalinan)
8. vanch'àl	his snout	Messier object 45 (Pleiades)
vantsi̱h	his nose	(variation)
9. vindee	his eyes	ι Aur (Hassaleh), β Tau (Elnath)
10. vikì'	his head	all the stars comprising the ears, eyes, and snout
11. vizhin	his body	15 Lyn, o UMa (Muscida), h UMa (Alhaud IV), 36 UMa, θ UMa (Alhaud V), ι UMa (Talitha), κ UMa, (Alkaphrah), 31 Lyn (Alsciaukat)
vatthą́į'	his flesh	(variation)
12. tł'o̱hts'ą́į́ vakwài'	his left foot	α Boo (Arcturus), η Boo (Muphrid)
13. shreets'ą́į́ vakwài'	his right foot	α Cyg (Deneb), γ Cyg (Sadr)
14. tł'o̱hts'ą́į́ vigin	his left arm	a general region of stars
15. shreets'ą́į́ vigin	his right arm	a general region of stars
16. vidrii	his heart	27 Lyn
17. vatòo	his cane	the stars in the top of the cane are η Leo, γ Leo (Algieba), ζ Leo (Adhafera), μ Leo (Rasalas), ε Leo the stars in the bottom of the cane are all the stars between o Leo (Subra) and α Hya (Alphard)
18. va'o̱htsùu	his bag	X UMa (Taiyangshou), ψ UMa, μ UMa (Tania Australis), λ UMa (Tania Borealis)
19. vatą́į́	his trail	Milky Way Galaxy
są' gwat'an tą́į́	trail of stars	(variation)
20. yeedàak gahàajil	they rose far up	three morning stars: δ Boo (Thiba), ε Boo (Izar), α Boo (Arcturus)
k'iidàk gahàajil	they rose straight up	(variation)
vành oozhrii	it is naming the morning	(variation)
21. zheetł'an dha'ą́į́	star in the middle of the sky	α UMi (Polaris)

[1] Stars identified by Bayer or else Flamsteed designations, when necessary, followed by common name in parentheses. Numbers preceding asterisms refer to locations in Fig. 5.

> If you didn't rely on the stars or anything, you go by the sun or the wind … because wind here [on the lower Porcupine River] is always blowing from the north or else from the south. So, if you got out of your boat and the wind was blowing from the south and you were back in here [the forest] and you got lost, then you stop and feel the wind. So, if it's coming this way, you know, that's the south and you know it's coming this way. You know that's the south. And you know when you started you were going north [with the wind at one's back].

Like the Yellowknives Dene strategy, trails and watercourses expand the size of the target destination given that travellers will recognize where they are along the familiar route after they intersect it above or below their parked transportation. Although travellers strive to arrive at the trail or river exactly where they left their transportation, a celestial or wind-based orientation device must only be accurate enough to ensure that a traveller intersects the trail or river at some point above or below his or her departure point. An alternative strategy is to occasionally break the ends of branches as one walks along to mark the route off the river or trail. Two drawbacks of this strategy are that it requires one to retrace his or her steps and it is not particularly effective after dark when broken spruce boughs are difficult to see. When back on the river, distances are typically measured in river bends and are referred to with phrases such as "*Yeenjì' tik neegòhdii izhit dinjik tr'ąqh'ya'"* (we saw a moose three bends upriver).

If it is dark and at least partially clear, Paul maintains his orientation to the landscape by observing the whole-sky constellation, *Yahdii*. This constellation is composed of 19 groups of named stars that span greater than 143˚ of which 16 are named using body part terminology. When accounting for the height of trees, *Yahdii* covers the entire visible portion of the sky. The bilateral symmetry of this constellation provides multiple axes and reference points for orientation. Body parts on the left and right side of *Yahdii* are distinguished using Gwich'in terms *tł'o̱hts'ą́į́* (left) and *shreets'ą́į́* (right), applied from his perspective. The stars that compose *Yahdii*'s left hand and part of his cane are the only stars in the constellation that are not quite circumpolar at the latitude of Gwich'in country. In autumn, the left side of *Yahdii* is partially below the evening horizon, becoming

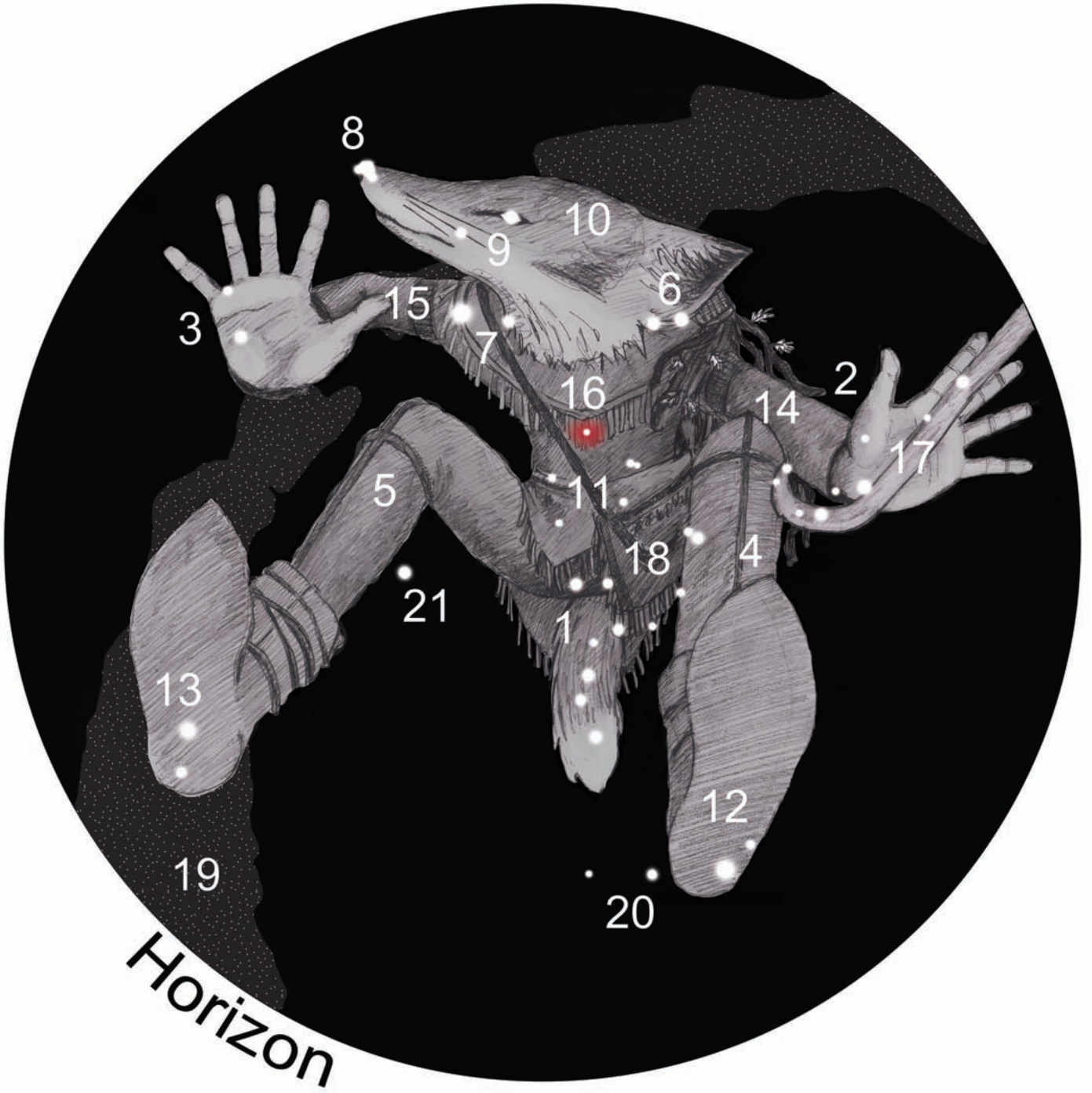

FIG. 5. Artistic depiction of the Gwich'in whole-sky constellation, *Yahdii*, the three morning stars or *vành oozhrii,* and Polaris as seen from Fort Yukon on 15 November 2018 at 7:30 AM local time. Zenith lies in the center of the circle. Numbers correspond to asterisms listed in Table 1. Illustration by Mareca Guthrie in consultation with Chris Cannon and Paul Herbert.

more centered towards morning. As the months advance from fall to winter, *Yahdii* becomes more centered in the evening sky. By late January through March *Yahdii* is arched across the zenith at evening twilight (Table 1, Fig. 5).

Once the stars corresponding to the individual body parts in *Yahdii* are known, their locations can be readily identified as he rotates through the night sky. Even when clouds partially obscure *Yahdii*, the recognition of one part of the constellation allows an observer to infer the locations of the other parts based on an existing mental map of the human body. For example, if *Yahdii*'s left hand is visible, then the observer can infer that his right hand is on the opposite side of the sky bisected by his tail, heart, and body located high overhead. When centered in this position, *Yahdii*'s hands and feet are each located in separate quadrants of the sky. His feet, hands, ears, and eyes are easily recognized as bright pairs of stars that form key reference points along with his tail (Big Dipper) and snout

TABLE 2. Prefixes and stem-suffix sets of Gwich'in directional morphology, adapted from Busch (2000:9).

Prefix	Translation
oo-	near (proximal)
yee-	far (medial)
yi'ee-	very far (distal)
k'ii-	straight (linear)
gw-	(areal nominalizer)
eh-	(postpositional)
geh-	(areal postpositional)

Stem/Suffix	Allative (going toward)	Punctual Locative (point location)	Areal Locative (areal location)	Ablative (coming from)
up (above)	-dàk	-dee	-dòk	-dąą
down (below)	-zhàk	-zhee	-zhòk	-zhąą
upstream	-njì'	-njìt	-njùk	-nii
downstream	-dì'	-dìt	-dùk	-dįį
upland	-ndàk	-ndee	-ndòk	-naa
downland	-tthàn	-kìt	-kyùk	-kyąą
across	-nìn	-ndìt	-ndùk	-nii
ahead	-ndàa	-ndaa	?	?
away	-'àn	-'àt	-'òk	-'ęę

(Pleiades). Collectively, *Yahdii* provides a single unifying system for mapping the night sky. The ability to infer the locations and spatial relationships of stars even when *Yahdii* is partially obscured by cloud cover, thick vegetation, or the horizon, is a testament to the ingenuity of a single unified whole-sky constellation uniquely adapted to a subarctic forest environment.

However, to use *Yahdii* as a celestial schema for orientation it must also be related to the landscape so that the different positions of *Yahdii* have directional meaning when the landscape becomes illegible. Paul has accomplished this by memorizing the different positions of *Yahdii* at different times of the night and seasons when stars are visible relative to the major local rivers and the Gwich'in directional system. This process is essentially the same as using the Big Dipper and other stars for time-reckoning, except that rather than simply noting their height or attitude relative to the horizon, the positions of stars must also be mentally correlated with a land-based frame of reference.

As is typical of Alaskan Dene languages, the Gwich'in direction system utilizes an absolute frame of reference anchored to the region's major river or waterway and its drainage system (Leer, 1989; Levinson, 2003; Brucks, 2015). Gwich'in directional terminology is composed of six prefixes that combine with nine "stem-suffix sets" (Busch, 2000:7) to form more than 200 possible direction terms (Kari, 1985) as shown in Table 2.

Leer (1989:576) notes that most of the Alaskan Dene directional stem-suffix sets occur in opposing pairs, such as upstream vs. downstream, upland vs. downland, and across the river, the latter of which "is its own opposite." The directionals are not, however, entirely anchored to a drainage-based or riverine frame of reference given that stem-suffix sets for up vs. down (vertically) and ahead have functional usage independent of the regional flow of water (Leer, 1989).

While Alaskan Dene directional systems are based on absolute frames of reference, the terminology anchors to a new major waterway (directional axis) when crossing drainage systems (Leer, 1989; Busch, 2000; Levinson, 2003; Kari, 2010; Berez, 2011; Brucks, 2015). In other words, the system is absolute, but only in a regional context. In this respect, Busch (2000:12) concludes that Gwich'in directionals and their frames of reference reflect a "regional consciousness" that is "congruent" with patterns of mobility. Directional terms also combine with an extensive place-names network (e.g., Kari et al., 2003, 2012; Kari, 2008, 2010; Matesi, 2016) to attain a high degree of "location precision" in which Kari (1996:445) states, "…the combination—[place] names plus directionals—functions much like a surveyors triangulation system." In summary of this perspective, Busch (2000:7) states that Northern Dene place names "are the fixed units in the cognitive map" while the "direction terms provide a dynamic way of linking places together." What has not been previously considered or described in the literature is how a celestial wayfinding schema, such as *Yahdii*, integrates with the landscape and directional system.

In the country utilized by Paul, the Porcupine River is the underlying frame of reference where *yeendàk* (far upland) is approximately north, *yetthàn* (far downland) is approximately south, *yeenjì'* (far upriver) is approximately northeast, *yeedì'* (far downstream) is approximately southwest, and *yeenìn* (far across) refers to either direction across the river along a northwest-southeast axis. Having spent many years memorizing the different nightly and seasonal positions of *Yahdii* from his home, Paul draws from that knowledge to infer the axis of the river and the directionals when out on the land by simply viewing all or part of *Yahdii*, even when miles from the river. In other words, the position of *Yahdii* informs Paul where the directions are based on his preexisting knowledge of the

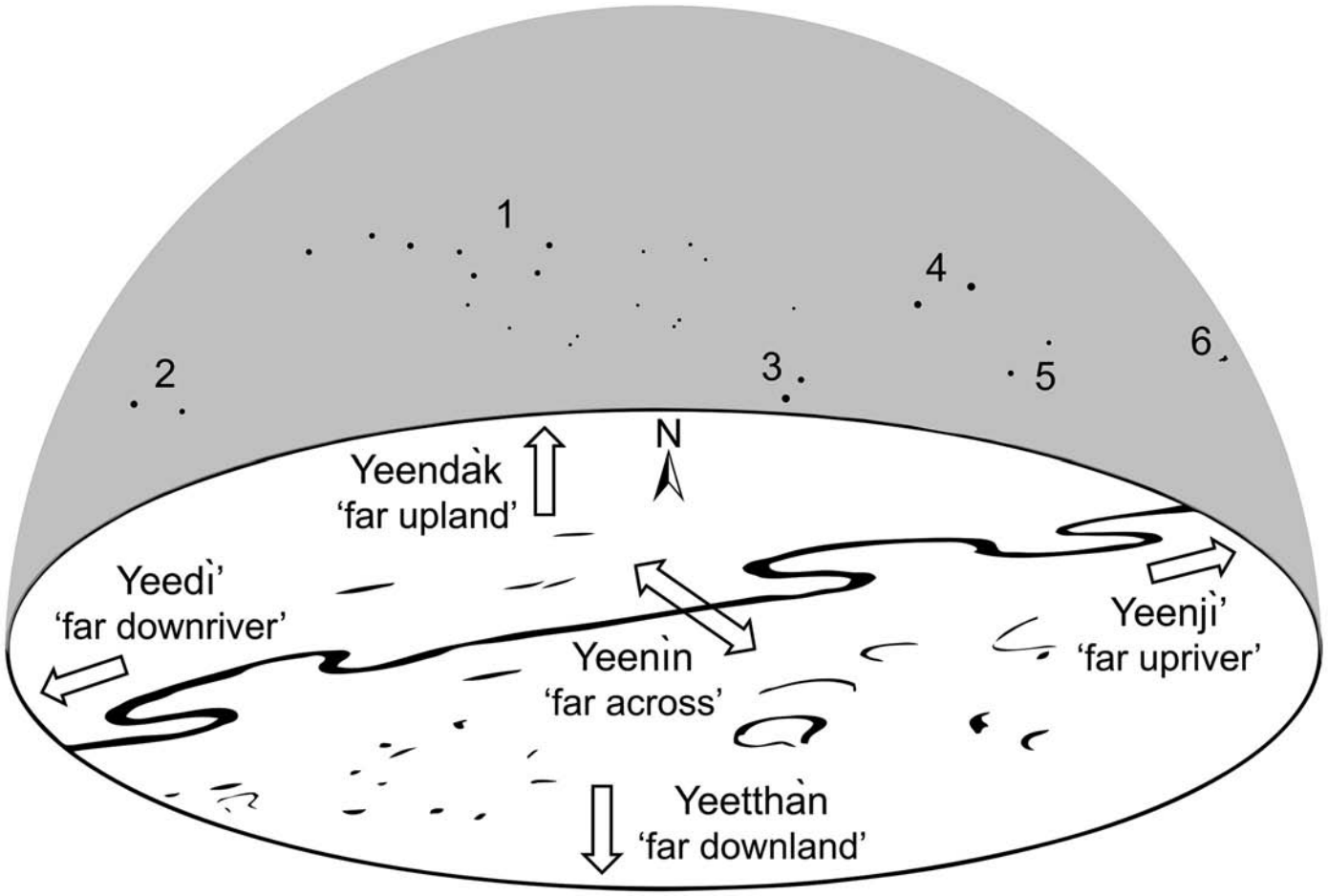

FIG. 6. An aerial view of a section of the Porcupine River marked with Gwich'in directional terminology relative to the position of *Yahdii* on 1 October at 10:00 pm local time. Key reference points shown are: 1) *vitsì'* (his tail, Big Dipper), 2) *tł'ǫhts'ąįį vakwài'* (his left foot, α Boo and η Boo), 3) *tł'ǫhts'ąįį vidzèe* (his left ear, α Gem and β Gem), 4), *shreets'ąįį vidzèe* (his right ear, α Aur and β Aur), 5) *vindee* (his eyes, ι Aur and β Tau), and 6) *vanch'àl* (his snout, Pleiades). His bag (*va'ǫhtsùu*), body (*vizhin*), and heart (*vidrii*) are shown but not labeled given that they are secondary markers in wayfinding contexts. Except for his right ear, body parts located on the right side of *Yahdii* are not shown in this figure.

way that *Yahdii* appears at different times of the night and seasons relative to the river and directionals. If disoriented when on the south side of the Porcupine River in autumn at evening twilight, for example, Paul would know that *Yahdii*'s snout (Pleiades) is approximately in the upriver direction (*yeenjì'*) while his tail, body, heart, packsack, ears, and left foot are parallel to the northern or upland (*yeendàk*) horizon. To return to the river where his boat is parked in this hypothetical example, he simply needs to walk toward *Yahdii*'s tail (Big Dipper) until intersecting the river (Fig. 6).

Although using this celestial schema to infer directions might seem complex, it is based on rote memorization and practice. In this respect, Paul emphasizes the importance of habitually observing the sky and living by it so that one can draw on that knowledge when it is needed on the land. He said:

> Years ago before all this modern stuff they said they live by it. You know, every day. You've got to do it every day to really believe it. You can't just unroll your [sleeping] mat every now and then and look at it and say, "Oh, yeah." Like me, I [observe the sky] almost every day. You know, it's an everyday thing.

Knowing the evening twilight positions of *Yahdii* is especially important given the frequency in which hunters and trappers find themselves out on the land shortly after it becomes dark, such as when harvesting an animal late in the day or dealing with an unexpected issue or mishap. In this respect, Paul said:

> A lot of times you go in the dark when you go out, eh. You go out and then it get dark out there. You know, you're wandering around through the woods, you know, and it get dark on you. "Hey, which way is back?" you know. I just look up at the stars and take a heading. Take a heading and a lot of times I come out and my snowmachine is on the ice right there, you know, or else my boat.

It is important to note, however, that the celestial schema embodied by *Yahdii* is only used when no prominent or distinguishing landmarks are visible, suggesting a

strong preference for classic route-based navigation. Notably, reference to the sun or other sky-based schema is abandoned after intersecting a river, trail, or other prominent landmark. As one might expect, employing a celestial schema is a secondary, if not a last resort option when directional orientation cannot be achieved from familiar land-based signs and their spatial relationships. However, what is familiar to one traveller may not be familiar to another, which emphasizes the role that travel behavior, personal experience, and sociocultural factors have in rendering a landscape more or less legible for different people and peoples (Golledge, 2003). Finally, the celestial schema described in this section should not be viewed strictly from a functionalistic perspective given that the spirituality of *Yahdii* is also at play in wayfinding contexts, demonstrating an additional way that the ancient traveller is a consummate ally, guide, teacher, and guardian (Cannon et al., 2019).

CONCLUSION

The Northern Dene stellar wayfinding systems described in this paper demonstrate two completely different approaches for determining a route through two different subarctic landscapes that lack views of prominent landmarks or an otherwise distinguishing ground pattern. Golledge (2003:35) states that landscape legibility "appears to have physical, spatial, social, or cultural markers as well as behavioral dimensions, and in any given setting one or more of these can dominate." The Yellowknives Dene wayfinding strategy has remarkable utility in that the celestial schema that it employs to account for a lack of perceptible landscape information requires no preexisting knowledge of specific stellar arrangements or their names to successfully track stars across the barrenlands (Taiga Shield High Subarctic). This strategy simply relies on taking an approximate southeast or northwest bearing according to the rising or setting positions of the sun and then tracking any sequence of rising or setting stars aligned to that bearing. Names and knowledge of specific star groups do, however, come into play in time-reckoning contexts, such as when determining the departure and ending times of one's daily or nightly travels.

Development of the Yellowknives Dene stellar wayfinding system might be related to their historic land-use pattern, which extended well into present-day Nunavut Territory. The Yellowknives Dene established seasonal camps in a contiguous area reaching to Contwoyto Lake at the northern end of their estate with occasional journeys reported as far north as the mouth of the Coppermine River (Smith, 1981; Weledeh Yellowknives Dene, 1997). Given the northern extent of the Yellowknives Dene travels, it is notable that the Copper Inuit of the Coronation Gulf also utilize a nearly identical stellar wayfinding strategy. The late Hudson Bay Company trader, Duncan Pryde, (quoted in MacDonald, 1998:167), explained:

> The usual routine is to follow the star as it rises obliquely [or sets for that matter, if you are following a setting star] on the horizon. The rapid displacement of the star means you can only use the star for a short time, then you discard it and pick up a new star roughly where the original one rose. Once the travelling-star has been displaced about 25° [roughly a hands-breadth at arm's length] from its original spot it is far enough away to start looking for another star to follow. The star has to be very low on the horizon since your eyes are focused ahead of the dogs to look out for rough ice or any other problems in your path, and if you have to keep looking away and then back it can eventually become bothersome. You can be certain that if you have to raise your head to see the star then it is too high, and if you have to turn your head to see the star then it is too far to one side. Only low stars in sequence are any good for dog travel.

Whether this shared stellar wayfinding strategy is a factor of borrowing or independent innovation is difficult to ascertain. In contrast, the Gwich'in celestial schema embodied by the whole-sky constellation, *Yahdii*, is highly cultural in the sense that it requires learning Gwich'in knowledge about star names and their conceptual representations that are then related to a regional land-based frame of reference encoded in directional terminology. While the system could be adapted to other absolute frames of reference, such as the cardinal directions or another river, the latitudes where *Yahdii* is functional as a celestial wayfinding schema is restricted to the circumpolar North where most of the constellation remains above the horizon throughout each night when stars are visible. Notably, Ahtna, Upper Tanana, and Lower Tanana Elders and traditional knowledge bearers who we worked with in Alaska also described analogous whole-sky constellations (Cannon et al., 2019). Although we cannot posit a specific southern limit where *Yahdii* breaks down as a functional celestial schema, it suffices to say that Gwich'in and other Indigenous astronomies throughout the world are uniquely adapted to place.

Like the sidereal compass used by Polynesian navigators (Goodenough, 1953; Gladwin, 1970; Lewis, 1972; Johnson and Mahelona, 1975), *Yahdii* is used as an elaborate celestial schema requiring rote memorization of stellar positions and spatial relationships that are mentally related to a terrestrial frame of reference and direction system. At the same time, *Yahdii* provides a highly functional mnemonic device based on an existing mental map of the human body plan. Although previous investigators have not described detailed knowledge of Northern Dene constellations or stellar wayfinding systems, directional orientation and travel in the Yukon Flats have apparently long baffled outsiders who have limited experience travelling in the area. For example, in his *Contributions to the Ethnography of the Kutchin,* Osgood (1936:64–65) states:

> In regard to travel, one of my informants pointed out that the Yukon Flats Kutchin were more sedentary than the other [Gwich'in] groups because of the nature of their country which, as he said, contains too many sloughs, mosquitos, and bushes which combined with its flatness leaves the traveller unable to see where he is going.

In contrast to the Gwich'in wayfinding system reported in this paper, Richard Nelson (1973:185) who worked extensively with the Draanjik Gwich'in in Chalkyitsik when Paul and his great grandmother, Belle Herbert, lived there, writes:

> …the Indians have very little knowledge of astronomical phenomena, with names for only a few stars and constellations. McKennan (1959: 110) points out that "small as the astronomical knowledge of the Upper Tanana is, it apparently is no smaller than that of the other Northern Athapaskan groups." This certainly holds true for the Tranjik Kutchin.
>
> The Kutchin very rarely become lost, since they nearly always follow established trails or stay on frozen rivers and lakes, and they know the land so well that they seldom find themselves in unfamiliar territory. If a man should lose his way, however, he may wander around until he reaches a known landmark, sometimes climbing a tree to look around. If there are hills it is difficult to get lost because these are highly visible points of orientation, and from a hill it is easy to sight prominent landmarks such as rivers or lakes.

Despite the statements quoted above, there are few vantage points in the forest of the Yukon Flats from which distant landmarks are visible, yet the Gwich'in of this region are by no means more sedentary than other adjacent groups. It is important to note, however, that using a celestial or wind-based schema is a subtle endeavor, and another traveller may not even recognize that his or her partner is glancing at the sun or stars or feeling the wind on his or her face to chart a course through the dense boreal forest. This subtlety may give a false impression that everything in the perceptible domain is familiar or known to the local Indigenous traveller while overlooking other innovative cognitive strategies for finding one's way through a large-scale environment that lacks views of distinguishing landmarks or topography.

While Paul is the only Gwich'in Elder that the lead author worked and travelled with who utilizes *Yahdii* in wayfinding, Ahtna Elder Charlie Hubbard, explained an identical method using the analogous Ahtna whole-sky constellation, *Nek'eltaeni* (that which moves over us). Charlie agrees that the body part metaphor embodied by *Nek'eltaeni* facilitates memory of the stars and their spatial relationships. Although Charlie is originally from the mountainous area around Cantwell, Alaska, where the landscape is highly legible, he agrees that the legibility of any landscape can decrease under different conditions and contexts (e.g., pitch darkness or low-level clouds or fog with clear sky above), in which case *Nek'eltaeni* offers an alternative orientation device external to the immediate landscape.

Both wayfinding systems described in this paper suggest that large-scale environments that lack views of prominent or distinguishing landmarks may be more conducive to the development or adoption of a celestial schema. However, use of these celestial schemata are suspended in favor of route-based navigation when the traveller intersects a familiar geographical feature or trail near his or her destination, suggesting strong preference for orienting and wayfinding by landmarks. Moreover, both systems use trails, rivers, and other large familiar landmarks or landmark clusters (e.g., a community) to expand the size of the target destination. While the traveller strives to arrive at a precise location, a greater emphasis is placed on simply reaching a broad familiar area, after which point the traveller can use route-based navigation to attain a specific destination.

Achieving an approximate bearing to a more familiar area is underscored by an alternative orientation device that Paul uses based on the northern lights or *yakaih*. Although he seldom employs this strategy, Paul described a situation where he took a bearing off the northern lights after seeing it glow between the treetops one autumn while moose hunting away from his boat. In interior Alaska, the northern lights regularly develop as a low arc across the east to northwest horizon before growing into a larger formation or dissipating as the night progresses. Due to the consistency in their formation, headings can be approximately obtained from auroral arcs. In comparison, Nelson (1969:138) reported that the Inupiaq of Wainwright, Alaska, also utilize auroral bands for directional orientation:

> Several Eskimos mentioned, when asked, that the northern lights are sometimes used for navigation, because they are always oriented in bands running from east to west across the sky. Throughout the entire winter, notes were kept on the auroral orientation, usually observed around midnight. The results of this check show a monotonous regularity at this hour; the east-west orientation occurred in nearly 100 percent of the observations, whenever there were long cohesive bands. There is also a characteristic curvature of the bands, such that their ends bend toward the north. It is therefore possible to get oriented by observing the luminescent auroral bands.

Although theories on human spatial orientation have received extensive attention across disciplines (Istomin and Dwyer, 2009), the material presented in this paper is an attempt to heed the call for additional ethnographic descriptions of "how different peoples perceive their environment and navigate around it" (Istomin and Dwyer, 2009:41), especially among hunter-gatherer groups (Levinson, 2003). The case studies presented in this paper

not only contribute to broader research in Northern Dene studies but are among the few detailed examples of stellar wayfinding systems utilized by Indigenous cultures outside of maritime contexts.

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