March, 2008

Llama Caravan Transport: A study of mobility with a contemporary Andean salt caravan

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Available at: https://works.bepress.com/tripcevich/7/
Llama Caravan Transport: A study of mobility with a contemporary Andean salt caravan.
Invited paper presented in the “Nomads Anew” symposium at the 73th Annual Meeting of the Society for American Archaeology, Vancouver, B.C., Canada.

This talk is about a study of transportation in highland Peru where we travelled with a traditional llama caravan for fourteen days. I’m going to begin this talk by showing a two minute clip from a longer video from our trip. Our focus was on studying transport speed and how trails and obstacles were negotiated, attention to changes in trail steepness and the footing, and other trail characteristics.

[Show two minutes of Llama Purichiq video online]
http://www.mapaspects.org/caravans/2007_project/mmedia

The ability to transport goods is a key attribute of mobile pastoralism in both contemporary settings and in the past. In mountainous environments, groups of cargo-bearing animals being led along trail systems was often the principal means of moving food and other goods between communities. These kinds of interrelationships facilitated the development of strong economic ties and influenced social organization through time. While the act of transport itself usually leaves little physical evidence along the route, the archaeological implications of regional transport and trade are far reaching.
The llama caravan we studied in 2007 was bearing rock salt from the Huarhua quarry in the Cotahuasi valley in Arequipa across the high grassland to southern Apurimac. In Apurimac, the salt was traded for tubers, maize, and other products, as well as sold for cash prior to our return. I selected this area for the study because llamas are still widely used here for transport, although they have largely been replaced by Old World domesticates like donkeys and mules in other parts of Peru.

The initial impetus behind this study sprang from my dissertation research which focused on prehispanic trade relationships in antiquity and interpreting regional obsidian distributions in archaeological contexts. I was able to study various long distance relationships using the Geographical Information System, ArcGIS, but explicit transport costs were largely unknown because we lack empirical data.
A general transport model might also inform on archaeological questions such as the role or capacity of households in long distance exchange, transport between ecological zones, interaction between state centers and colonies, and military provisioning by the expansionist states. Furthermore, consider the mountainous context for many Andean civilizations: they arose at high altitude far from the coast or major rivers and transport was largely overland. The extraordinary but costly Inka road system was described by 16th century Spanish invaders as being far better than European roads of the time, and it was central for state integration, communication and transport.
A quick review of llama caravans: cargo bearers are mostly castrated male llamas, although alpacas sometimes do short trips and we mustn’t forget that historical sources indicate that human porters were widely used by the Inka. Our larger findings confirm what is generally known about llama caravans: They travel about 15 to 20km per day and on long journeys they carry between 20 and 30 kg per animal in two costales. Our caravan involved two families of Quechua herders contributing 13 and 15 llamas each to the caravan. Caravan drivers are strong and self-sufficient and while it is usually only men and boys making long journeys, we saw many women with loaded llamas doing shorter, local trips. On long journeys, caravan drivers also serve a diplomatic role interfacing with neighboring groups, conveying information, and maintaining ties over distance.
The research in 2007 used GPS and heart rate monitors to gather high resolution spatial data during the journey, but more subjective data concerning concepts of space, route choice, and social relationships across distance are also critical. Much of this information came in the form of interviews along the route. We also recorded cargo types and the daily shifting of loads between animals depending on performance, and the negotiation of obstacles like rivers and canyons and potentially hostile communities. Scheduling of grazing was a key issue, and we left early in the mornings, often waking at 4 am, to allow for grazing time in the late afternoon and rumination at night.
During nearly the entire journey we gathered 2 second interval GPS data to model transport speeds as a function of slope. The goal was to develop a model of travel speed known as an asymmetrical cost-distance function specifically for llama caravans. With these functions, slope in degrees is used in a GIS to estimate the time to cross a single cell of a topographic surface raster.
Along with topography-based analyses like viewshed, these cost-distance models include many assumptions about the past. However, it has been argued that these provide a perspective is closer to the experience of the traveler, in units such as hours, rather than abstracted, linear map measurements. Folk estimates for travel, such as “3 miles per hour, plus ½ hour for every 1000 feet climbed” are common among people living in mountain areas. The best known example of this is from the work of geographer Waldo Tobler who derived an explicit function based on data from marching Swiss soldiers gathered in the 1950s in a format that is amenable to GIS analyses and provides an example for this study. In this example, optimal speed is 6 km per hour on a slight downslope of -3.5 degrees.
Why are such models useful? Consider, for example, the temporal signs one can now encounter on roads in dense urban areas. Despite the assumptions involved, these signs are usually more informative to drivers than are linear distance measures.
I have applied this function to obsidian distributions from the Chivay source in highland Peru and the GIS then calculates the path with the shortest cumulative time to sites where this obsidian was consumed. In personal experience, however, I found these travel rates to be too fast and for this reason, I felt that what is needed is to construct a model from additional empirical evidence.
The caravan drivers during our 2007 study are native Quechua speakers who live year
around in the herding community of Chancara at 4600 masl where they raise llama, alpaca,
sheep and a few cattle. This community is one of a number of dispersed herding
settlements on the high grassland bordering on the deep Cotahuasi valley. The Cotahuasi
valley is a rich agricultural area and herd- ers like Fidel Cruz can trade pastoralist products for
agricultural goods, as well as use llamas as cargo bearers for transporting bushels of grain
and other items. While mutualism between herders and farmers occurs throughout the
Andes, these herders also belong to a community that controls the regionally important
salt quarry of Huarhua.

Thus, interaction with agriculturalists is a regular subsistence pattern for Fidel Cruz, while
long-distance caravans to trade salt were annual events.

Many of these relationships are described in the 27 hours of Quechua interviews that were
recorded by a Peruvian student in our project, which have been transcribed but remains to
be translated.
This research focused on both quantitative and qualitative aspects of transport. We logged GPS points the entire journey at a 2 sec interval using a data logger, and an equine heart rate monitor was used to estimate exertion. We also weighed the cargo borne by each animal, and periodically used a GPS/Heart rate monitor on the herders and on the foreigners to compare exertion. A more formal behavioral study might convert these data to caloric consumption, but for the initial goals of this project, time estimates by distance are suitable.
[THESE RESULTS WERE PRELIMINARY AND ARE NOW OBSOLETE]

Analysis of our results is ongoing, and I am presenting the first round of these findings. The optimal travel speed is on a -8.6 degree slope where llamas travelled over 4 km per hour.

The GPS data logger functioned all eleven travel days except on one particularly cold morning when the batteries froze despite my best efforts. We have about 60 hours of travel data, amounting to approximately 100,000 GPS positions including rest times. The preliminary results shown here are only from the biggest descent and ascent days.

Showing Green Tobler’s curve: This is not as fast as Tobler’s model estimates for unladen human travel, but is steeper than the optimal slop in Tobler’s function perhaps because quadrupeds often descend more swiftly than bipeds.
We also made general observations about travel: A given llama will travel in the front, middle, or rear of the caravan, with the lead llama undergoing some training but the rest of the llamas naturally assuming a position based on their disposition. We were able to make observations about llama caravan flocking behavior on different types of terrain. When travelling on open grassland, or along a normal road, the llamas travel in a wedge-shaped formation with the lead llama always at the front.

However, when the trails become narrower travel speeds slow considerably as they must assume a double or single file caravan. This suggests that the Inka roads, often 6 or more meters across (and surprisingly wide in mountainous areas) would have permitted rapid caravan travel.

We found that delays occurred before and after steep pitches, when the llamas were driven into corrals that were nearly always available near inclines so that loads could be refastened. The route choice on the whole, and the links to the town that was our destination, turned out to be based on long-standing family ties. This was despite a period of serious violence during the late 1980s.

Thus while reciprocal relationships and barter opportunities that underlay many of the trade ventures, family links permeated the larger ties across distance and motivated Fidel Cruz to set out on a long distance voyage of uncertain economic return. Obviously, our cash compensation for allowing us to accompany them didn't hurt either.
In addition to traveling speed, defined here as travel greater than \( \frac{1}{2} \) km per hour, this study focuses on temporal patterns of caravan travel. Using a separate GPS unit I noted rest breaks and classified the reason for each break into groups such as: cargo refastening, rests for humans and animals with or without snacks, breaks to begin a fresh coca-chew, and conversations with passersby. Breaks have bases in environmental and cultural demands, and the GPS data permits these to be linked to topography and other environmental features. On longer journeys, a lay-over rest day is common every 4-5 days of travel, which is another interesting temporal issue. Additional ethnoarchaeological observations, such as use of corral architecture, ritual practices, food preparation and bone disposal were important aspects of our study but was not part of this talk.

A number of assumptions such as the specific routes in the past, the comparability of contemporary llama caravans, the influence of market economies on behavior, and the changes in the behavior and attitudes of llameros are relevant. These cost-distance estimates attempt to approximate a *minimum* of travel time, as any number of delays can slow travel. Finally, it is likely these cost measures are useful for comparisons between consumption sites in a relative sense, more than absolute accuracy with respect to hours travelled.
While these general models have various limitations in terms of specifics of human behavior, empirical research with the remaining llama caravan traditions contributes to our understanding of ancient transport. The Andean highlands are an interior region with few navigable rivers and only one major cargo bearer besides human porters and possibly dogs, thus the modern llama caravan represents an import source of insights about past transport with cargo animals.