

Beyond Depression? A Review of the Optimal Foraging Theory Literature in Zooarchaeology and Archaeobotany

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Abstract The use of optimal foraging theory in archaeology has been criticized for focusing heavily on “negative” human-environmental interactions, particularly anthropogenic resource depression, in which prey populations are reduced by foragers’ own foraging activities. In addition, some researchers have suggested the focus on resource depression is more common in the zooarchaeological literature than in the archaeobotanical literature, indicating fundamental differences in the ways zooarchaeologists and archaeobotanists approach the archaeological record. In this paper, we assess these critiques through a review of the literature between 1997 and 2017. We find that studies identifying resource depression occur at similar rates in the archaeobotanical and zooarchaeological literature. In addition, while earlier archaeological applications of optimal foraging theory did focus heavily on the identification of resource depression, the literature published between 2013 and 2017 shows a wider variety of approaches.

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Introduction

The debate on the use of optimal foraging theory in archaeology—particularly in zooarchaeology and archaeobotany—has been heated in recent years, with critiques emerging in a variety of different contexts (e.g., Coddling et al. 2010; Jones 2016a:9–22; Reitz et al. 2009; Smith 2015; Speth 2013; Zeder 2012, 2015a, b). While these critiques vary both in their natures and in the bases of their arguments, many of them concern, at least in part, the use of foraging theory to identify cases of prehistoric resource depression, or decreases in foraging efficiency based on the foragers’ own activities (here, we use resource depression in a large sense, including behavioral depression and microhabitat depression as well as exploitation depression; see Charnov et al. 1976). Zeder (2012:254) puts it succinctly: “In this way a broad spectrum diet, resource depression, and a decrease in foraging efficiency are all inextricably linked together, imbedded within the foundational assumptions of the OFT world view.” Similarly, some have suggested

that anthropogenic resource depression is primarily evidenced in zooarchaeological, rather than archaeobotanical, data. The bases of this belief range from differences in human-plant relationships as opposed to human-animal ones to methodological differences (see for instance Campbell and Butler 2010a; Deur and Turner 2005; Peacock and Turner 2000; Smith 2014; Turner et al. 2000). While explanations vary, the impression that archaeobotanists are less likely to identify resource depression than zooarchaeologists is widespread.

However, neither the dominance of resource depression in the zooarchaeological foraging theory literature nor the lack of evidence for resource depression in the archaeobotanical literature have been demonstrated through literature review. In fact, there is some evidence to contradict both these ideas (Coddling and Bird 2015). Foraging theory models are used by archaeobotanists and zooarchaeologists to explore themes other than resource depression; indeed, these models have been used archaeologically



to identify, among other things, instances of prehistoric sustainability (e.g., Campbell and Butler 2010b), cases of environmental rebound (e.g., Jones 2016b), climate-driven changes in resource acquisition (e.g., Broughton et al. 2008), and gendered foraging (e.g., Zeanah 2004). On the other hand, in at least some cases archaeobotanical data have been used to support studies of resource depression (e.g., Simms 1984).

However, this evidence is anecdotal. It does not negate the possibilities that 1) other mechanisms for change identified are adjunct and subordinate to studies of resource depression in the foraging theory literature; and 2) archaeobotanical studies identify resource depression less frequently than zooarchaeological studies.

To explore these possibilities, in this paper we consider the role resource depression and other topics within the zooarchaeology and archaeobotany optimal foraging literature have played over the last 20 years. We assess patterns in publications' analytical foci overall, by subdiscipline, and through time.

Methods

Data collection

We searched multiple databases of scholarly publications including Anthropology Plus, Anthrosource, Google Scholar, Web of Knowledge, and WorldCat to identify the relevant literature. Our search criteria required any one of the following phrases: foraging theory, prey choice model, or patch choice model, in addition to some variation of any of the following terms: archaeology, archaeobotany, archaeozoology, paleoethnobotany, or zooarchaeology. Though the exact search differed slightly by database, the search logic can generally be represented as:

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("Optimal foraging theory" OR "Prey Choice model" OR "Patch Choice model") AND (archaeology OR archeology OR paleoethno* OR paleobot* OR archaeobot* OR zooarch* OR archaeozoo*)
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The search was further limited by year to works published in 1997 or later, and by language to works written in English.

Our search strategy was deliberately broad and emphasized recall over precision (i.e., prioritizing not missing relevant articles over limiting irrelevant results). Therefore, we assessed each article individually to exclude works in which foraging theory was mentioned only in passing, in which

zooarchaeological and archaeobotanical data were not the basis of the overall argument, and/or which were purely conceptual. For reasons both practical (we could not obtain all the publications) and abstract (content was not designed as a "publication" per se), we excluded undergraduate theses, conference papers and posters, and non-peer-reviewed reports.

Duplicate results were frequent both within and across databases, with Google Scholar presenting particular challenges. Google Scholar might find the same article on the journal's website, the authors' webpages, social networking sites such as Academia.edu, as well as in one or more institutional repositories. In some cases, the versions retrieved by Google Scholar were uncorrected proofs or otherwise different from the final published form. We used the version of record—that is, the final published form—whenever available.

Despite our focus on recall, our search undoubtedly missed relevant publications. Works not included in the databases searched were, obviously, not found. Additionally, indexing varies across publication and database. If the full text of the publication is not searchable, and the terms we searched for do not appear in the indexed fields (e.g., in title, abstract, keyword, or subject fields), the publication would not be retrieved even if the work was relevant. Finally, in dealing with large results sets with significant duplication, human error was also likely a factor.

Our final dataset contained 244 individual articles, chapters, books, dissertations and theses, representing the work of more than 250 individual authors working on six continents (see supplementary dataset and bibliography). As these data are limited to those authors publishing explicitly within foraging theory, they cannot be used to study trends within zooarchaeology or archaeobotany overall. However, we believe they do provide a reasonable sample to understand the zooarchaeology and archaeobotany foraging theory literature. Citations to these articles are provided in the supplementary files.

Analyses

We read all publications in the dataset and recorded whether they used zooarchaeological data, archaeobotanical data, or both. "Zooarchaeology" comprised any study using animal (vertebrate or invertebrate) remains as the basis of study, while "archaeobotany" included any study using plant data (pollen, phytoliths, macrobotanical data, etc.).

Table 1 Descriptions of topical categories used in this analysis.

Category	Examples of topics	Overall n
Resource depression	Reduced foraging efficiency due to foragers' own activities	85
Domestication	Prey/patch choice approaches to domestication of either (or both) plants and animals	22
Patch choice/CPF	Patch choice, central place foraging, and/or marginal value theorem approaches to understanding subsistence and/or resource use	70
Sustainability	Sustainable use; conservation	37
Environment/climate change	Connection between environmental variables and changes in prey choice and/or patch use	50
Culture	Costly signaling; gender and risk; niche construction	39
Method/Theory	Prey ranking systems; patch reconstruction; ethnoarchaeology	54

We then assigned each publication to at least one broad topical category (Table 1). We developed the categories organically, based on the topics represented in the readings, eventually arriving at seven: anthropogenic resource depression, environmental/climate change, patch choice/central place foraging, sustainability, domestication, culture and method. We chose not to make these categories mutually exclusive, so as not to underrepresent the presence of resource depression in the literature; a paper could be assigned to more than one category, and indeed most of them were.

The resource depression category included papers which either identified anthropogenic resource depression in a specific instance or which did not rule it out. Conversely, environmental/climate change papers invoked environment as the explanatory mechanism for change. Patch choice and central place foraging were originally separate categories, but so many papers that used one also made use of the other that we decided to collapse them into a single category. The categories of sustainability, domestication, and culture all invoke human activity as a causal mechanism: to be classed as a “sustainability” publication, the paper had to explicitly use that term or claim a demonstration of forager conservation; domestication papers focused on either plant or animal domestication or husbandry, or some combination thereof; and culture papers identified other aspect(s) of human behavior as causal in subsistence patterns, including technology, settlement strategy, costly signaling, and/or gender. Finally, method papers focused on the application of foraging theory to the zooarchaeological or archaeobotanical record.

Finally, we considered change in topic representation through time, using four broad time categories: 1997–2004 (number of papers = 49); 2005–2008 (number of papers = 54); 2009–2012 (number of papers = 76); and 2013–2017 (number of papers = 65). A numerical summary of the categories represented by group can be seen in Table 2; the full analytical dataset and associated bibliography are available as supplementary files.

Results

There are significantly more zooarchaeological publications ($n = 208$) than archaeobotanical ($n = 60$) in our final dataset. Twenty-four publications (or 10% of the total dataset) used a combination of zooarchaeological and archaeobotanical data, resulting in some overlap between these two categories. Interestingly, the percentage of papers using a combination of data types remains consistent through time (1997–2004: 10%; 2005–2008: 8%; 2009–2012: 11%; 2013–2017: 11%).

In the dataset as a whole, anthropogenic resource depression is the most common literature category (24%). However, resource depression is by no means as dominant as has sometimes been suggested; many of the other categories are also well-represented. Patch choice/central place foraging analyses are present in 20% of the publications, and papers in all categories except domestication average over 10% of the dataset (Figure 1; Table 1).

When zooarchaeological and archaeobotanical publications are considered separately, some interesting patterns emerge. Resource depression is less common in archaeobotanical papers (19%) than

Table 2 Sample size by analytical category.

Category	Zooarchaeology ¹	Archaeobotany ¹	Both ZA and AB ¹	1997–2004	2005–2008	2009–2012	2013–2017
Resource depression	75	20	11	20	20	28	16
Domestication	10	15	4	3	8	3	7
Patch choice/CPF	56	18	5	15	13	26	15
Sustainability	30	10	4	4	11	8	13
Environment/	39	14	4	7	16	9	17
Culture	33	15	7	11	10	12	8
Method/Theory	47	12	5	18	11	11	14

¹The Zooarchaeology and Archaeobotany columns are not mutually exclusive; the number of papers using both methods can be found in the “Both ZA and AB” column.

in zooarchaeological ones (26%), though not dramatically so (Figure 1). More strikingly, papers focusing on domestication are more common in the archaeobotany literature (14%) than in zooarchaeology (3%) and, conversely, method papers are more common in zooarchaeology (16%) than in archaeobotany (11%). That the differences in categorical representation between the two subdisciplines are driven by these two categories is confirmed by a Spearman’s rank-order correlation: when the categories of domestication and method are excluded, the distributions of categories in the zooarchaeology and archaeobotany literature are significantly correlated ($r_s = 0.90$; $p = 0.02$). This suggests that, in this dataset, the differences between the zooarchaeology foraging theory literature and that in archaeobotany are not a result of more zooarchaeologists identifying resource depression; instead, they seem to reflect more foraging-theory oriented archaeobotanists publishing on domestication, while more zooarchaeologists explore methodological issues. The strength of this result suggests as well that the uneven sample sizes between the zooarchaeology and archaeobotany papers are not causing the difference.

The distribution of categories through time highlights another interesting result (Figure 2). While there are variations through time, the most striking trend is the apparent decrease in the number of resource depression papers in the period 2013–2017. Between 1997 and 2012, papers identifying resource

depression in some form comprised between 22–29% of all optimal foraging zooarchaeology and archaeobotany papers. In the period between 2013 and 2017, resource depression papers drop to 18%. A Spearman’s rank order correlation suggests a difference in category rank from 1997–2012 and 2013–2016 ($r_s = 0.57$; $p = 0.17$).

Another pattern in the chronological analysis concerns the prevalence of method papers. Method papers are relatively frequent in the period 1997–2004 (23%), diminish in frequency between 2005 and 2012 (2005–2008: 12%; 2009–2012: 11%), and then increase between 2013 and 2017 (16%).

Discussion

Three major patterns in optimal foraging research in zooarchaeology and archaeobotany emerge from these data: 1) differences between the archaeobotanical and zooarchaeological literature seem to reflect the prevalence of domestication and methods papers, rather than a willingness to identify resource depression; 2) studies identifying prehistoric resource depression appear to be decreasing in frequency in the last few years; and 3) method-oriented papers, which were relatively common between 1997 and 2004, have, after a period of decline, increased again. We discuss each of these findings below.

First, our review suggests identification of resource depression appears in the archaeobotanical foraging theory literature at rates similar to its

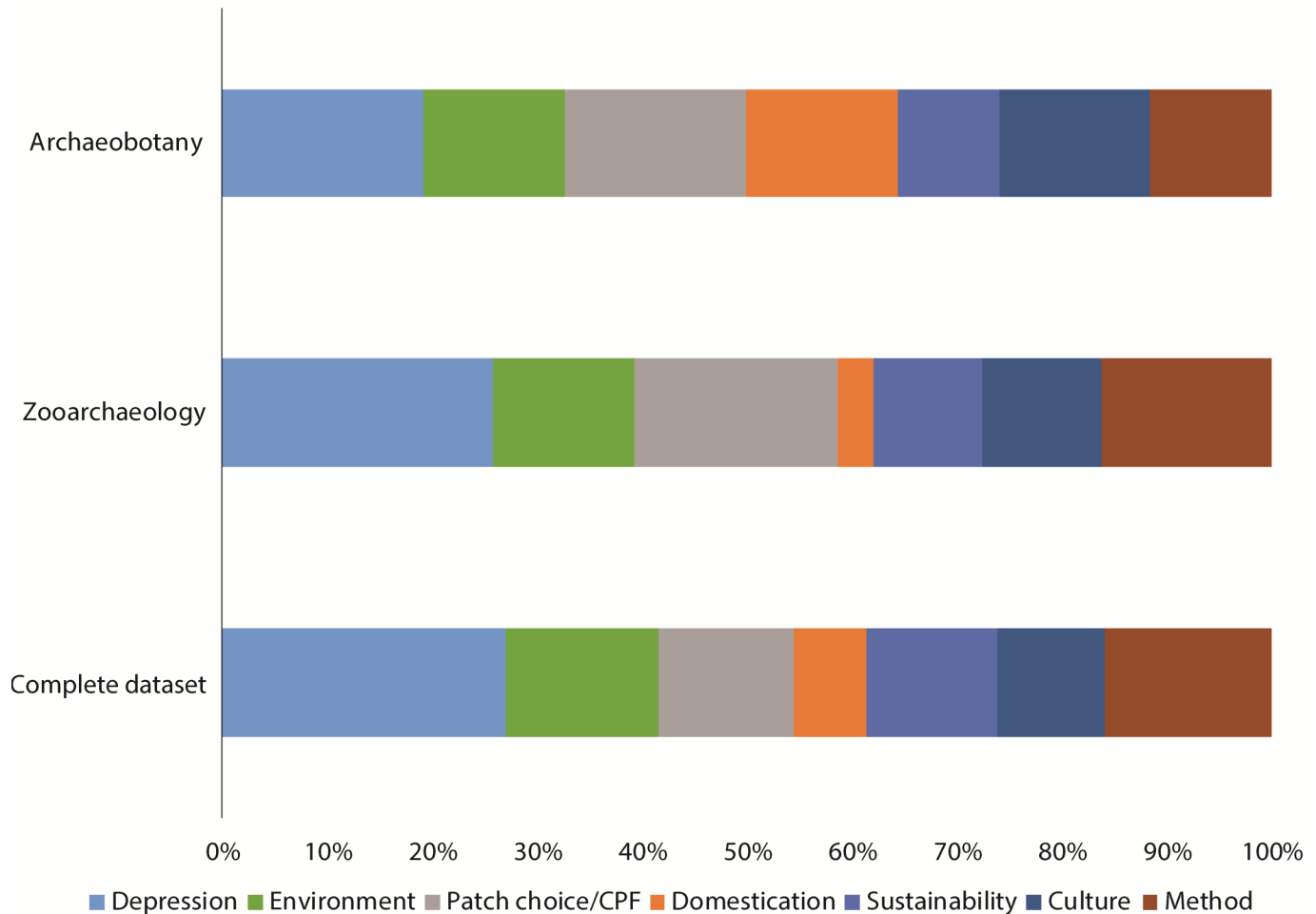


Figure 1 Topics of foraging theory publications in archaeobotany, in zooarchaeology, and in both.

appearance in the zooarchaeological foraging theory literature; the more significant difference in the foraging theory literature between these two disciplines is the prevalence of domestication publications in the archaeobotanical literature and that of methods-oriented papers in the zooarchaeological literature. There are several important caveats to this finding. As discussed in the methods section, our search was limited to foraging theory publications; it did not consider analyses taking place outside of this theoretical framework. The work of archaeobotanists who fully reject optimal foraging theory is thus not represented in this dataset. However, these data do allow us to say resource depression has been identified in both the archaeobotanical and zooarchaeological literature, which has previously been a matter of some debate.

Second, although resource depression has been widely identified in archaeological papers over the last decade, foraging theory has been used to explore many other topics as well. These data show resource depression is far from as dominant in the foraging theory literature as it has been portrayed. In addition, identification of resource depression has decreased in the most recent literature, while papers assigning sustainable practice or environmental change as the causal mechanism for subsistence change have increased. This trend may reflect any of several different factors: it may be a stochastic change, it may be the result of increased funding for climate-related work available from U.S. governmental agencies associated with the American Recovery and Reinvestment Act of 2009, it may be due to foraging theorists responding to critiques. But it is also possible that, in intellectual approaches as in the biological

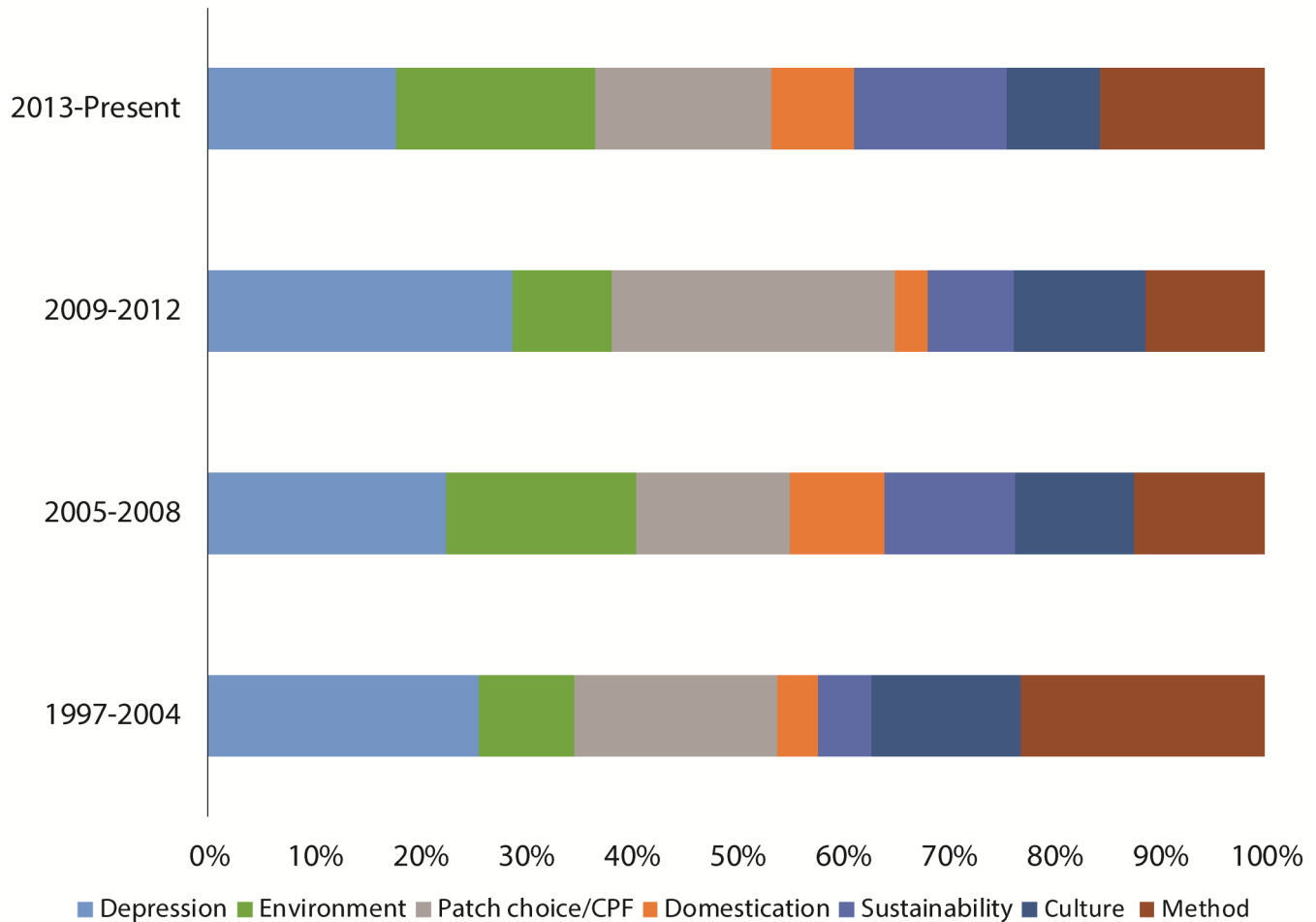


Figure 2 Topics of foraging theory publications from 1997 through 2017.

world, diversity increases with time. Foraging theory in archaeology began with resource depression. Should it be any surprise, thirty years later, that the richness of foraging theory approaches has increased?

The third finding, that method papers are again on the rise in the foraging theory literature, lends some support to the idea that the decrease in identification of resource depression may be at least in part a response to critiques. The prevalence of method papers relatively early in the history of foraging theory in archaeology is reasonable: the first applications of a new approach necessitate methodological conversations and the decline of such publications in later years, as researchers come to agreement on methods, makes sense. However, the recent increase is a surprise. While this may be stochastic variation rather than a true trend, the correlation of these papers with the timing of the

publication of critiques associated with niche construction theory (e.g., Gremillion et al. 2014; Mohlenhoff et al. 2015; Smith 2015; Zeder 2015b) is suggestive.

Studies identifying resource depression in the archaeological record have, without a doubt, been one of the major contributions of optimal foraging theory to archaeology more broadly. We do not wish to downplay the importance of such studies. Instead, the goal of this paper has been, quite simply, to address the question of whether studies of resource depression are as dominant in the archaeological optimal foraging literature as critiques often imply. Our data show that in the past two decades, regardless of time of publication or of subdiscipline, resource depression is far from the only application of foraging theory. However, there are numerous questions that remain about how foraging theory is represented in

zooarchaeology and archaeobotany, which are beyond the scope of this paper but nonetheless intriguing. To what degree is the literature dominated by certain prolific authors? While this dataset shows a wide range of approaches to foraging theory from many different researchers, the influence of specific individuals is apparent in the raw data. Similarly, while the publications assessed here are based on research around the world in a multitude of countries and contexts, there does appear to be bias towards research originating in North America and particularly, Western North America. Is this regional focus changing, and if so, how? Finally, the relationship between foraging theory and niche construction in the literature is not merely one of conflict; indeed, as several of the articles cited earlier in this discussion show, many authors find these to be compatible approaches (e.g., Broughton et al. 2010; Piperno et al. 2017; Stiner and Kuhn 2016). Historical ecology, resilience, and sustainability, similarly, are non-optimality-based approaches used by researchers who also use foraging theory (see discussions in Giovas 2016; Redman 2005; Reitz 2004; Reitz et al. 2009). To what degree are hybrid approaches increasing in the literature?

These questions remain to be answered. For now, however, we can say with certainty that while foraging theory in zooarchaeology and archaeobotany may not be “beyond depression,” it is certainly *more* than depression.

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