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On optimal use of a patchy environment: archaeobotany in the Argentinean Andes (Argentina)

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A B S T R A C T

In this paper, optimal foraging theory is used to interpret wild plant collecting behaviors using experimental data and remains recovered from eleven archaeological sites in the Argentine Andes. Using simple techniques believed to approximate those of traditional hunting and gathering societies, I collected and processed twelve plant species endemic to southern Mendoza Province to assess their utility as human food resources. Experimental collection and processing events were timed and total caloric yield weighed against post-encounter handling time to determine each resource's relative rank. In addition, I calculated maximum transport distances to better understand which resources are likely to be recovered in the archaeological record. The results suggest that the distance that must be traveled to reach each plant gathering site determines the whether particular plants will be collected since people should maximize caloric yield relative to both handling costs and transport distance. I conclude by cautioning that optimal foraging theory does not explain all of the variation in hunter-gatherer plant collection, but suggest that the value of the approach lies in its capacity to provide testable hypotheses of foraging behavior and behavioral changes likely to occur under different circumstances.

1. Introduction

Cost-benefit models derived from optimal foraging theory provide a robust framework for the analysis of hunter-gatherer subsistence patterns (e.g. Bettinger, 2009; Kaplan and Hill, 1992; Pyke et al., 1977; Smith and Winterhalder, 1992). I argue that these models provide a new perspective on the assessment of human dietary breadth in the Argentine Andes, a patchy environment characterized by dramatic ecological changes in relatively short distances. This paper provides a synthesis of experimental and archaeobotanical research conducted over the course of the last five years in central western Argentina and northern Patagonia (Llano and Ugan, 2010; Llano, 2011; Llano et al., 2012; Llano and Barberena, 2013). I have produced data on the costs and nutritional benefits of obtaining and processing native plant resources, providing the basis for a quantitative application of foraging models at a macro-regional scale.

Evolutionary ecology is distinguished as a subfield of biology by the use of simple mathematical models to predict relationships between features of the natural environment and variation in animal behavior that can be tested with quantitative observations (Winterhalder and Smith, 1992).

Ecological and evolutionary models facilitate pattern detection and offer testable predictions and are therefore well suited for the study of decision-making criteria related to natural resource and landscape use (Soldati and Albuquerque, 2012). Despite some early criticism (e.g. Begossi, 1993; Pierce and Ollason, 1987), optimal foraging theory is an increasingly common approach to the study of human behaviors (Borgerhoff Mulder and Schacht, 2012; Brown and Richerson, 2014; Figueroa and Dantas, 2012; Winterhalder and Smith, 2000).

Optimal foraging models generate hypotheses for the study of benefits and costs associated with various strategies of food procurement (Bettinger, 2009; Simms, 1984; Smith and Winterhalder, 1992; Stephens and Krebs, 1986). Two primary foraging models consider the costs and benefits of acquiring resources: prey and patch choice models (Charnov, 1976; MacArthur and Pianka, 1966). Prey choice models are designed to predict the food items foragers should attempt to exploit ("handle") and those they should ignore in favor of continued search for higher-ranked foods (Kaplan and Hill, 1992). The currency in the simplest model is energy. The

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model assumes that foragers' decisions are designed to maximize the long-term net rate at which energy is acquired during foraging, and that foragers have no impact on resource abundance and distribution (Kaplan and Hill, 1992). Because foragers spend energy and time in obtaining resources (MacArthur and Pianka, 1966), the distance that must be traveled to obtain them may determine which resource patches will be visited. Patch choice models consider that when a forager enters a patch and begins to exploit it, the rate at which he or she gains energy from the patch may change as a function of time spent there (Kaplan and Hill, 1992). The patch choice model assumes that resource return rates diminish exponentially as foraging time in a patch increases.

The data presented here represent handling costs, that is, the cost of collecting and processing a resource once it has been encountered. The accompanying nutritional data should be useful to those interested in the food value of wild plants, and may also prove useful in foraging models requiring the analysis of variables other than energy.

The cost/benefit data presented here are expressed as post-encounter return rates measured in units of energy acquired per unit of time invested. Post-encounter costs are termed “handling time” and can be used to construct a ranking of resources to assess dietary breadth (Simms, 1985). Resource ranking is a tool for making initial predictions about the order in which resources will be added to or excluded from a changing diet (e.g., Charnov and Orians, 1973; MacArthur and Pianka, 1966; O'Connell and Hawkes, 1984; Simms, 1984:30–35).

From this perspective, I utilize the ecological variables proposed by OFT to assess whether prehistoric people acquired wild resources according to a strategy designed to minimize energy expended in foraging. I develop a method of estimating the cost of resource transportation and use the results to illustrate how these and similar data can be incorporated into existing diet breadth models to generate hypotheses concerning resource exploitation. This study is an important starting point because it is well matched to a level of data typically found in the archaeological record. Analyses of eleven archaeological sites, in different areas of southern Mendoza and northern Neuquén (Fig. 1) are presented here. The results form the basis of a novel paleodietary and spatial interpretation of past human behavior in patchy environments.

1.1. Environmental setting

The study area, from central Mendoza Province to northern Neuquén Province (between 33° and 40° S, 70° and 67° W) is characterized by marked environmental diversity (Fig. 1). In geomorphological terms it includes the Andes mountains to the west, a piedmont fringe extending along the mountain front, and a large eastern plain (Abraham, 2000; González Díaz and Fauqué, 1993). The Diamante, Atuel, Grande, and Colorado Rivers drain the area (Dessanti, 1956, 1978; González Díaz, 1972). In this part of Patagonia, there is a transition between two atmospheric circulation systems, the Subtropical and the Temperate (Páez et al., 2004), resulting in arid and semi-arid conditions, with annual precipitation ranging between 900 mm in the west and 250 mm in the east (Abraham, 2000). Based on the northern and southern weather patterns described by Páez et al. (2004), the study area is under the influence of the southern pattern reflecting variability in the seasonality of rainfall. Large seasonal variations are due to elevation and continental conditions (Capitanelli, 1972). Plant communities of several phytogeographic provinces (e.g., Monte, Patagonia, Altoandina) are distributed following altitudinal and latitudinal gradients (Cabrera, 1976; Mare et al., 1985; Morrone, 2001; Roig, 1972; Roig et al., 2000; Ruiz Leal, 1972). The

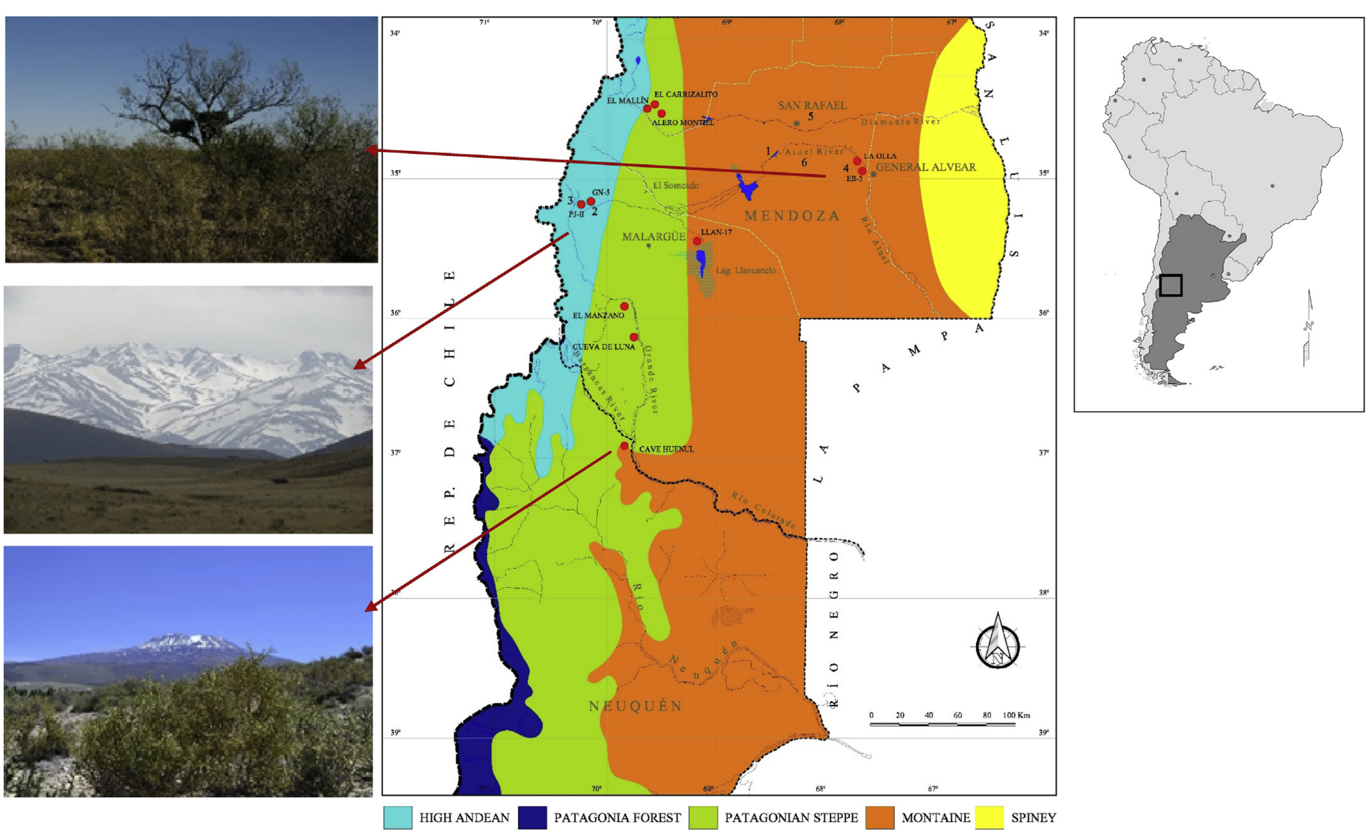

Fig. 1. Location of archaeological sites.