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- Minor, Rick, and Ruth L. Greenspan  
1985 Archaeological Testing in the Southeast Area of the Headquarters Site, Malheur National Wildlife Refuge, Harney County, Oregon. Eugene: Heritage Research Associates Report No. 36.
- Moyle, Peter B.  
1976 *Inland Fishes of California*. Berkeley: University of California Press.
- Pettigrew, Richard M.  
1985 Archaeological Investigations on the East Shore of Lake Abert, Lake County, Oregon. University of Oregon Anthropological Papers No. 32.
- Phillips, Kenneth N., and A. S. Van Denburgh  
1971 Hydrology and Geochemistry of Abert, Summer, and Goose Lakes, and Other Closed-basin Lakes in South-central Oregon. United States Geological Survey Professional Paper 502-B.
- Snyder, John Otterbein  
1908 Relationships of the Fish Fauna of the Lakes of Southeastern Oregon. United States Bureau of Fisheries Bulletin 27: 69-102.
- 1917 The Fishes of the Lahontan System of Nevada and Northeastern California. United States Bureau of Fisheries Bulletin 35: 31-86.
- Spier, Leslie  
1930 Klamath Ethnography. University of California Publications in American Archaeology and Ethnology 30.
- Stewart, Omer C.  
1941 Culture Element Distributions, XIV: Northern Paiute. University of California Anthropological Records 2(3).
- Thomas, David Hurst  
1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3: 7-43.
- Toepel, Kathryn Anne, and Stephen Dow Beckham  
1981 Survey and Testing of Cultural Resources along the Proposed Bonneville Power Administration's Buckley-Summer Lake Transmission Line Corridor, Central Oregon. Eastern Washington University Reports in Archaeology and History 100-5.
- Toepel, Kathryn Anne, Rick Minor, and Ruth L. Greenspan  
1984 Archaeological Testing in Diamond Valley, Malheur National Wildlife Refuge, Harney County, Oregon. Eugene: Heritage Research Associates Report No. 30.
- Toepel, Kathryn Anne, Rick Minor, and William F. Willingham  
1980 Human Adaptation in the Fort Rock Basin: A Class II Cultural Resources Inventory of BLM Lands in Christmas Lake Valley, South-central Oregon. Report on file at the Bureau of Land Management, Lakeview, Oregon.



## Acquisition Cost and Nutritional Data on Great Basin Resources

STEVEN R. SIMMS

As part of an earlier study (Simms 1984), data on the costs and benefits of obtaining native food resources in the Great Basin were generated for use in foraging models developed from evolutionary ecology. Portions of these data are presented here for the benefit of researchers interested in the acquisition costs and nutrition of wild foods.<sup>1</sup>

These data represent handling costs only; that is, the cost of acquisition once a resource has been encountered. They are applicable to a variety of questions, some beyond the goals of the study for which they were collected, involving the addition and deletion of resources to human diets. 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. On the other hand, data on search

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costs reported in Simms (1984) tend to be more problem-specific and their presentation is beyond the scope of this paper. Hypotheses about search costs and discussions of issues regarding them can be found in Simms (1984).

The cost/benefit data presented here are expressed as post-encounter return rates measured in units of energy acquired per unit of time. Post-encounter costs are termed "handling time" and can be used to construct a *resource ranking* to investigate questions about dietary breadth. Resource ranking is a tool for making initial predictions about the order in which resources will be added to or deleted from a changing diet (e.g., MacArthur and Pianka 1966; Charnov and Orians 1973; O'Connell and Hawkes 1984; Simms 1984: 30-35). However, without some knowledge of search time, which is primarily a function of resource abundance, it is not possible to make predictions about the proportional contribution of a resource to the total diet. Nevertheless, given that many subsistence changes observable in the archaeological record are of the diet-breadth type where a resource is first becoming utilized or being deleted, data on handling time can be informative. Archaeology is replete with cases where the appearance or disappearance of resources in the environment and diet are known to have occurred, but where knowledge about the past relative *quantities* of resources remains elusive. The diet-breadth model is an important starting point because it is well matched to a level of data typically found in the archaeological record. Two examples that show the kinds of applications possible and illustrate some of the relationships made evident by this approach are included here.

### METHODS

The post-encounter return rates and resource rankings discussed in this paper were derived from direct field experiments (plants)

or estimated based on previous studies and consultant observations (animals). Methods of measurement are described below.

### Plants

Handling-time data for plants were obtained through collecting experiments conducted between 1980 and 1982. Only those experiments that produced reliable data were considered. Among others, this excludes experiments conducted while the author was learning the collecting techniques. Figure 1 and Table 1 identify the field experiment

Table 1  
LIST OF PLANT-GATHERING LOCATIONS  
SHOWN IN FIGURE 1

Reference Number on Fig. 1	Location	Resources Collected
1	Gund Ranch	<i>Elymus cinereus</i> , <i>Sitanion hystrix</i> , <i>Distichlis stricta</i>
2	Pine Valley	<i>Elymus cinereus</i> , <i>Sitanion hystrix</i> , <i>Distichlis stricta</i>
3	Pine Valley	<i>Lepidium perfoliatum</i>
4	Ruby Mountains	<i>Poa bulbosa</i>
5	Toano Range	<i>Pinus monophylla</i>
6	near Wendover	<i>Oryzopsis hymenoides</i>
7	Crystal Peak	<i>Pinus monophylla</i>
8	Skull Valley	<i>Lewisia rediviva</i>
9	Baker Hot Springs	<i>Allenrolfea occidentalis</i> , <i>Scirpus</i>
10	near Grantsville	<i>Atriplex confertifolia</i> , <i>Atriplex nuttalli</i>
11	near Grantsville	<i>Muhlenbergia asperifolia</i> , <i>Scirpus</i> , <i>Hordeum jubatum</i>
12	near Grantsville	<i>Typha latifolia</i>
13	Great Salt Lake	<i>Scirpus microcarpus</i>
14	Emigration Canyon	<i>Quercus gambelli</i>
15	Great Salt Lake	<i>Typha latifolia</i>
16	Sevier River	<i>Scirpus</i>
17	Sevier River	<i>Phalaris arundinacea</i>
18	Brine Creek	<i>Oryzopsis hymenoides</i>
19	Abes Creek, Fishlake Mountains	<i>Poa compressa</i>
20	Fishlake Plateau	<i>Carex</i>
21	Sanpete Valley	<i>Distichlis stricta</i>
22	Sanpete Valley	<i>Elymus salinas</i>
23	Ferron Creek	<i>Muhlenbergia asperifolia</i> , <i>Echinochloa crusgalli</i>
24	near Huntington	<i>Helianthus annuus</i>

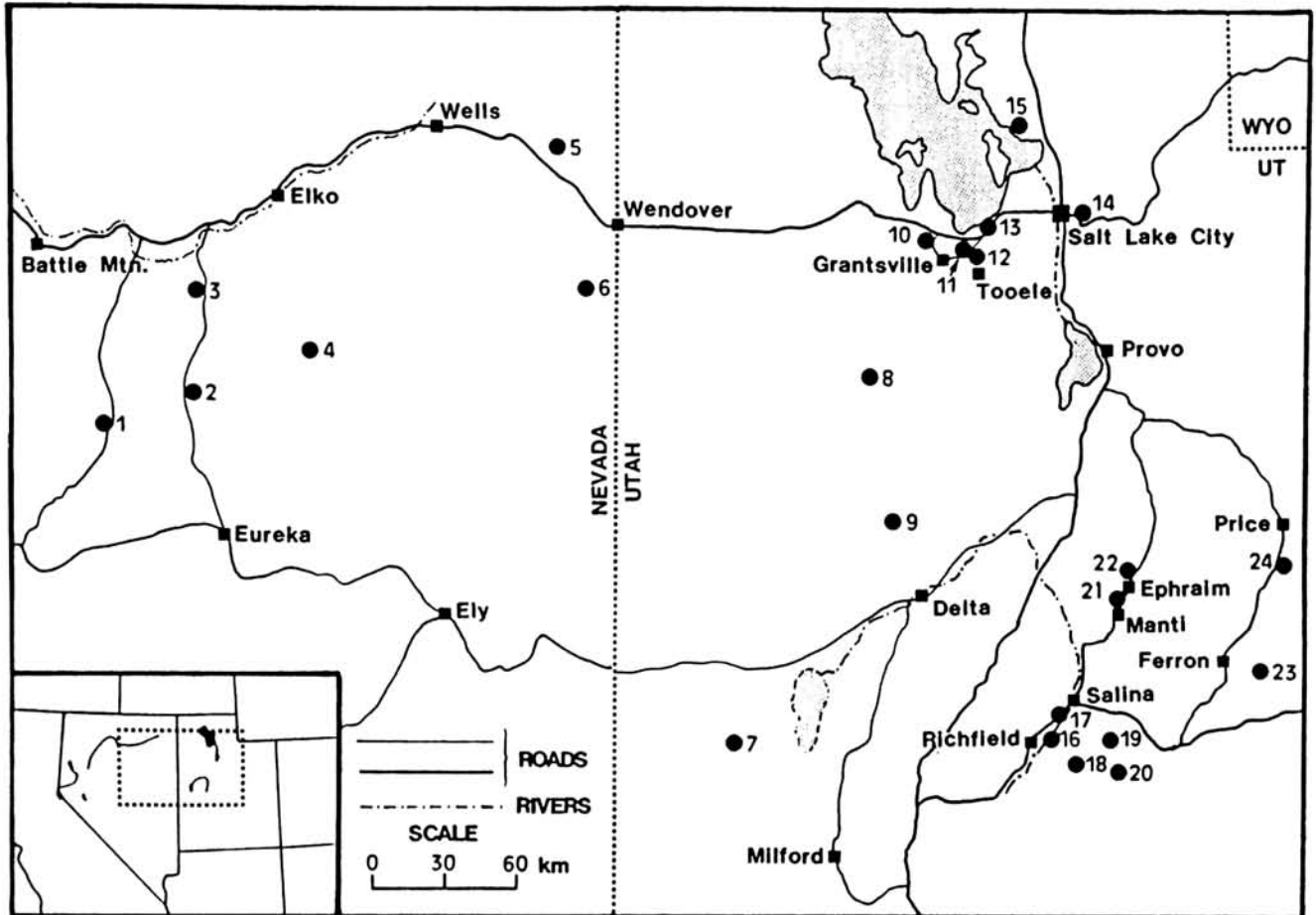


Fig. 1. Map showing locations of plant collecting experiments (see Table 1 for key to reference numbers).

locations. Table 2 presents nutritional data, and Table 3 provides return-rate data and notes on resource characteristics. More detailed comments about the resources, strengths and weaknesses in the data, and archaeological issues relevant to specific aspects of the data are offered in Simms (1984: Appendix).

Few tools were used to collect the plant resources. Two open-faced baskets, each about 40 cm. in diameter and 10 to 15 cm. deep, served as receptacles. One was bowled, similar in design to ethnographic Great Basin baskets, and shallow enough to be effective in winnowing small seeds. A flat winnowing tray was also used. A slightly dished metate, measuring 50 by 25 cm., and a one-handed

mano were used when grinding was necessary (e.g., in the case of pine-nut hulling).

The return rates shown in Table 3 reflect the costs in time of pursuit and processing. Pursuit time is that spent gathering the resource into a receptacle. Processing time reflects the winnowing and parching of seeds to prepare them for storage. Seeds were not ground into meal. While this would add to the processing time, it was found that for most seeds in the Great Basin, grinding represents a small fraction of total processing time (Simms 1984: 85). This would not hold true for larger, harder seeds such as those of mesquite. Root processing was limited to cleaning and removal of the epidermis. The density of plants within a stand can affect return rates to

Table 2  
NUTRITIONAL COMPOSITION OF PLANT RESOURCES

Resource	Cal./kg.	Percent Protein	Percent Carbohydrates	Percent Fat	Percent Ash	Percent Moisture
<i>Allenrolfea occidentalis</i>	2,300	10.5	46.9	0.50	36.6	5.5
<i>Atriplex confertifolia</i>	2,790	3.9	67.9	0.01	21.3	6.9
<i>Atriplex nuttalli</i>	3,000	7.7	69.3	0.01	17.9	5.2
<i>Carex</i>	2,590	10.6	54.9	0.30	30.9	3.4
<i>Descurainia pinnata</i>	3,660	27.2	63.3	0.50	2.9	6.1
<i>Distichlis stricta</i>	2,540	6.2	58.0	0.40	28.1	7.4
<i>Echinochloa crusgalli</i>	3,510	9.5	80.4	0.01	5.3	4.9
<i>Elymus cinereus</i>	2,800	8.8	59.3	1.40	26.8	3.6
<i>Elymus salinas</i>	2,750	12.5	55.9	0.60	24.1	6.9
<i>Helianthus annuus</i>	3,650	15.9	69.6	3.00	2.9	8.7
<i>Hordeum jubatum</i>	3,070	13.4	64.0	0.30	18.3	4.0
<i>Lepidium fremontii</i>	3,160	23.5	55.6	0.10	13.6	7.1
<i>Oryzopsis hymenoides</i>	2,740	15.2	53.9	0.10	27.3	3.6
<i>Phalaris arundinacea</i>	2,610	13.5	52.6	0.02	28.8	5.1
<i>Poa bulbosa</i>	—	11.9	64.5	0.60	19.2	3.8
<i>Poa compressa</i>	3,340	10.9	73.5	0.40	6.1	9.2
<i>Scirpus paludosus</i> (seeds)	3,050	6.5	56.9	6.30	23.7	6.6
<i>Scirpus acutus</i> (unchewed root)	630	0.2	15.4	0.30	1.6	82.6
<i>Scirpus acutus</i> (roots chewed into quids)	510	0.1	12.5	0.30	0.5	86.8
<i>Muhlenbergia asperifolia</i> or <i>Sporobolus asperifolius</i>	2,420	10.9	50.0	0.30	4.5	34.5
<i>Typha latifolia</i> (pollen)	1,040	4.9	18.2	1.50	6.4	69.0

some degree. Estimates of plant density were made based on counts within sample areas, but these data are not reported here.

Although experiments to compare the efficiency of various seed beaters against hand collection of seeds were not routinely conducted, a stick seed beater (35 cm. long by 2 cm. in diameter) and, occasionally, a woven beater (20-cm.-diameter fan) were used on selected plants that exhibited structural differences. Comments about seed beater effectiveness in Table 3 refer to whether the beaters worked at all, and do not imply that higher return rates can be obtained by using a beater. To compare all of the variability in the effectiveness of seed beaters versus other techniques would require many more experiments than were done in the original study (Simms 1984). The goal in acquiring the return-rate data was to produce general figures amenable to *ordinal* level comparison

between resources and between classes of resources (e.g., nuts vs. seeds vs. roots).

Nutritional data were provided by Ford Chemical Labs in Salt Lake City, Utah. All specimens submitted for analysis were less than three weeks old. Roots were kept cold in the field, then frozen. In addition to calories, the samples were measured for protein, fats, carbohydrates, ash, and moisture. The values for ash are largely a product of the parching process. Seeds with chaff that was difficult to remove tended to have a larger ash component from burned chaff that continued to adhere to the seeds after parching.

### Animals

Handling-cost data for animals were generated through knowledge of edible animal weights (based on a variety of modern game studies) and estimates of the ranges of pursuit and processing times. The weights used here

Table 3

## PLANT RESOURCE RANKING: PURSUIT AND PROCESSING TIME AND RETURN RATE

Resource	Pursuit (hrs./kg.)	Processing (hrs./kg.)	Return Rate (Cals./hr.)	Notes
<i>Typha latifolia</i> Cattail (pollen)	0.12-0.37	0	2,750-9,360	Pure pollen; can be made into cakes (Wheat 1967:11).
<i>Quercus gambelli</i> Gambel Oak (acorns)	0.6-2.4	1.0-1.1	1,488	Lower tannin content than California species; leaching unnecessary if not a staple.
<i>Descurainia pinnata</i> Tansymustard (seeds)	2.0	0.8	1,307	Woven seed beater effective; low processing time relative to most seeds.
<i>Pinus monophylla</i> (cones) Pinyon Pine (nuts)	0.7 1.8-2.0	3.8 3.6-3.2	841-1,408+	Brown cone procurement and picking nuts off the ground are measured; available over many weeks with successive harvest strategies; if mats are placed under tree as Steward (1933:241) reported and Lanner (1981:102) has done, return can rise to over 4,000 Cals./hr.; predator competition can alter return rates; nuts rich in tryptophan, an amino acid deficient in corn.
<i>Lewisia rediviva</i> Bitterroot (roots)	1.4	1.3	1,237	Used digging stick; skins come off best and are easiest to find in late spring to early summer; return rates lower in other seasons.
<i>Elymus salinas</i> Salina Wild Rye (seeds)	1.0*	1.2*	921-1,238	Extremely high density caused by stand growing next to agricultural field; high end of range in return rates.
<i>Atriplex nuttalli</i> Nuttall Shadscale (seeds)	0.9	1.6	1,200	Similar to <i>A. confertifolia</i> , but small bracts require less processing.
<i>Atriplex confertifolia</i> Shadscale (seeds)	0.4	2.3	1,033	Large seeds; available into mid-late winter because of tenacious attachments; seed beater effective.
<i>Scirpus</i> sp. Bulrush (seeds)	1.1-6.6	0.6-3.5	302-1,699	Low return rate during early-season (July) harvest; high rate during late-season (October) harvest of large-seed species on dry ground; seed beater effective.
<i>Echinochloa crusgalli</i> Barnyard Grass (seeds)	4.2	0.8	702	
<i>Lepidium fremontii</i> Peppergrass (seeds)	1.0-2.1	1.7-4.9	537	Seed beater fairly effective; native species requires more processing than more common, introduced species, <i>L. perfoliatum</i> .
<i>Helianthus annuus</i> Sunflower (seeds)	5.8-6.5	0.7-2.0	467-504	Several successive harvests possible at some stands.
<i>Poa</i> sp. Bluegrass (seeds)	3.0-5.7	1.1-5.0	418-491	Seed beater ineffective; several weeks of availability at most stands.
<i>Elymus cinereus</i> Great Basin Wild Rye (seeds)	4.0-7.1	1.9-3.4	266-473	Amenable to mass processing; cutting spikes and threshing, seed beater ineffective except for brief period during harvest.
<i>Oryzopsis hymenoides</i> Indian Rice Grass (seeds)	4.0-5.7	1.8-3.5	301-392	Amenable to mass processing; seed beater effective only during peak harvest period.
<i>Muhlenbergia asperifolia</i> or <i>Sporobolus asperifolius</i> Scratchgrass (seeds)	6.5-12.5	1.4-2.9	162-294	Seed beater effectiveness variable; dependent on timing of harvest.
<i>Hordeum jubatum</i> Foxtail Barley (seeds)	2.5-11.1	8.7-11.1	138-273	Best when picked in masses and processed by threshing.
<i>Carex</i> sp. Sedge (seeds)	10.6	2.2	202	Higher return rates likely with better timing of harvest.
<i>Typha latifolia</i> Cattail (roots) – optional	9.0	3.5	128-267	High return rate with minimal processing (cleaning only); low return rate when starch removed by pounding; collected in large masses; low starch content in winter/spring; not amenable to winter harvesting.
<i>Scirpus</i> sp. Bulrush (roots)	0.7-1.5	0.3-1.4	185	Collected in large masses; cleaning and skin removal only; return rate based on chewing roots into quids, inedible fraction not counted.
<i>Distichlis stricta</i> Saltgrass (seeds)	12.5-13.3	3.3-4.1	146-160	Long availability (June-September); amenable to mass processing.
<i>Allenrolfea occidentalis</i> Pickleweed (seeds)	8.6-16.6	9.8-11.6	90-150	Very small seeds; seed beater not effective; long availability (late August - early November).
<i>Sitanion hystrix</i> Squirreltail Grass (seeds)	19.2	11.8	91	Similar to <i>Distichlis</i> , but shorter span of availability.

\*using seed beater



Table 4  
ANIMAL RESOURCE RANKING: PURSUIT AND  
PROCESSING TIME AND RETURN RATE

Resource	Total (Cals./ind.)	Pursuit (hrs./ind.)	Pursuit (hrs./kg.)	Processing (hrs./ind.)	Processing (hrs./kg.)	Handling (hrs./kg.)	Return Rate (Cals./hr.)
Deer and Bighorn Sheep	42,900	0.01-1.00	0.0006-0.03	1.50	0.040	0.04-0.07	17,971-31,450
Pronghorn	30,888	0.02-1.00	0.0008-0.04	1.00	0.040	0.04-0.08	15,725-31,450
Jackrabbit	1,103	0.02-0.03	0.02 -0.03	0.05	0.050	0.07-0.08	13,475-15,400
Gophers	464	0.02-0.03	0.05 -0.07	0.02	0.050	0.10-0.12	8,983-10,780
Cottontail Rabbit	637	0.02-0.03	0.03 -0.05	0.03	0.083	0.11-0.13	8,983- 9,800
Ground Squirrel	309	0.02-0.03	0.07 -0.10	0.03	0.100	0.17-0.20	5,390- 6,341
13-lined Ground Squirrel	140	0.02-0.03	0.15 -0.23	0.02	0.150	0.30-0.38	2,837- 3,593
Ducks	630	0.02-0.10	0.03 -0.16	0.20	0.320	0.35-0.48	1,975- 2,709

for large game are smaller than weights found in White (1953), who seemed to have examined rather large specimens. Estimates of pursuit and processing time were determined through conversations with modern hunters and with ethnographers who have foraged with hunter-gatherers (K. Hill, H. Kaplan, and J. F. O'Connell, personal communications 1980-1984). As with the plants, the goal in developing these data was to make ordinal-level comparisons between specific resources and between general classes of resources (e.g., large vs. small game).

These data are best seen as providing a range of estimated post-encounter costs for different hunting situations that involve widely varying pursuit times. In the cases of bighorn sheep or deer, for example, pursuit began once the animal was encountered. If a successful kill was made shortly after encounter, the pursuit time may have been only a minute or two (hence the value of 0.02 hours/individual for deer pursuit shown in Table 4). On the other hand, pursuit may have lasted for some time if an animal was tracked after an unsuccessful initial encounter (a maximum pursuit of one hour was used in the case of large game). The time required for tracking prior to encounter is not counted as pursuit, but falls into the category of search time. As with the plants, search time is highly case-dependent and applicable to questions

about the relative contribution of resources to the diet. Presentation of search-cost data and examples are beyond the scope of this paper.

These handling-time data show an important relationship between the components of cost. The large ranges in estimated pursuit times illustrate how great a variation in pursuit time is needed to produce a significant change in the return rate. Table 4 shows that it would take large differences in pursuit time, beyond the ranges shown here, to change the resource ranking. For example, even doubling the pursuit time for deer, to two hours instead of one, only lowers the return rate for deer from 17,971 Cals./hr. (Table 4) to 12,580 Cals./hr. Similarly, if the pursuit time for duck is doubled from the 0.156 hr./kg. used in Table 4 to 0.3 hr./kg., the return rate only falls from 1,508 Cals./hr. (Table 4) to 1,231 Cals./hr.

In contrast to pursuit time, processing time is relative to the body size of the animal. Given the wide range in body sizes among the hunted animals, it is processing rather than pursuit time that produces large variances in the return rates. This is relevant to the potential criticism that hunting return rates must vary too much between situations for these data to be useful. The relationship between pursuit and processing costs suggests that relative body size and consequent processing time may be more revealing than

pursuit time for ascertaining post-encounter return rates. This is an example of only one relationship made evident by conceptualizing the problem in terms of a diet-breadth model that requires pursuit and processing (which are measures of efficiency) to be considered separately from each other and from search (which is a measure of resource abundance). Of course, pursuit, processing, and search costs are interactive and higher order foraging models reveal relationships among all three variables as well.

The estimates of processing time are based on the experience of seasoned Utah hunters and on the butchering practices of modern hunter-gatherers. Values include the time to gut, skin, and butcher the animal into sizable portions. Butchery standards estimated here do not approach the culinary standards for meat in Western society. Skinning time adds significantly to overall processing cost, but is included on the assumption that skins of many animals would have been important in an environment like the Great Basin because of the need for winter clothing. Finally, the reasons that some of the values in Table 4 are carried out to so many decimal places are that the return rates are: (1) expressed in hours so minutes must be expressed as fractions; and (2) the equations used in the foraging models for which these data were developed require that handling times are expressed in units of weight rather than as individual animals.

### SOME EXAMPLES OF DATA APPLICATION

#### Simple Predictions About Large Game Exploitations

Large game such as bighorn sheep, mule deer, and pronghorn (antelope) should be taken when encountered. From a post-encounter perspective, these animals constitute high-ranking resources and stand apart from all other resource classes. The data

considered here apply to individual hunts only, but estimates of returns from game drives suggest that driving also produces high return rates (Simms 1984). Ethnographic and ethnohistoric accounts refer to either the lack of large game in the Great Basin or to the small amount of large game in postcontact, aboriginal diets (Brooks 1977: 180-182, 187; McAdoo 1980: 44; Morgan 1953: 210; Steward 1938), but these animals do appear to have been taken when encountered (Steward 1938). When consultants spoke of not eating large game, the statements were often qualified with the caveat that large game animals were rare (a fact that affects search time and, hence, the relative contribution to the diet, and not whether it was exploited or not upon encounter).

In a study of the Great Basin Culture Element Distributions (CEDs), Gazunis (1982) determined that there is a scaled pattern of resource choice in 37 Great Basin ethnographic groups that is consistent with the predictions of an optimal diet model. The CEDs for Nevada Shoshoni (Steward 1941), Northern and Goshiute Shoshoni (Steward 1943), Ute and Southern Paiute (Stewart 1941), and Northern Paiute (Stewart 1942) indicated that deer and pronghorn were taken by all 37 groups and bighorn sheep were taken by all but one of the groups. The CEDs also show that large game were never taboo, and no consultant stated that they did not eat large game. Thus, while large game may have been rare in the diet, it was probably always sought and taken when possible, even if the overall subsistence system was not focused around procuring these resources in the proto-historic/historic period.

The practice of Great Basin aboriginals "hunting" cattle and horses belonging to Euroamerican immigrants reflects the workings of the diet-breadth model. In contrast to an explanation that attributes the eating of horses and cattle to contact-induced starva-



tion, the addition of these high-ranked resources to the diet more likely stemmed from aboriginal diet optimization. Why collect grass seeds in the "traditional" manner when there are easily hunted cows rambling through the fields of grass? This explanation is independent of the starvation question because the significant change in the system was the increased abundance of livestock, a high-ranked resource. The decrease in the abundance of grass brought about by livestock grazing was secondary. This illustrates a prediction of diet-breadth models that has been substantiated among nonhuman organisms: inclusion of low-ranked resources in the diet will depend *not on their own abundance, but on the abundance of higher-ranked resources* (MacArthur and Pianka 1966; Charnov and Orians 1973). Of course, the strategy of killing livestock for food would only be optimal until the negative sanctions imposed for stealing livestock effectively raised their cost. Again, it is the shift in the post-encounter return rates of high-ranked resources that predicts the behavioral change. An analogous situation existed in central Australia where livestock were hunted by aboriginals almost immediately upon introduction, despite negative sanctions (White with O'Connell 1982: 93).

### Issues About Seed Exploitation

Seeds vary widely in return rates, but in general are the lowest-ranked class of resources. The fact that seeds were repeatedly mentioned as being important in the historic period shows that in terms of energy and time, the Great Basin diet was very broad. In fact, some seeds were taken that probably provided minimal energetic gain over the metabolic costs of gathering them. Others appear to only be obtainable at an energetic loss! This perplexing situation can lead to two research options. One could dismiss these

data, and "optimal foraging theory," as somehow wrong. Or, one could continue the research process and explore other variables that may help better account for the system of interest. The latter option suggests that optimality modeling is as much a research strategy as it is a particular statement about how the world works.

There is probably more variation in the handling times for low-ranked seeds than shown in the data examined here, but the return rates are useful approximations representing numerous gathering situations. The experiments on low-ranked resources such as pickleweed, foxtail barley, saltgrass, and squirreltail, were conducted in areas where plant densities were as great as any encountered by this author elsewhere in the Great Basin. In at least one experiment with each plant, harvest timing was quite accurate and allowed for a maximum yield. It is possible that mass processing would slightly increase the return rate, but mass processing does not really exclude any steps, primarily being a strategy aimed at producing large quantities of food (in this respect akin to the productive, but highly inefficient modern American food system). For example, if the return rates for squirreltail grass, ethnographically known to have been exploited in more than a few areas (Steward 1938: 30), is doubled from the reported 91 Cals./hr. (Table 3) to 182 Cals./hr., this resource nevertheless remains at the bottom of the ranking (Table 3).

Perhaps the *storability* of seeds is important to understanding patterns of seed exploitation. Given a region where some types of winter-food storage may have been essential, seeds may have constituted a crucial resource relative to non-storable foodstuffs. Storage of seeds, collected during summer, for consumption during winter when few alternative foods were available is a form of resource banking and suggests an adaptive strategy focused on low-ranked, but highly storable resources.

The question of seed exploitation is important precisely because of their low resource ranking. An investigation of small-seed use is relevant to the dietary expansion that characterizes the concept of an Archaic stage at different times in different parts of the Great Basin; in the early Holocene in the eastern Great Basin (Jennings 1957), mid-Holocene in the central portion (Elston 1982), and mid-to-late Holocene in the southern Great Basin (Lyneis 1982). Apparently, broadening of the diet to include a wider range of resources (in terms of post-encounter return rates), occurred at different times as the structure of the natural habitats changed during the Holocene.

An understanding of seed exploitation patterns during ethnographic times, when diets were extremely broad, is important for the creation of a baseline from which prehistoric diets can be investigated. A foraging model that successfully predicts known ethnographic behavior can help define expectations about and lead to explanations of the prehistoric record. This encourages the search for new archaeological data, focuses hypothesis-testing strategies, and invites the exploration of variables such as risk or transport costs, among others, whose significance may vary with the situation at hand.

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#### REFERENCES

- Brooks, George R., editor  
 1977 *The Southwest Expedition of Jedediah S. Smith: His Personal Account of the Journey to California, 1826-1827*. Glendale: Arthur A. Clark.
- Charnov, Eric L., and Gordon H. Orians  
 1973 *Optimal Foraging: Some Theoretical Explorations*. Salt Lake City: University of Utah Department of Biology.
- Elston, Robert G.  
 1982 *Good Times, Hard Times: Prehistoric Culture Change in the Western Great Basin*. In: *Man and Environment in the Great Basin*, D. B. Madsen and J. F. O'Connell, eds., pp. 186-206. Society for American Archaeology Papers 2.
- Gazunis, Katherine-Teresa  
 1982 *Scalogram Analysis of Hunting Strategies Among Native American Groups in the Great Basin/Plateau Region*. M.A. thesis, University of Utah.
- Jennings, Jesse D.  
 1957 *Danger Cave*. University of Utah Anthropological Papers No. 27.
- Lanner, Ronald M.  
 1981 *The Piñon Pine: A Natural and Cultural History*. Reno: University of Nevada Press.
- Lyneis, Margaret M.  
 1982 *Prehistory in the Southern Great Basin*. In: *Man and Environment in the Great Basin*, D. B. Madsen and J. F. O'Connell, eds., pp. 172-185. Society for American Archaeology Papers 2.
- MacArthur, Robert, and Eric Pianka  
 1966 *On the Optimal Use of a Patchy Environment*. *American Naturalist* 100: 603-309.
- McAdoo, Kent  
 1980 *Wildlife, With Annotated List of Mammals, Birds, Reptiles, and Amphibians*. In: *Physical, Biological, and Cultural Resources of the Gund Research and Demonstration Ranch, Nevada*, James A. Young and Raymond A. Evans, eds., pp. 44-63. U. S. Department of Agriculture Science and Education Administration Agricultural Reviews and Manuals ARM-W-11.

- Morgan, Dale  
1957 *Jedediah Smith and the Opening of the West*. Lincoln: University of Nebraska Press.
- O'Connell, James F., and Kristen Hawkes  
1984 Food Choice and Foraging Sites Among the Alyawara. *Journal of Anthropological Research* 40: 504-535.
- Simms, Steven R.  
1984 *Aboriginal Great Basin Foraging Strategies: An Evolutionary Analysis*. Ph.D. dissertation, University of Utah.
- Steward, Julian H.  
1933 *Ethnography of the Owens Valley Paiute*. University of California Publications in American Archaeology and Ethnology 33: 233-250  
1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin 120.  
1941 *Culture Element Distributions XIII: Nevada Shoshoni*. University of California Anthropological Records 4: 209-259.  
1943 *Culture Element Distributions XXIII: Northern and Goshiute Shoshoni*. University of California Anthropological Records 8: 263-292.
- Stewart, Omer C.  
1941 *Culture Element Distributions XIV: Northern Paiute*. University of California Anthropological Records 4: 361-446.  
1942 *Culture Element Distributions XVIII: Ute - Southern Paiute*. University of California Anthropological Records 6: 231-355.
- Wheat, Margaret  
1967 *Survival Arts of the Primitive Paiutes*. Reno: University of Nevada Press.
- White, J. Peter, with James F. O'Connell  
1982 *A Prehistory of Australia, New Guinea, and Sahul*. New York: Academic Press.
- White, Theodore E.  
1953 A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. *American Antiquity* 18: 396-398.



## Changing Shellfish Exploitation in San Luis Obispo County, California

JAMES L. RUDOLPH

Analysis of shellfish remains from two sites in the Lodge Hill subdivision near Cambria, California (Fig. 1), suggests that a major change in mollusc exploitation may have occurred there prior to the Middle Period (1400 B.C. to A.D. 1150 [King 1981]). Specifically, by the end of the Early Period (7200 - 1400 B.C. [King 1981]) there was a pronounced shift from the intensive exploitation of *Mytilus californianus* to the exploitation of a more diverse molluscan assemblage consisting primarily of *Tegula funebris*, limpets, and chitons. This change might have been a result of overexploitation of the *Mytilus* sp. population, but it also may

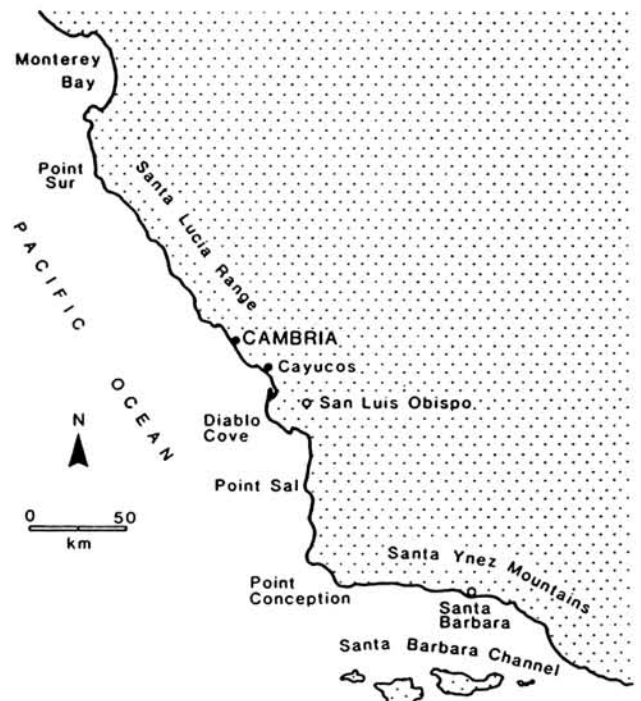


Fig. 1. Location of project area on the California coast.

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