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## HUNTER-GATHERER FORAGING AND COLONIZATION OF THE WESTERN HEMISPHERE

**ABSTRACT:** *A foraging model that incorporates the effect that "naïve" fauna would have on the foraging return rates and subsequent residential mobility of those hunter-gatherers who first entered the New World is used to propose that a rapid colonization would be expected in the particular Late Pleistocene environment of the northern New World. Analysis of uncorrected radiocarbon dates from the earliest sites in Beringia, North and South America show that regardless of whether Clovis is accepted as the earliest evidence of occupation, or whether sites such as Monte Verde and Meadowcroft are used, the rate of migration across the New World was much higher than that across Siberia, as the model predicts. As suggested by Todd and Kelly in 1988, the initial occupants of the New World were a hunting and gathering society that combined elements commonly associated today with arctic hunters with those associated with tropical foragers. No easy ethnographic analogy for Paleo-Indians exists in the ethnographic record.*

**KEY WORDS:** *Colonization of the New World – Modelling – Late Pleistocene foragers – Late Pleistocene environments of the Americas*

### INTRODUCTION

The human tide that washed over Europe, Asia, and the New World beginning around 1.5 million years ago consisted initially of pre-sapiens hominids and later of *H. sapiens sapiens*. There can be little doubt that pre-sapiens hominids were not human in the way that we know humanity. They were different from us. It is not clear what those differences are, but understanding them is necessary to understanding the process of human evolution.

Understanding the biological difference between pre-sapiens hominids and modern humans comes from an examination of skeletal remains; understanding the cultural difference comes from examining archaeological evidence of behaviour. One potential research area is to examine on broad spatial and temporal scales the differences in how pre-sapiens and *H. sapiens sapiens* colonized large, unpopulated land masses. I suggest broad temporal and

spatial scales because the nature of archaeological data makes it difficult to specify dates of colonization very accurately and because the colonization process is one that occurs on a broad spatial scale. Examining how pre-sapiens and modern humans coped with a similar problem may point to ways in which they were similar or different. The three largest land masses that were colonized initially by *H. sapiens sapiens* are Australia, north-eastern Asia, and, by far the largest, the western hemisphere. We will examine the last of these.

The colonization of the western hemisphere was a historical event (or events) that was part of demographic, economic, and ecological processes. We know that Native Americans came from north-eastern Asia across Beringia, entering lower North America through the ice-free corridor or by traversing the western coast. We also know that people were in North America by at least 11,200 B.P. Unsettled, however, is the question of exactly when people

first arrived in the New World. The answer to this question bears not only on the culture history of Native Americans, but on theoretical concerns as well because the timing of the arrival tells us something about the way in which people occupied the Americas. Therefore, the question of New World colonization needs to be couched in theoretical terms.

Discussions and critiques of the colonization of the New World often assume that the colonization process was one of demic expansion, population growth and subsequent group fissioning (Belovsky 1988, Martin 1973). There is considerable and not completely unwarranted scepticism of the growth and migration rates used in these models (e.g. Whitley, Dorn 1993). However, Lawrence Todd and I argued (1988) that the colonization of North America could be understood in terms of a model that did not assume population growth and subsequent fissioning as the driving force behind the colonization of the western hemisphere. Our major point all along has been that the archaeology of the early Paleo-Indian period (11,200 to 10,500 B.P.) suggests that Paleo-Indian lifeway was strikingly different than that of ethnographically known foragers, although both must, we assume, represent manifestations of the same decision making processes and evolutionary principles. Elsewhere I have considered criticisms of the model's use of archaeological data, and alternative reconstructions of Paleo-Indian lifeway that employ ethnographic analogy (Kelly 1996). Here, I wish to consider the relationship between foraging and migration. My purpose is to suggest that while population growth undoubtedly occurred during the initial colonization of the western hemisphere and helped it along, it may not have been the primary driving force. Consequently, refutations of density-dependent migration rates for Paleo-Indians to account for the apparently rapid occupation of the Americas may be irrelevant (e.g. Whitley, Dorn 1993).

## FORAGING AND MODELS OF MIGRATION

Ethnographic data show that there is a relationship between individual foraging and residential movement such that people rarely use all the food they could from a given camp (see Kelly 1995). In the central Kalahari, for example, Kade G/wi women "begin to gather food near the campsite [and] they can complete their work in a trip of 1 to 2 km during the first few days of their stay. Then, gradually, as they consume the plants near camp, they must go farther. If the round trip for gathering food plants exceeds 10 km or so, convenience dictates that they move themselves with all their belongings to virgin territory" (Tanaka 1980: 66). Optimal foraging theory's marginal value theorem also suggests that if foragers wish to forage efficiently, and maintain as high a rate of food intake as possible, then they should leave a foraging area before depleting it of food. But the marginal value theorem is designed for a forager who eats food at the point of capture, and one who

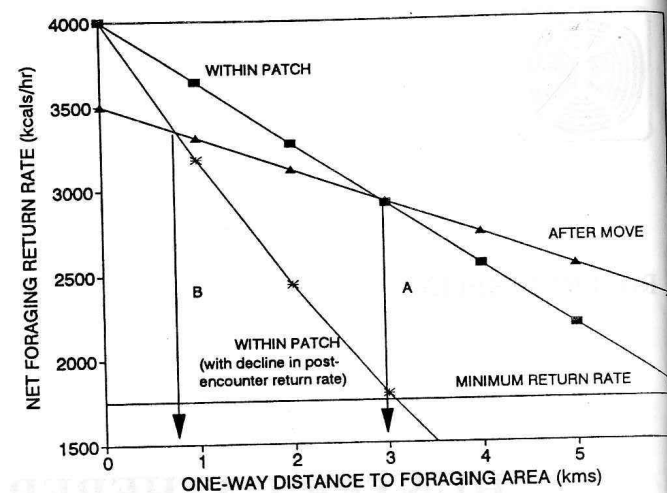


FIGURE 1. The relationship between the return rate experienced within a foraging area relative to that which could be expected if the foragers moved to a new area. The model predicts camp movement at the point at which foragers are travelling about 3 km from camp in order to find food (arrow A). If post-encounter return rate declines (at a rate of 500 kcal/km radius) as a function of the presence of humans, then movement is predicted after resources within only 1 km of camp (arrow B).

encounters food randomly. For the most part, this does not describe living foragers who transport food back to camp and who, for the most part, know where they are going and what they are seeking before leaving camp.

Imagine, therefore, a foraging family living in an environment where a resource with a post-encounter return rate of 4000 kcal/hr is homogeneously distributed. This food is collected by a forager who walks at a leisurely pace of three km/hr at a caloric cost of 300 kcal/hr that increases by 30 percent when returning home with food. For the sake of simplicity, let's assume this forager must collect 14,000 kcal/day to feed his or her family. Assuming an eight-hour workday, this means that the forager must gather the resource at a minimum net daily return rate of 1750 kcal/hr. The net return rate (RR) declines as the forager spends more time (T) and energy traveling out to and back from the foraging area (Figure 1):

$$RR = ((8 \text{ hrs} - (2 \times T)) \times 4000) - ((300 \text{ kcal/hr} \times T) + (390 \text{ kcal/hr} \times T)) / 8$$

This gives an effective foraging radius of 6 km. Food cannot be gathered beyond this point.

We can also compute the return rate if the family were to move to a new foraging area after exploiting the resources within a given radius of the site. Since food is homogeneously distributed, we will assume that they move the minimum distance to position themselves in a pristine foraging area, that is, twice the current foraging radius. The post-move return rate of the individual forager, allowing an hour for camp breakdown and setup is figured

as:

$$RR = \{([7 \text{ hrs} - (2 \times T)] \times 4000) - [300 \times (2 \times T)]\} / 8$$

The after-move line in Figure 1 shows the daily return rate if the forager were to move camp after foraging within 1, 2, 3 ... km of camp. Note that at a return rate of just under 3000 kcal/hour (achieved at a foraging distance of about 3 km) the net after-move return rate is equal to the within patch return rate. After foraging within about 3 km of camp (arrow A), the family would do better to move to the centre of a new foraging area (6 km away). Many other variables alter this model's predictions (see Kelly 1995), but it suggests that even if foragers could remain in their current camp or territory, they will move to maximize their foraging efficiency. We may be justified in assuming, therefore, that if Clovis hunters moved into an environment rich in large game, as late Pleistocene North America apparently was, with no human competitors, and no territorial boundaries, that they would still have been a mobile people. But they might have been even more mobile than this simulation suggests.

The simple model used above assumes that hunter-gatherers have no immediate effect on the resources they exploit. What if this were different? What if a resource responded in such a way that its return rate decreased as a function of the presence of humans? The first inhabitants of North America found a game population that had never encountered people. It is hard to say how these animals would have responded to humans, but perhaps the arctic archaeologist Moreau Maxwell can give us a clue. Conducting an archaeological survey in 1958 on northern Ellsmere Island, Maxwell set foot where no human had been since 1881. He found game there to be downright placid: ptarmigan did not fly away; he could come within 30 m of musk ox; seals only a meter away from his tent ignored him. A hunter in this landscape could have achieved a very high return rate.

But game quickly learn the dangers of humanity. Had Maxwell hunted these animals, they would have figured out soon that he was something to be avoided, and initially high return rates would have decreased rapidly. We try to model this situation also in figure one. Using the same model as above, we decreased the post-encounter return rate by 500 kcal/hr with each km radius, that is, the return rate does not stay the same but decreases the longer the camp is occupied to reflect the increased time it would take to pursue an increasingly more wary prey (I have no idea what the correct reduction factor should be; the example serves only to show the predicted direction of the effect of a change in prey knowledge). Note that now a higher return rate could be achieved by moving after eating everything within only 1 km from camp (arrow B) before moving to virgin territory where prey have not learned to avoid humans. An initially naive prey that rapidly learns to avoid a new predator by avoidance would cause the predator to become more residentially mobile.

TABLE 1. Potential causes of migration.

1. When population reaches local carrying capacity.
2. When the local habitat has low stability relative to species generational length.
3. When suitable foraging patches are relatively close together, or when the "hostility" of transition habitat (the land to be crossed between foraging patches) decreases.
4. When mortality creates vacant patches (assumes a previous population was inhabiting the land to be colonized).
5. When social hierarchy reduces rate of food intake or reproductive possibility for some individuals.
6. When patch size decreases relative to population size.

Dramatic population growth may not be needed for migration to occur, for the critical variable is the difference between the return rate experienced in the current area and the expected return rate of a neighbouring area, allowing for the costs of movement. By even slightly increasing the rate of local resource depletion, even modest population growth would soon make the cost of moving to virgin territory worthwhile.

## TWO MODELS OF MIGRATION

As Table 1 shows, migration can occur under a number of circumstances. In all of these, migration entails a cost – the cost of giving up a known environment for an unknown environment. Migration occurs when the cost of remaining in a current territory is higher than the potential cost of migration, or when the local net foraging return rate falls below that which could be obtained by moving to new territory after taking the cost of moving into the new territory into account.

Under different circumstances, however, migration will take different forms. John Beaton (1991) has proposed two potential models to describe colonization. The chief characteristics of each model are listed in Table 2. In the Estate Settlers Model (ESM), colonization occurs as a result of population growth and group fissioning as local carrying capacity is reached. (Group fissioning could occur as a function of poorly-adapted individuals – the old, infirm, or weak-moving away from areas of high competition. These "colonists" would probably not survive.) In this model, colonization occurs at a rate that is controlled by the local rate of population growth (this is in turn controlled by a number of variables, e.g. maternal nutrition and labour patterns, breast-feeding; see Kelly 1995). Regardless of the speed, however, migration would be incremental, with daughter groups budding off from the parent group and moving to an "edge" of the currently inhabited region. This form of colonization probably occurs when new territory is close and the new environment is not radically different from the old one.

TABLE 2. Characteristics of transient explorers and estate settlers (modified from Beaton, 1991).

Characteristic	Transient explorers	Estate settlers
Demography	Low	High
Threshold to fission	Stable	Fluid
Group composition	Founder effects, Drift local natural selection	Gene flow, Clinal distributions
Genetic factors		
Fecundity	Low	High
Population growth	Low	High
Local group extinction probability	High	Low
Parent population	May not be left behind	Will be left behind
Economy		
Territory	Unconstrained	Constrained
Niche differentiation between groups	Low	High
Diet diversity	Low	High
Seasonal mobility	High	Possibly high
Territorial mobility	High	Low
Geographic pattern of colonization	Lineal advances	Wave front

TABLE 3. Rates of population movement, north-eastern Asia versus the western hemisphere for different possible migration dates.

From:	At:	To:	At:	Distance: km	kms/year
Across Beringia:					
Lake Baikal	33,000	Tanana Valley	11,800	5,000	0.24
			11,300		0.24
		Bluefish Cave	15,500	5,600	0.32
			13,000		0.28
Aldan River	18,000	Tanana Valley	11,800	3,500	0.56
			11,300		0.52
		Bluefish Cave	15,500	3,730	1.49
			13,000		0.75
Clovis-First:					
Tanana Valley	11,800	Blackwater Draw	11,170	4,500	7.14
Bluefish Cave	15,500	Blackwater Draw	11,170	4,500	1.04
	13,000		11,170	4,500	2.46
Tanana Valley	11,800	Tierra del Fuego	10,700	16,600	15.09
	11,300		10,700		27.67
Bluefish Cave	15,500	Tierra del Fuego	10,700	16,200	3.38
	13,000		10,700		7.04
Blackwater Draw	11,170	Tierra del Fuego	10,700	12,100	25.74
Pre-Clovis:					
Bluefish Cave	15,500	Meadowcroft	14,500	5,040	5.04
			14,000		3.36
Bluefish Cave	15,500	Monte Verde	13,900	15,050	9.41
			12,400		4.85
	13,000	Monte Verde	12,400	15,050	25.08
Meadowcroft	14,500	Monte Verde	13,900	12,800	21.33
			12,400		6.10
	14,000	Monte Verde	12,400	12,800	8.00
Meadowcroft	14,500	Tierra del Fuego	10,700	13,660	3.59
	14,000		10,700	13,660	4.14

However, migration occurs in many species long before carrying capacity is reached. In the Transient Explorers Model (TEM), migration occurs when fluctuations in resources increase the cost of remaining in place for all members, and/or when the distance between foraging patches is great. Migration and colonization in this case would probably be rapid, either as a function of moving long distances between patches or as a function of rapid declines in initially high return rates – as when foragers exploit high-ranked, but naïve game resources.

One major difference in the two models is that in the ESM, a colonizing population leaves a parent population behind; in the TEM, a colonizing population may or may not leave a parent population behind. In the TEM, populations could be separated by long distances, whereas in the ESM populations would be more or less equally-spaced and maintain contact with one another, permitting both the continual flow of genes and cultural ideas. The ESM would be susceptible to the effects of gene flow, and might result in clinal gene distributions, whereas in the TEM, migration could result in discrete populations subject to founder effects, genetic drift, and the effects of localized natural selection.

In the ESM it is unlikely that local population extinction could occur (at least, on a scale that is archaeologically visible), although there could be retractions in response to climatic change. In the TSM, local population extinctions could occur regularly as a function of a combination of small population size, isolation and chance events (e.g. winter storms, disease).

In the ESM, some areas could be occupied, then abandoned, then reoccupied as the population along the "front" of the colonizing wave goes through pulses generated by demographic and/or environmental fluctuations. Land eventually occupied permanently by a daughter group would probably not be "unknown" land. It could, therefore, be used in a fashion different from that of the parent population as the daughter population altered its strategy to suit the particular environmental features of the new territory. This could result in clinal distributions of foraging strategies that parallel clinal distributions of resources.

In the TEM, colonizers could move long distances into unknown terrain. Under these circumstances, they might continue to use familiar resources and tried and true strategies, resulting in behavioural homogeneity rather than cultural differentiation across large regions. Models of cultural transmission (Boyd, Richerson 1985) suggest that in cases where an individual confronts circumstances where experimentation is costly, that individual should mimic whatever behaviour or trait appears to be successful for others in that environment. If Clovis peoples moved into an unoccupied environment, then they should have continued doing whatever they had been doing before moving into the new environment since they themselves were the only models available. In this model, we can expect that the original behavioural repertoire of the colonizers would exert strong influence over the character

of the colonizers' adaptation and a similar behavioural strategy could be practised across very different kinds of environments.

## COLONIZATION OF THE WESTERN HEMISPHERE

Which of these models describes the colonization of the western hemisphere? Let us first ask what we know about the colonization of the western hemisphere. We know that people came to North America from Siberia via the land bridge. The land bridge was open, most recently, from 60,000 to 10,000 B.P., reaching its maximum extent between 20,000 and 18,000 B.P. (The bridge was first breached about 14,300 B.P., but would have remained passable at times until 10,000 B.P. While it probably provided a diversity of large fauna, it was apparently not until 12,000 B.P. that trees were present in river valleys to provide a source of firewood [see Guthrie 1990, Hoffecker *et al.* 1993]; this would not, however, have prevented migration along the coast, where driftwood would have been available.) To move south from Alaska, people had to pass through the ice-free corridor when it was open – before 30,000 or after 11,500 B.P. (the ice-free corridor was open earlier at its southern reach, by about 14,500 B.P., but was apparently still closed north of 60° until later). Alternatively, people could have travelled along the western coast. The Cordilleran ice sheet did not form until as late as 20,000 B.P.; before this date, people could have moved along the interior valleys of the Canadian Rockies (Jackson, Duk-Rodkin 1996). By about 13,000 B.P. an ice-free coast was available to entering populations. Coming along the south coast of Beringia, humans could have entered North America south of the ice sheets quite early.

However, archaeological data from eastern Siberia do not provide much support for this possibility. The earliest evidence of human occupation there, in the Aldan River Valley, is at the site of Verkhene-Troitskaya, which dates conservatively to 18,000 B.P. (Figure 2)<sup>11</sup>. At Dyuktai Cave, the earliest well-dated levels are between 14 and 12,000 yrs old (Yi, Clark 1985). On the north coast, Berelekh dates to only about 12,000 B.P. and Ushki Lake to less than 14,300 B.P. Thus, present data suggest that people were not in Beringia before about 13,000 B.P., or, if they were, they travelled along a now submerged coast. More research is obviously needed in far eastern Siberia.

From the Tanana Valley sites in Alaska we know that people had crossed the Bering Strait possibly by 11,800 years ago. And, by at least 11,200 years ago, people had

<sup>11</sup> On the Chukchee Peninsula there is a site that is a moraine deposit containing slaked stone some 32–33 meters below the surface (Laukhin, Drozdov 1991). This location may predate 30,000 B.P., but the dating of the site is not certain and the stone tools, based on the published illustrations, may only be fractured cobbles.

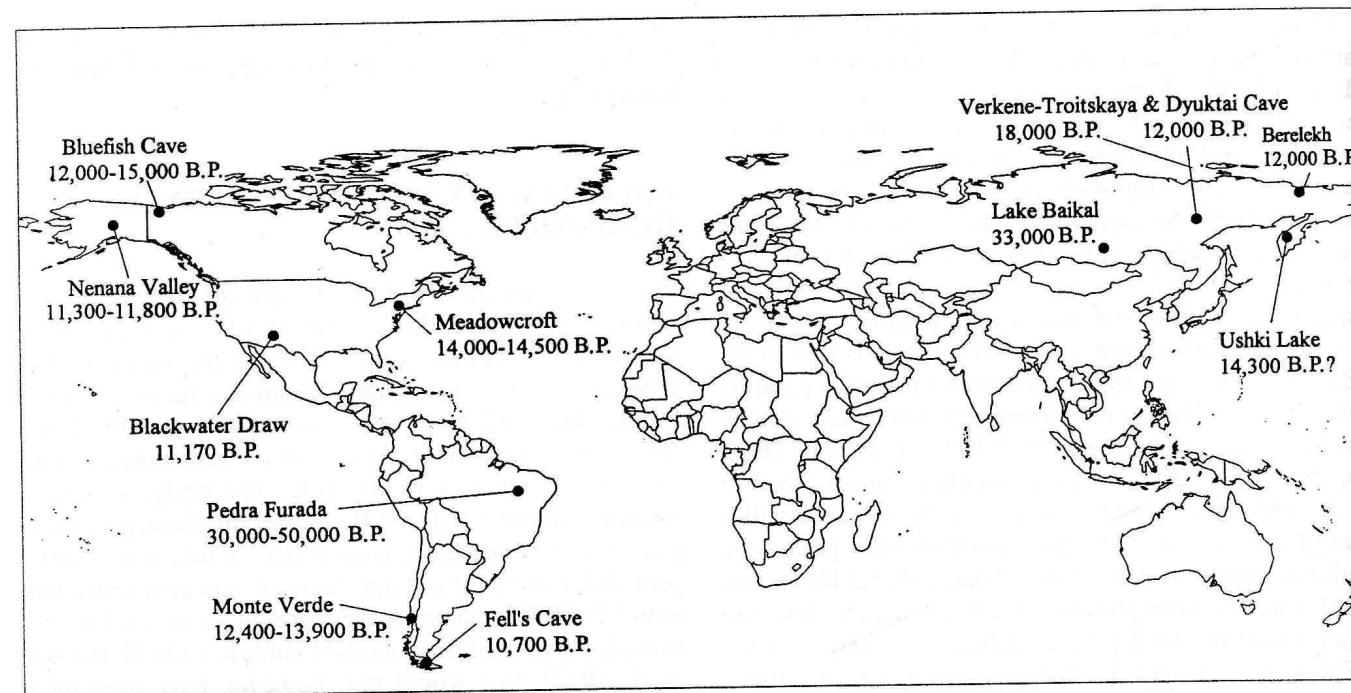


FIGURE 2. Locations of the sites used in the text to calculate potential migration rates.

moved south into the present day United States, where the distinctive stone tools that comprise the Clovis tool kit are well-dated between 11,200 and 10,900 B.P. (Haynes 1993, Figure 3). By at least 10,700 years ago, people had pushed south to Tierra del Fuego.

But were the people who fashioned Clovis points the first in North America? Recently, geneticists and linguists both have answered in the negative. Patterns in the mtDNA of Native Americans suggest that Amerindians separated from Siberian populations 17,000 to 34,000 (Torroni *et al.* 1993a,b) or possibly as many as 78,000 years ago (Ward *et al.* 1991), suggesting an occupation of the Americas significantly before Clovis. Other researchers, however, suggest that the divergence occurred between 12,100 and 13,200 B.P., more in line with Clovis dates (Shields *et al.* 1993; these researchers only examined northern populations, however). There are some difficulties with mtDNA as a record of population movements because mtDNA dates lineage divergence and not necessarily population divergence; thus it provides only a maximum age for the latter. Additionally, many of the assumptions of the models have also not yet been tested for the western hemisphere (Szathmary 1993). Linguists make claims similar to those made by geneticists. By making some assumptions about the rate of linguistic change, some argue that the diversity of Native American languages cannot be accounted for within the Clovis time frame. Nichols (1990), for example, suggests that different lineages must have entered North America at the rate of one every 3500 years, ascribing considerable antiquity to the earliest migration, or that a population from a single language family entered the New World some 35,000 years ago, and then

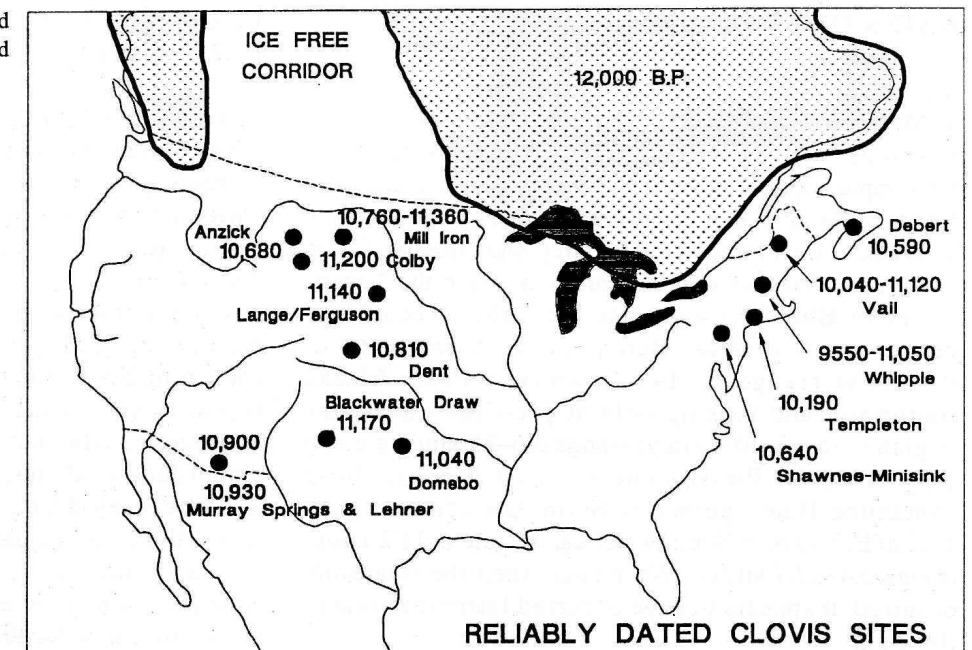
diversified. Yet there are questions here, too, about the rate of linguistic change in small populations, and the effects of adaptive processes. For me, therefore, the bottom line is the archaeology. If people were here in sizeable numbers before 11,200 B.P., then we should be able to find evidence of them.

There is some archaeological evidence of a pre-Clovis occupation, but it is not altogether convincing. Stone tools and their associated dates from Bluefish Cave in the Canadian Yukon (Cinq-Mars 1979) may suggest that people were in north-western North America between 12,000 and 15,000 years ago (Figure 2). From Meadowcroft Rock-shelter, there is perhaps evidence of the presence of humans in the continental U.S. 14,000 or 14,500 years ago (Adovasio *et al.* 1990) although the site still has some unresolved questions. From South America, Monte Verde suggests an occupation by at least 12,300 and possibly as early as 13,900 years ago (Dillehay 1989, Dillehay *et al.* 1992). Still greater antiquity is ascribed to the Brazilian sites of Pedra Furada and Toca da Esperanca, but there are significant problems with each of these (Lynch 1990). Most recently, Whitley and Dorn (1993) propose that rock varnish dating of artifacts in the Mohave Desert of southern California indicate that the tools were manufactured in excess of 20,000 years ago, but the accuracy of cation ratio dating and AMS dating of organics recovered from rock varnish is still debated (see Bierman, Gillespie 1994, Reneau *et al.* 1991).

Given the best evidence at hand, therefore, we have four major scenarios of colonization:

- (1) Clovis is the first migration and there are currently unknown problems with the dating or analysis of the

FIGURE 3. Location of reliably-dated Clovis sites, based on Haynes (1993) and Frison (1991a).



purported pre-Clovis sites. The linguistic and genetic arguments would also have to be incorrect.

- (2) There was at least one pre-Clovis occupation that moved only along the western coast of North America, but which turned east into the interior of South America (or which jumped over the isthmus of Panama and moved along the northern and eastern coasts of South America, to eventually turn inward and leave artifacts behind at Pedra Furada). A migrating population, those who would develop the Clovis technology, then occupied (the still empty interior) of North America at a later date by coming through the ice-free corridor soon after it opened.
- (3) A pre-Clovis population in North America became extinct relatively soon after its arrival (but perhaps not in South America, although whether it did is not critical to the argument here); Clovis-bearing peoples then later migrated into the empty North American continent.
- (4) A pre-Clovis population in North America was initially small, but grew in size, not becoming large enough to be recognizable archaeologically until about 11,200 years ago (Meltzer 1993: 162). This could be complicated by geomorphic processes at the end of the Pleistocene in North (but not South) America that may have prevented site burial and/or eroded earlier deposits (Butzer 1991).

As others have suggested, it seems likely that if there were a pre-Clovis population, that we would have found substantial evidence of it by now – especially if that population entered North America some 30 or 40,000 years ago. The Pleistocene population of eastern Siberia was undoubtedly sparse, and yet evidence of that population has still been recovered (in an area that has seen far less intensive archaeological research than the United States).

Compare this to the eastern United States, where there is only one good pre-Clovis candidate (Meadowcroft) but where there are some 50 sites containing fluted points (Meltzer 1988, 1991; although only a few have good radiocarbon dates) and over 9000 isolated fluted points (Anderson 1990).

The systematic removal or non-formation of pre-Clovis archaeological sites is a real possibility. The earliest evidence of the use of caves and rock-shelters on the High Plains of the United States is about 10,000 B.P. (Frison 1991a: 69), but earlier deposits may have been scoured out of these, as may have been the case at Medicine Lodge Creek Cave (Frison, personal communication, 1992). The same may have happened at some rock-shelters in Tennessee (Daniel Amick, personal communication, 1992). Pre-Clovis rock-shelters may also have completely eroded away, hiding the presence of pre-Clovis deposits to rock-shelter-fixated archaeologists (Collins 1991). Nonetheless, there are many rock-shelters that contain late Pleistocene deposits, but no cultural materials. And some archaeologists have intentionally sought out deposits of the appropriate age, but have come home empty-handed. While we would continue to look for pre-Clovis deposits, at present it is hard to draw conclusions from negative evidence.

In sum, in three of these four scenarios, we may have two or more instances of colonization of an empty landscape in the western hemisphere; Meadowcroft and Monte Verde, along with perhaps some other, less secure localities may record one and Clovis may record another. But in these three, Clovis-bearing peoples may have still been the successful occupants of an empty continent. Perhaps they cannot claim the distinction of being first, but they may still have been an instance of *H. sapiens sapiens* inhabiting an empty continent.

## RATES OF MIGRATION

Whether we accept Clovis, or those who left tools behind at Meadowcroft and Monte Verde as the first occupants, migration through the western hemisphere appears to have been rapid when compared to the rate of colonization of Beringia. Using available radiocarbon dates from sites such as Dyuktai Cave, the Nenana Valley and Bluefish Caves (Figure 2), and including scenarios in which the Nenana Valley or Bluefish Caves date the earliest occupation, people migrated across Beringia at an average rate of 0.5 km/yr (range 0.24–1.49 km/yr). From Alaska southward, and looking only at pre-Clovis sites, the migration rate is 10.3 km/yr (range 3.6–25 km/yr); using only terminal Pleistocene sites in Alaska, those containing fluted points in North America, and post-11,200 B.P. sites in South America, the rate is 11.2 km/yr (range 3.4–27.7 km/yr). No matter when the migration occurred, it appears to have occurred faster than that in Beringia.

Is the postulated rate of Clovis migration too fast? Certainly, it is not physically impossible: even the fastest unathletic of us could migrate on foot 11 km/year. But is it too fast for a population? We have almost no other instances of colonization of unpopulated land for comparison. From archaeological data, however, we can look to the initial occupation of the eastern Arctic of North America. Here, bearers of the Arctic Small Tool tradition migrated from Alaska across the northern reaches of Canada to Labrador and northern Greenland, a distance of 5500 km. Maxwell (1985) suggests the migration probably took about 300–500 years for a migration rate of 11–18 km/year. However, the 300–500 year range is only a guess, and available radiocarbon dates indicate an instantaneous occupation of the far eastern and western arctic (and the same happened again during the Thule occupation around 900 B.P.) – in much the same way that radiocarbon dates on fluted point sites suggest a nearly instantaneous occupation of the continental U.S. Thus, a migration rate of 11–18 km/yr for the Arctic Small Tool Tradition is only a minimum and it makes the postulated Clovis rate of migration appear reasonable. However, we must be cautious in offering this as an analogy, for Arctic Small Tool Tradition people moved along a strip of land that was similar environmentally, rather than across a continental land mass and through radically different biomes. It is not clear how long it would take Paleo-Indians to adapt to these new environments.

Having calculated a migration rate for Clovis from archaeological data (rather than from historical analogies or from population-density driven models), we must hasten to point out that this does not imply a continual year by year migration. As Todd and I argued (Kelly, Todd 1988), Paleo-Indians probably used large annual ranges that shifted long distances every few years. Thus, migration may have been, on the scale of an individual living at that time, more jerky, rather than continuous.

## COLONIZATION OF THE WESTERN HEMISPHERE

Lawrence Todd and I proposed a model to account for what we saw as unique features of early Paleo-Indian archaeology and that we thought was expectable given what is known about the ecology of foraging peoples. That is, we arrived at this model both inductively and deductively.

Coming from an arctic climate, colonizers would have been pre-adapted to hunting. But the environment they entered in North America was undergoing rapid change. Game was initially more abundant and more homogeneously distributed than today, but rapidly diminishing in abundance and becoming more localized as Late Pleistocene climate changed from non-seasonal to seasonal. Local fluctuations in game density dramatically lowered return rates periodically. In such instances, the colonizers would either have turned to new resources or moved to a new location. It is difficult to predict which option they would have selected. However, since experimenting with new resources is costly in the short term, Paleo-Indians may have chosen to move, following familiar game resources, rather than stay in place and shift to new foods (Kelly, Todd 1988). Modern foragers frequently move in preference to using secondary or less familiar resources because this gives them a higher mean return rate from foraging. Given the foraging model described above, we can expect a people who (a) move into an unknown region, (b) exploit a faunal base whose post-encounter return rates decline with exploitation, and (c) experience declines in foraging returns, relative to the cost of moving to a new region, from even slight increases in local population density to shift their ranges long distances after occupying them for fairly short periods of time.

We thought that Paleo-Indians faced a unique difficulty in moving into a new hunting area in response to local resource failure or diminishing returns. When modern foragers move, they move to be with relatives or friends who know their home region well. But the first occupants of North America had few or no neighbours – they moved into unknown terrain. Under these circumstances Paleo-Indians would have continued to rely upon game as their primary food source, because knowledge of game is more easily transferred from one region to another than knowledge of plants. This strategy would have been possible in the late Pleistocene given that game was more homogeneously distributed than during the Holocene. To a carnivore, the different environments Paleo-Indians crossed would have looked more similar than they would to a herbivore. This strategy, however, also put Paleo-Indians in a bind: to survive in a new place using familiar skills, they had to rely on animals that were rapidly disappearing or responding to humans by making themselves harder to catch (obviously, this would not be a problem if plants were the focus of diet). This required

Paleo-Indians to move constantly into new territory and thus they were pulled south, throughout the Americas.

We proposed that Paleo-Indians would move into a region, learn a few features, and use them redundantly as they continued to use familiar resources and strategies. Paleo-Indians had no recourse to "resource geography" to fall back upon, that is, knowing where to find food in a particular region, during a particular season, under a range of conditions. Resource areas used initially could have been used repetitively because they were locations that, although they may not have been the best places to use, could nonetheless be counted on to meet minimal needs.

Todd and I concluded that early Paleo-Indians were like Arctic hunters in some ways, but like tropical foragers in other. Just as there are no modern analogues for Pleistocene environments, there are no modern analogues for Pleistocene society in North America.

## PATTERNS IN PALEO-INDIAN ARCHAEOLOGY

The unique features of early Paleo-Indian archaeology, other than the apparently rapid spread of Clovis-bearing peoples throughout North America, can be accounted for within the proposed model. These are discussed elsewhere in more detail (Kelly, Todd 1988, Kelly 1995, 1996), and are only briefly reviewed here.

First, there is a reliance upon a bifacial technology and the use of high-quality stone for manufacturing tools. These tools are often transported long distances from their sources, several hundred or even over a thousand kilometres (e.g. Tankersley 1991). Made from high quality material, bifacial implements provided Paleo-Indians with long use-life tools. These would have been essential to a lifeway that was both residentially and logistically mobile, that is, where people moved frequently and long distances individually and in residential groups.

Second, the tools found in fluted point sites, beginning with the fluted points themselves, are more similar to one another, even from opposite coasts of North America, than tools from later time periods. While there are some stylistic differences among fluted points, the flute itself, which is difficult to learn to make and which frequently results in the breakage of the point testifies to strong cultural continuity across the continent. The similarity of the stone tools (see e.g. Goebel *et al.* 1991), despite the fact that they were deposited in many different kinds of paleoenvironments suggests that a similar niche was occupied across North America. Todd and I argued that Paleo-Indians were generalists with regard to fauna (not just large game) and opportunists in regard to everything else in a diversity of environments.

Third, relative to later time periods, there is virtually no fluted point material found in caves or rock-shelters. In the entire eastern U.S., there are no fluted points in good context in a cave or rock-shelter (Meltzer 1988). In the

state of Wyoming, a state thoroughly searched for Paleo-Indian sites by George Frison, there is not a single fluted point in a cave or rock-shelter. This could be a function of preservation of the deposits or the shelters themselves, as noted above. On the other hand, it is not an unexpected consequence of the model we proposed since shelters and caves are unique attributes of a region, and may not have been found and used by a people who remain in a region for relatively short periods of time. Some may point out that Paleo-Indians managed to locate high quality stone sources, which are also unique features of a landscape. But these sources occur over large exposures (geologically and through secondary deposits), increasing the probability that they will be encountered (Kelly 1996).

Fourth, relative to later time periods, there are very few cases of tool caching or food storage. While there are a few instances of Clovis tool caching (none for Folsom), most of these are associated with burials or cannot be accurately dated (Kelly 1996). For fluted point sites, there is only one demonstrated case of food storage, the Colby mammoth cache (Frison, Todd 1986) a location to which no one apparently returned. In sum, storage and caching were unimportant strategies in Paleo-Indian life. This, too, is expectable when a people cannot always anticipate how much of a resource will be available before a lean period, or where they will be or what will be available after the lean period. Storage implies a commitment to a particular region that is predicated upon an intimate knowledge of the resource potential of that region, the location and timing of resources.

## CONCLUSIONS

As noted above, the nature of migration is partially contingent upon the nature of the host population. In this regard, three things are important here to the colonization of the western hemisphere. First, the colonizers came from an arctic environment where they were well adapted to a hunting way of life, one in which plant collection did not figure prominently.

Second, they were adapted to a way of life in which technology was undoubtedly important. Data from ethnographically known hunting and gathering societies shows that technology is far more complex and diversified for arctic groups than for tropical groups. The initial inhabitants of the western hemisphere may have seen the maintenance of technology to be of great importance.

Third, the initial inhabitants of the continental U.S., regardless of when they entered, came either along the coast, or through the ice-free corridor. Neither route would have been pleasant, and I guess that foraging groups would have moved through them rapidly. A slow demic expansion through the ice-free corridor may not even have been possible (see Aoki 1993, Mandryk 1993); a rapid intentional trek may have been the only way through it. Since both routes are linear paths, migrating groups would

probably have been aware of the fact that they were moving in a single direction, southward, and that they were moving into new, unexplored terrain, someplace that even their grandparents knew nothing about. Exploration might very well have been part of their cultural ethic, but this was an ethic that was grounded in the unique economy of hunting in the rapidly changing, unpopulated environment of late Pleistocene North America. Knowing they were in unknown terrain, Paleo-Indians may have channelled their movements along major geographic features, e.g. the rivers feeding into the Mississippi (Anderson 1990) or the Rocky Mountains. In so doing, they may have been able to move across North America but not by a process of regional population saturation and group fissioning that would result if population growth were the primary driving factor in the colonization process.

In sum, the first colonists would have been hunting-adapted people who were accustomed to movement, exploration, and to a life dependent on technology. Entering North America just after 12,000 years ago, Clovis hunters entered a world undergoing a rapid climatic change, from a non-seasonal to a seasonal environment and in which many species of fauna were going extinct. Local environments were probably very unstable, giving these hunters a reason to move, and the rapid decrease in return rates that would come from the hunting of a naive fauna would make other areas look all the more rewarding. Paleoenvironmental data indicate that there was less environmental differentiation between regions than exists today, thus lowering the cost of migration and encouraging movement. A dependence on game is probably what permitted these first hunters to move across North America, although it is also probably what forced them to move frequently as well, since they could not turn to other resources as a response to declines in the return rate from hunting. In sum, Paleo-Indians had every reason to move, and no reason not to, but little time in which to learn much about each new local environment.

These facts suggest an initial Paleo-Indian lifeway that was highly mobile and that fits a model of Transient Explorers rather than Estate Settlers, and points to a rapid occupation of North America (at least) but not one that necessarily was driven by high population growth and density-dependent migration. I expect that the variation that exists within Paleo-Indian archaeology can be accounted for by variation in the variables described here: density of fauna, fluctuations in game, responses by different species to humans, etc. Looking further afield, I would not expect the colonization of other land masses by *H. sapiens sapiens* to have been the same as that reconstructed here for North America, given differences in environment and the nature of the colonizing population, but I would expect it to have operated in terms of the same economic and evolutionary principles.

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