An Optimal Foraging Model of Hunter-Gatherer Land Use in the Carson Desert. David W. Zeanah, James A. Carter, Daniel P. Dugas, Robert G. Elston, and Julia E. Hammett. Silver City, NV: U. S. Fish and Wildlife Service, U. S. Department of the Navy, and Intermountain Research, 1995, xi + 357 pp., 134 fig., 72 tables, bibliography, 8 appendices, gratis (paper).

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In 1989, Christopher Raven and Robert Elston of Intermountain Research described a predictive model of land use for the Stillwater Marsh of west central Nevada (Raven and Elston 1989), which commanded considerable interest within the Great Basin archaeological community. Since then, a team from Intermountain Research led by David Zeanah has elaborated and refined the model, as well as providing an expanded archaeological test. This work resulted in *An Optimal Foraging Model of Hunter-Gatherer Land Use in the Carson Desert*, an excellent case study of model formulation and operationalization and of the potential utility of foraging theory in archaeological research.

Predictive models come in two basic forms (Kohler 1988). Inductive models are correlative approaches, moving usually from known spatial distributions of archaeological and environmental variables to estimates of the spatial patterning and content of archaeological populations. Deductive models, of which the monograph under review is a good example, begin "with a theory as to how people use a landscape and deduce from that theory where archaeological materials should be located" (Kohler 1988:37). Although inductive models are typically informed by some knowledge of human/land relationships, those premises need not be explicit, nor is it necessary to put forth any formal treatment of the correspondence between human behavior in the systemic context and the archaeological record. In contrast, deductive models require just such explicit treatment—bridging arguments—in order to operationalize the model.

In Zeanah et al., two sources are used to construct the model, optimal foraging theory (OFT) and the reported foraging practices of the 1850 Toedokado Paiute, whose territory forms the spatial boundaries of the relevant archaeological record. Regarding the theoretical rationale of the model, two of the best known components of OFT, diet breadth and patch choice models, are used. Briefly, the diet breadth model predicts which food resources will be included in a forager's diet from a set of potential resources that are ranked according to their net caloric return, factoring energy expenditures on the search and processing of those resources. OFT predicts when diet breadth will expand (e.g., under conditions of a degrading resource environment) or contract (e.g., when a technological innovation reduces the time required to search for food items). Patch choice models recognize that resources are rarely uniformly distributed over a landscape, but more often are clustered in resource sets or patches. Thus, foragers using patchy environments are faced with decisions as to whether to remain in patches and increase diet breadth as resources are diminished by their foraging, or to leave for a new patch, factoring the cost of travel between patches and the cost of transporting their technology to the new patch.

For their model, Zeanah et al. offer two additional conditions. The first is seasonality, referring to the intra-annular fluctuations in resource availability. The point in doing so, of course, is that foraging decisions are conditioned at any particular time by the actual resources available or anticipated to be available. For the model, the annual cycle is broken down into seasons. Although realism would be enhanced with finer time divisions, this would add considerably to the cost of operationalization. The second model condition observes that the Toedokado Paiute organized subsistence efforts along gender lines, a practice followed in many foraging societies faced with patchy resource distribution.

The model is operationalized in several steps. First, the geographic territory of the Toedokado Paiute at the A.D. 1850 datum is established at something less than one million hectares, centering on the Stillwater Marshes. Next, the foraging potential of the 1850 landscape is evaluated. This is some of the most detailed work in the monograph, for it is here that the authors estimate how resources known to have been used by the Toedokado Paiute were distributed, in what densities, and at what times of the year. This is not a straightforward exercise, since modifications to the landscape from historic agricultural practices have been significant. To estimate the 1850 environment, the authors construct a classification of habitat types relying on soil surveys and range type studies. Their work is complicated by the fact that comparable surveys have not been undertaken by the various agencies that oversee lands in the study area. The classification partitions the Toedokado territory into 77 habitat types.

The habitat distribution and seasonal availability of ethnographic food resources are paired with estimated caloric returns for these resources, drawn primarily—although not exclusively—from studies like those of Simms (1987) conducted in the Great Basin. With these estimates, habitats are ranked as to their foraging potential. In this exercise, the authors wisely group resources of similar return rates, rather than placing reliance on small, apparent differences between resources based upon experimentally derived estimates. Next, the ethnographic literature is used to associate resources and gender. Although not every resource is exclusively procured by either females or males, usually the efforts of one sex dominate in procurement. When the results are tabulated, resources procured by males tend to be high ranking, including large mammals. Female resources overlap with male resources in the high ranks, but also include a wider array of low-ranking resources, including seeds and other vegetal foods. Female resources are relatively stationary with high processing costs, while male resources tend to be mobile, requiring long search times.

From this exercise, the authors conclude that the optimal location for residence will be closer to female foraging patches, since these patches do not provide sufficient returns to merit the higher costs that would be associated with travel if residential bases were located at great distance. If this prediction is not surprising, it is because it describes the familiar logistic mobility strategy followed by foragers throughout temperate latitudes.

The last step in operationalization is to design expectations as to how the archaeological record will reflect subsistence organization if the model correctly predicts foraging decisions. This may be the weakest part of the argument, although altogether expectable in view of the complex relationships between the systemic and archaeological domains. Several major expectations are set out that are to be evaluated against the composition and diversity of the archaeological record of the region. First, residential locations will contribute disproportionately to the record, since these places combine many tool-using activities with subsistence activities. Second, as mentioned above, the locations of residential sites relate more strongly to female foraging patches. Third, outside the confines of residential locations, female foraging activities will leave few traces, since such practices rely so heavily on perishable technologies. By contrast, male activities, such as hunting, have greater visibility, generating artifacts like projectile points. Finally, lithic tool manufacture will always have high visibility because it produces so much debris.

The model was tested as part of an archaeological assessment of proposed land transfers to the Naval Air Station in Fallon, Nevada. A 5% sample of these lands, or 57 km.^{2} quadrats, was drawn for surface inspection. As a result, full coverage of all classified habitats was not possible. However, for the habitats represented in the proposed impact areas, the sample contacted habitats in about the proportion that they occur in the larger Toedokado territory. Archaeological manifestations were broadly differentiated on the basis of the presence of features, flaked stone, groundstone, and artifact density. Time-sensitive projectile points were not numerous; as many Elko points as arrow points were recovered, suggesting that the surface record does not date exclusively to the Late Prehistoric Period.

Analyses focus on assemblage richness—we learn that sites with features have a greater variety of tools for their sizes than featureless assemblages—and assemblage content. Regarding the latter, sites with features are strongly associated with groundstone and utilized flakes, while projectile points and bifaces are rare, indicating fairly long-term habitation and female subsistence activities. Compared with habitation sites, large and small lithic scatters tend to have higher frequencies of projectile points, which the authors believe suggests logistic hunting activities. Although these interpretations may be largely correct, a tool manufacture signal is strong in each of these site types. An explanation of how toolstone procurement and manufacture articulate with subsistence activities would significantly advance this model and improve its predictive power, as the authors note. Even without this, however, the model correctly predicts in two-thirds or more of the cases what the archaeological record of a sample unit will be. This predictive power is slightly lower than that achieved by Thomas's (1971) Reese River model, but it must be remembered that the present model partitions the environment into much finer strata.

As mentioned, one of the incongruities between model predictions and the empirical record relates to the significant contribution of tool manufacture. The authors discuss a second point as well, relating to the foraging activities of Early and Middle Holocene occupants who faced different foraging landscapes. During episodes such as the Pleistocene-Holocene transition, if resources assumed distributions and frequencies that differed from modern conditions, we should anticipate different foraging patterns which would necessitate adjustments to the model. This point is taken up in the final chapter.

Reviewing paleoenvironmental evidence from the Pleistocene-Holocene transition (to 7,000 B.P.), the Middle Holocene, and the Late Holocene (after 4,500 B.P.), the authors posit how resource patches may have differed in content and distribution with wetter and drier conditions, and the ways in which diet breadth might be altered. The most interesting result, to my mind, relates to the earliest occupations and helps to explain one part of the empirical record that is poorly handled by the model. The authors suggest much higher environmental uniformity—less patchiness—during this time interval and, as a result, mobile prey associated with male foraging were far more common in the lowlands. With these revised conditions, the model would predict less conflict between male and female foraging decisions; in effect, all foragers could operate from the same settlement locations. With unrestricted access to new foraging patches, predicated on the assumption of low regional human population, early foraging groups would tend to shift residence rather than expand diet breadth. An archaeological record reflecting brief occupations, few or no facilities at sites, and high assemblage redundancy should result.

In sum, provided that reasonably accurate biotic reconstructions are possible, the model is sufficiently flexible to generate useful predictions about foraging patterns during the entire span of occupation of the Toedokado territory and is a good beginning point for modeling these practices in other parts of the Great Basin.

My final comments concern how results from a good predictive model are used. As I hope is clear, I regard predictive modeling and this particular example as good intellectual exercises, but I am sensitive to the failure of the model to fully predict archaeological structure. This relates in part to the lack of conformity between conditions set by the model and the actual environments in which people foraged during earlier parts of the Holocene. But it also relates to the nature of what foraging theory predicts. The locations of artifacts may be a reasonable measure of the choice of patches in which foraging took place, but artifacts are a rather poor proxy of the actual resources being exploited. That is, the diet breadth model predicts either the time or energy that will be expended in procuring one resource relative to a suite of potential resources. The archaeological record very imperfectly mirrors those decisions. It would even be difficult to monitor foraging behavior from a record composed of the exploited resources themselves. My point is simply that we must continue to think seriously about the links between subsistence activities and the record, and to realize that a perfect match might never be realized. For one thing, this means that as useful as predictive modeling is, it will not capture all aspects of the record, and this awareness must be brought into decisions regarding the conservation of the remaining archaeological record.

My second concern is how we treat archaeological significance in light of the test in this model. For example, the model accurately predicts that female foraging activities will leave a rather ephemeral record, especially in habitats comprised of low-ranking resources. For purposes of explicating foraging patterns, this record is every bit as important as the male foraging record or the residential record. But it is precisely the low density, ephemeral patterns that the authors conclude have inadequate data content for eligibility to the National Register, and thus have no bearing on management decisions concerning those properties. As this study should make clear, however, we cannot continue to judge eligibility on cultural historical criteria alone. We will see a revolution in dating surface phenomena in the next few years, making questionable those decisions about the significance of a site or an isolate based primarily on whether it appears to have a buried component or contains projectile points. If we are to regard all aspects of subsistence behavior as important to our understanding of prehistory, we need to understand the implications that such models hold for the conservation of all parts of the archaeological record. Site preservation alone is not the route to take; as this study shows, large land parcels must be protected in order to preserve ephemeral patterns.

As of this writing, *An Optimal Foraging Model of Hunter-Gatherer Land Use in the Carson Desert* is available from the U. S. Department of the Navy or Intermountain Research, although future publication in a more widely available monograph series is anticipated by the authors. The report is a well-executed example of predictive modeling that should be on the reading lists of Great Basin anthropologists.

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The Oxford dictionary defines a flora as "a descriptive catalogue of the plants of any geographical area." As such, *The Alpine Flora of the Rocky Mountains, Volume 1: The Middle Rocky Mountains* fulfills this condition well. The harsh and formidable alpine zone is known not only for its rock and snow, but also for brief interludes of brilliant color from countless flowers. Nowhere in the United States is alpine flora as well developed as in the Rocky Mountains, and here at last is the first volume in a definitive text that enlists, describes, and maps that flora. The alpine flora of the Middle Rocky Mountains is now known to consist of at least 700 vascular taxa belonging to 609 species in 204 genera and 51 families.

This volume has all the signs of a life work. The first chapter provides the reader with background on the Alpine Zone with short and well-referenced sections that define timberline, discuss the alpine landscape and its geomorphic processes, and outline the adaptations of its plants. The second chapter concerns the physiography and natural history of the Middle Rocky Mountains, including maps of the drainage basins, the extent of Pleistocene glaciers, and the major mountain ranges, as well as a figure that shows the structural features in the physiographic province. The chapter concludes with brief descriptions of the major mountain ranges. The third chapter summarizes the floristics of the province, with tables that elucidate the taxonomic composition of the flora. Additionally, this chapter compares the Arctic flora with the Middle Rocky Mountain alpine flora, and contains a figure that displays the species richness of the major mountain ranges. It concludes with a detailed explanation of the methods and format used in the preparation of the species monographs. These introductory chapters occupy only 29 pages, but they are packed with important background information.

The main body of the work begins with reader-friendly keys to the families, and then an alphabetically ordered treatment of each family. The family treatments begin with a description of family characteristics followed by a key to its genera. Common names are provided for the families and genera. Each genus is described, after which readable keys to its species are presented.

By far most of the book is composed of monographs of each species. Each monograph