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The Future from the Past

Archaeozoology in wildlife conservation and heritage management

Edited by
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2. Pristine Benchmarks and Indigenous Conservation? Implications from California Zooarchaeology

Jack M. Broughton

The superabundance of tame wildlife during the early historic period in California astonished European explorers. And the historic accounts of incredible animal densities, most notably artiodactyls, have influenced a long-held perception that California Indians lived in harmony with nature. However, analyses of archaeological faunal materials from sites covering a wide range of ecological contexts provide evidence for substantial impacts on a variety of large vertebrate taxa as human population densities expanded over the last c. *3000 years. The evidence suggests that many large vertebrate species, including sturgeon (*Acipenser *spp.), geese (*Anser, Chen, Branta*), tule elk (*Cervus elpahus nannodes*), mountain sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*), were driven to extremely low numbers by human hunting by late prehistoric times. The early historic accounts of large game superabundances almost surely reflect irruptions of those populations after preceding waves of European-based disease dramatically reduced their chief predators - the California Indians. These results have implications for conservation policies that are founded on early historic period landscape benchmarks and proposals involving the management of wilderness areas through the use of indigenous hunting and harvesting methods.*

Introduction

The early explorers of California struggled to find superlatives that would describe the spectacular densities of large vertebrates they encountered. Sir Francis Drake was one of the first who was struck by this land of 'inexpressible fertility' (Margolin 1979, 11). On landing north of San Francisco Bay in 1579 he described the region as 'a goodly country and fruitful soil, stored with many blessings fit for the use of man: infinite was the company of very large fat deer, which there we saw by the thousands as we supposed in a herd' (quoted in McCullough 1969, 18). In 1602, Sebastian Vizcaino (1891) also reported an abundance of deer 'larger than cows' in the Monterey area. Drake's and Vizcaino's 'fat deer' were undoubtedly tule elk *(Cervus elaphus nannodes)*, whose numbers 'taxed the descriptive powers' (McCullough 1969) of colonial period travelers and settlers that followed (taxonomic nomenclature for mammals follows Kays and Wilson [2002]; for birds, AOU [1998]; for fishes, Robins *et al.* [1991]). During the 1830s, Wilkes (1845,113), for instance, was astonished by the abundance of artiodactyls in the Central Valley: 'The variety of game in this country almost exceeds belief. The elk may be said to predominate.' Pronghorn *(Antilocapra americana)* and black-tailed deer *(Odocoileus hemionus)* were thick here as well. As another explorer noted, 'At times we saw bands of elk, deer, and antelope in such numbers that they actually darkened the plains for miles, and looked in the distance like great herds of cattle' (Bosqui 1904, 62). In 1841, John Bidwell provided an almost nonchalant characterization of the Central Valley faunal landscape: 'These plains are now the province of thousands of elk, antelope, deer, etc. ¼ These are the haunts of incalculable thousands of wild geese, ducks, brandts, cranes, pelicans, etc. Fish – there is a great abundance of salmon in every stream' (quoted in Preston 2002, 114).

The early explorers were equally impressed by the high densities of marine fauna they observed in coastal settings. Sea otters *(Enhydra lutris)* were particularly abundant. In the 1830s, the high densities of sea otters in

San Francisco Bay actually obstructed the view of the shore. As Jose Fernandez noted, the shore 'appeared covered with black sheets due to the great quantity of otters which were there' (quoted in Ogden 1941, 142). Geese, ducks, and seabirds were extremely abundant here too, as Yount noted in 1833: 'The wild geese, and every species of waterfowl darkened the surface of every bay¼in flocks of millions. When disturbed, they arose to fly, the sound of their wings was like that of distant thunder' (Camp 1923, 52).

Not surprisingly, high densities of predators including grizzly bears (*Ursus arctos*), wolves (*Canis lupus*), and mountain lions (*Puma concolor*) prowled the California landscape during these times as well. George Nidever, for instance, boasted of killing 'upwards of 200 grizzlies' along the central California coast during the early 1800s (quoted in Preston 2002, 113). At about the same time, George Yount marveled at the abundance of bears in the San Francisco Bay area commenting that 'it was not unusual to see fifty or sixty in twenty-four hours'. Similarly, Du Petit-Thouars cautioned about 'the bears, wolves or tiger-cats which are very plentiful in these woods' (quoted in Preston 2002, 113).

Not only was California's early historic faunal landscape noteworthy for its variety and abundance, but numerous chroniclers, foreign visitors and settlers observed, puzzled over, or were simply aghast by, the docile behavior of the animals they encountered. George Yount noted, for instance, that not only were the deer, antelope and elk of the San Francisco Bay area 'numerous beyond all parallel' but that they were also 'so tame that they would hardly move to open the way for the traveler to pass' (Camp 1923, 52). Edwin Bryant had the same reaction during his 1840s visit to the Central Valley: 'elk, deer, and even antelope, are comparatively very tame, and rarely run from the traveller¼' (quoted in Preston 2002, 117). In the 1820s, Captain F. Beechey also observed this curious lack of wariness, noting that the 'animals seem to have lost there fear and become familiar with man' (quoted in Margolin 1978, 9). Some foreign hunters were sorely disappointed by the dispirited quarry and griped about the lack of sport. William Thomes, for example, was so disenchanted with the docile waterfowl around San Francisco Bay that he derived 'no pleasure in shooting such tame game' (quoted in Preston 2002, 117).

Interestingly, many of these observations were made by veteran travellers who themselves had reasoned that the unwary game must have resulted from a virtual lack of human hunting pressure. They even went so far as to fault the Hispanic settlers for their lack of interest in hunting and even 'contemplated how the relative ease of hunting contributed to the perceived 'indolence' of both settler and native alike' (Preston 2002, 117).

While the various chroniclers, explorers, trappers, and settlers, may have had a variety of motivations to exaggerate in diaries, ships logs, or scientific survey reports, it is the overall consistency of the accounts that suggest they provide a generally accurate portrayal of California's early historic zoological context. For the 1830s and 1840s in particular, all available accounts, regardless of the specific source, attest to an extremely rich faunal landscape (Preston 1997, 2002).

The consistency in the reports of vertebrate superabundances provided by these and other explorers and settlers has almost surely influenced the perception, long-held by anthropologists as well as natural history writers, that native Californians struck a harmonious balance with the vertebrate populations with whom they shared the land (Kroeber 1925; Heizer 1958:20; Bean and Lawton 1973; Swezey and Heizer 1977; Leventhal *et al.* 1994; Margolin 1978). This perception continues to hold strong, as evidenced by such recent works as *Before the Wilderness* (Blackburn and Anderson 1993), a set of essays that celebrate the sophisticated extractive practices of California Indians that simultaneously ensured high biodiversity and food yields 'where abundance came with thrift and restraint' (Anderson 1993:156; see an identical position in Anderson *et al.* 1998).

However, the spectacular densities of tame terrestrial and marine vertebrates reported during the early historic period may, in fact, be a very poor analog for prey populations during truly prehistoric times. If Drake, Bidwell, Yount and the other early chroniclers and settlers were preceded by waves of infectious disease and human population declines (Dobyns 1983; Ramenofsky 1987; Reff 1991; Erlandson and Bartoy 1995; Preston 1996) - perhaps initiated first by Juan Rodríquez Cabrillo's 1542 exploration of southern California - the hoards of tame wildlife they encountered may have resulted from the earlier decimation of their chief predators, that is, the California Indians (Broughton 1994a; 1995; 1997; 1999; 2002a; 2002b; Preston 1997; 2002). In fact, this point was even suggested by some of the early explorers themselves. As Yount noted, for instance, on his 1833 visit to the San Francisco Bay area: 'The rivers were literally crowded with salmon, which, *since the pestilence had swept away the Indians*, no one disturbed' (quoted in Camp 1923, 52; emphasis added).

Testing this vertebrate population irruption argument requires not only early historic period accounts of faunal superabundances in California, but physical evidence of game depletion and scarcity in prehistoric times. That evidence can only be provided through zooarchaeological analyses. In this paper, I review several of the best documented studies that have provided evidence for late Holocene human impacts on prehistoric faunas in California. This analysis shows that by late prehistoric times in California, the faunal landscapes in a variety of different environmental settings were fundamentally anthropogenic. Ultimately, this analysis has implications for the role of 'benchmarks' in wilderness policy issues and the involvement of indigenous peoples in resource management contexts.

Archaeological Vertebrate Measures of Change in Large Prey Densities

Recent archaeological research on prehistoric human prey choice in California has been guided by the prey choice and patch-use models of optimal-foraging theory (see Stephens and Krebs 1986 and references therein). In particular, these models have been used to derive indices of change in the natural abundances or densities of large vertebrate prey taxa from patterns in archaeological faunas (see the review in Broughton 2002a).

The prey model, also known as the diet-breadth model, was designed first in evolutionary biology to predict prey selection by predators foraging within more-or-less homogeneous resource patches. The model assumes that natural selection has designed predators to maximize the net rate of caloric return from foraging within a patch. To apply the model, the various prey types potentially exploited by a predator are ranked according to their profitability. Prey ranks are defined as a ratio of the net value gained by acquiring a prey item, on the one hand, to the time costs of pursuing and processing the prey once it has been encountered, on the other. The model predicts that the most profitable or highest-ranked prey will be taken whenever they are encountered, while prey of lower rank may or may not be selected, depending on the abundance of the highest-ranked prey. As the encounter rates of higher-ranked prey decrease, prey are added to the diet sequentially in order of decreasing rank (see Stephens and Krebs 1986, 17–24 and references therein). It follows that the relative frequency that prehistoric foragers selected high- and low-ranked prey within a patch can provide an index of the encounter rate of high-ranked prey. Hence, decreasing frequencies of high-ranked prey species, as represented in dated archaeological deposits, should be a measure of declines in the encounter rate or density of the species in the surrounding environment over the time the fauna accumulated (Bayham 1979; 1982; Broughton 1994a; 1994b; 1995; 1999; Broughton and Grayson 1993).

Theoretical arguments suggest (Griffiths 1975; Bayham 1979; 1982; Broughton 1994a; 1994b; 1995; 1999) and empirical data from experimental and ethnographic settings clearly demonstrate (*e.g.* Winterhalder 1981; Hill *et al.* 1987; Simms 1987; Smith 1991; Alvard 1993; Bird 1996) that for singly handled animal prey, post-encounter return rates are closely scaled to prey body mass. At least among the size range of vertebrate species that occurred in late Holocene settings in western North America, the larger the size of the animal the higher the post-encounter return rate or rank. Indeed, recent ethnographic research on men's hunting goals underscores the overriding importance of prey body size to hunter prey choice (*e.g.* Hawkes 1990; 1991; 1996; Hawkes and Bliege Bird 2002). So, for a variety of economic and social reasons, body size appears to be the single most critical determinant of hunter prey preference (Broughton and Bayham 2003).

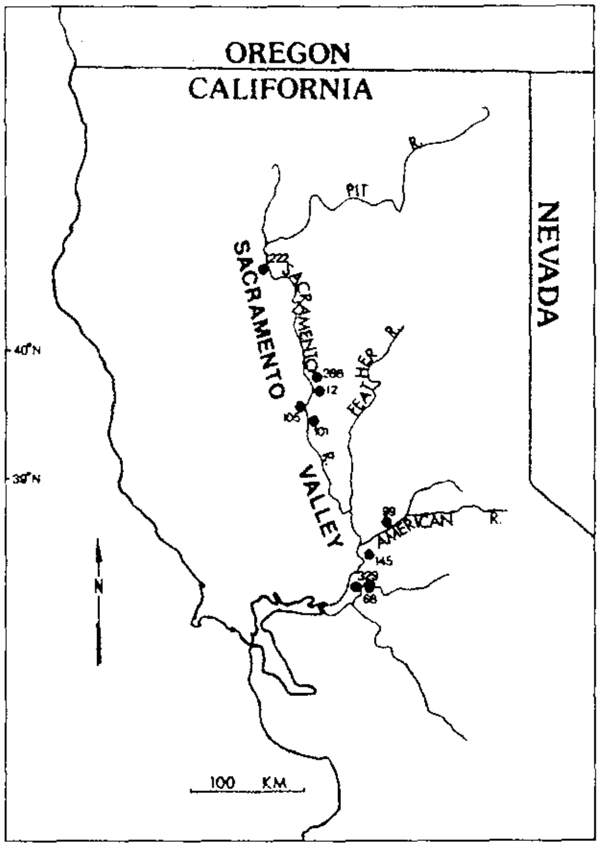

Fig. 1. Map of northern California and the Sacramento Valley indicating the location of archaeological sites.

Thus, if large-sized prey were abundant in an ancient environment, they should also be plentiful in the deposits of human foragers that lived there, given the usual taphonomic and recovery caveats. It also follows that any widespread regional decline in the archaeological representation of large prey should signal declining densities of large prey in the environment.

Zooarchaeological Case Studies

A Low-Elevation Interior Floodplain: The Sacramento Valley

Evidence for human impacts on prehistoric vertebrate faunas has been revealed from a series of archaeological sites from the northern part of the Great Central Valley: the Sacramento Valley (Fig. 1). This region, recall, provided many of the more fulsome early historic accounts of large game superabundances. All of sites in the study sample (N = 9) are located on the valley floodplain near the Sacramento River or its major tributaries. These sites span the past 4000 years and all have been interpreted as representing prehistoric villages (Broughton 1994a).

The prehistoric inhabitants of these sites would have had access to the vertebrate faunas of four primary vegetational zones: freshwater marsh, grassland, oak woodland, and riparian forest. In addition, aquatic resources, especially fishes, could be taken in both lentic (warm oxbow and floodplain lakes, swamps and sloughs) and riverine habitats (the swifter, cooler waters of the main channel of the Sacramento River and its larger tributaries).

Mammals and fishes overwhelmingly dominate all Sacramento Valley archaeological faunas and I focus on these classes here. Sacramento Valley mammals, as a group, are considerably larger by weight than resident freshwater fishes. Resident fishes are represented by eight species of minnow (Cyprinidae), Sacramento sucker (*Catostomus occidentalis*), Sacramento perch (*Archoplites interruptus*), and tule perch (*Hysterocarpus traski*). The average body size of these fishes exploited by prehistoric foragers of the Sacramento Valley typically did not exceed 500g, to judge from live weight estimates calculated from archaeological fish remains in several sites. Even the smallest mammal exceeds the average weight of resident fishes (*i.e.* brush rabbit (*Sylvilagus bachmani*) = ca. 610g). Artiodactyls such as tule elk, black-tailed deer, and pronghorn are enormous by comparison (see Madsen and Schmit [1997]; Ugan *et al.* [2003]; Broughton and Bayham [2003] for discussions on the ranking of mass-captured resources).

In order to monitor the densities of high-ranked prey in the local environment, a simple quantitative index of the relative abundances of freshwater fishes and non-fossorial mammals may be calculated as:

$$\Sigma\ Mammals\ /\ \Sigma\ (Mammals + Freshwater\ Fishes).$$

Values of this 'mammal/fish index' which approach 1.0 indicate high frequencies of mammals relative to freshwater fishes, whereas values closer to 0.0 indicate lower frequencies of mammals relative to freshwater fishes. This index should provide a measure of the encounter rate and hence, the local density of the larger higher-ranked mammals (but see Broughton 2002 on a possible violation here of the prey model's fine-grained search assumption).

Figure 2 shows the relationship between the mammal/fish index and the mean occupation dates for the nine Sacramento Valley sites analyzed. This relationship is negative, linear, and highly significant ($r = -0.94$, $P < 0.001$). The earliest occupations are dominated by mammals such as deer and elk, while later assemblages are represented by significantly lower frequencies of those taxa and higher frequencies of small freshwater fishes. However, since the bones of resident fishes are much smaller, on average, than those of mammals, and screen mesh size used to recover the faunas varied among the sites, it is possible that differential recovery may have biased these values. Previous work has demonstrated however, that when separate analyses are conducted among the faunas collected with the same methods (*i.e.* when screen size is held constant) a significant decline in mammals is still indicated (Broughton 1994a).

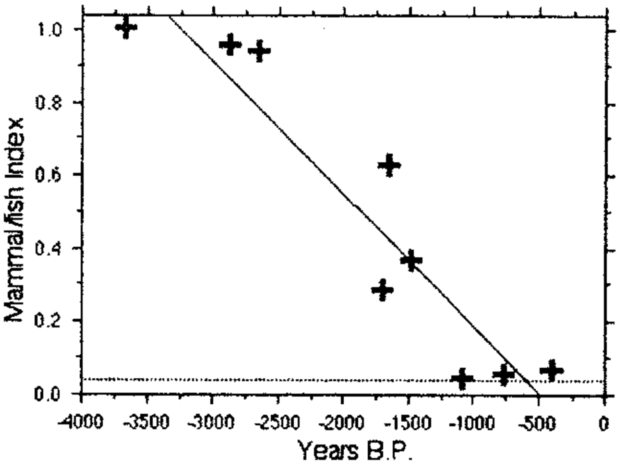

Fig. 2. The changing relative abundance of medium and large mammals and small fishes (the Mammal/fish Index) through time for Sacramento Valley archaeological sites. B.P. = radiocarbon years before present.

Fishes of the Sacramento Valley can be separated into two broad groups based on pronounced differences in body size as well: the larger anadromous fishes and the smaller resident freshwater fishes. Anadromous fishes are represented by three primary taxa: chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), and white sturgeon (*Acipenser transmontanus*). The proportional contribution of large, high-ranked anadromous fishes in an assemblage may be calculated by the 'fish index':

$$\Sigma\ Anadromous\ Fishes\ /\ \Sigma\ (Anadromous\ Fishes + Freshwater\ Fishes).$$

Higher fish index values indicate higher proportions of anadromous fishes relative to the smaller freshwater taxa. This ratio should provide a measure of the encounter rate with the larger high-ranked taxa.

The analysis of temporal patterns in the relative frequencies of large and small sized fishes is confounded by both the season during which the sites were occupied as well as by latitudinal variation in the capturability of large anadromous fishes (Broughton 1994a). For example, sites occupied only during the summer months should not contain anadromous fishes since spawning runs of those species do not occur during that season. In addition, anadromous fishes comprise less than 1.0% of the identified fishes from sites located south of 39° N latitude, regardless of when they were occupied. As I have discussed in detail elsewhere (Broughton 1994a), the paucity of anadromous fishes in southern Sacramento Valley sites is very likely due to the high flow level of the main channel of the Sacramento River and the associated difficulties in efficiently extracting fish in those settings. Insofar as the anadromous fishery was far less accessible along the Sacramento River below 39°, such assemblages

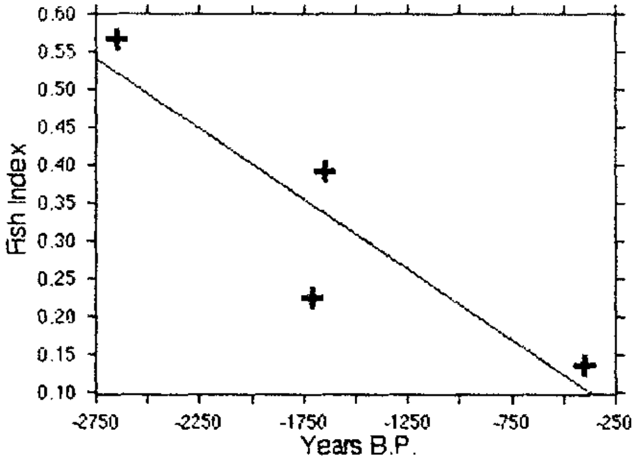

Fig. 3. The changing relative abundance of large anadromous and small resident fishes (the Fish Index) through time for Sacramento Valley sites excluding the summer occupied GLE-105 and sites south of 39° N latitude. B.P. = radiocarbon years before present.

provide little information on changes through time in the densities of large anadromous fishes.

Figure 3 displays the relationship between the fish index and time, excluding sites located south of 39° N latitude and those occupied during the summer only. Though the available sample is quite small, the relationship suggests a decline in the relative abundance of the large anadromous fishes through time (r = -0.90, P= 0.102). Indeed, the difference in the relative abundance of anadromous and resident fishes between the earliest (site GLE-101) and latest (site BUT-12) assemblages in the northern Sacramento Valley is dramatically significant ($X^2 = 76.595$, $P < 0.0001$). Anadromous fishes are heavily overrepresented, and resident fishes heavily underrepresented, in the early assemblage. Differences in the relative abundances of these fishes across early and late assemblages also remain significant when recovery method is held constant (Broughton 1994b).

In sum, when spatial and seasonal variation in the availability of anadromous fishes is isolated and removed, the temporal pattern in the relative abundance of large and small fishes duplicates the pattern found between mammals and resident fishes: the relative abundance of large species decrease through time. These patterns, uncorrelated with environmental changes that may have effected vertebrate densities (*e.g.* Benson *et al.* 2002; Adams and West 1983; Lloyd and Graumlich 1997; Ingram *et al.* 1996), suggest that the encounter rate with, and hence the local densities of, large vertebrate resources steadily declined across the late Holocene occupational history of the Sacramento Valley as a result of human predation.

A Coastal Estuary: The San Francisco Bay

Regional Level Analyses

In their broad-scale analysis of the dynamics of marine mammal hunting on the Pacific Coast, Hildebrandt and Jones (1992; 2002; Jones and Hildebrandt 1995) suggested that temporal patterns in the relative abundances of different marine mammals provided from eleven San Francisco Bay site components indicate that human hunting pressure led to local declines in certain especially attractive species. Assigning those components to the Early (4500 to 2500 B.P.), Middle (2500 to 2000 B.P.), or Late (2000 B.P. -contact) Period, they indicated that the frequencies of large-bodied pinnipeds such as Steller's sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), and northern fur seal (*Callorhinus ursinus*) declined through time relative to the much smaller harbor seal and sea otter. Hildebrandt and Jones (1992, 383) argued, 'Ever-growing human populations resorted to the exploitation of more elusive resident marine mammals in San Francisco Bay... in order to compensate for the decreasing yields of large pinnipeds.'

In an earlier analysis (Broughton 1994b), I calculated the frequencies of artiodactyls relative to the much smaller-sized sea otter (*i.e.* 'the Artiodactyl Index', ($\Sigma NISP$ *Artiodactyls*/$\Sigma NISP$ *(Artiodactyls + Sea Otters)*)) from fourteen dated San Francisco Bay Shellmound sites, representing 18 faunal samples, distributed throughout the region (Figure 4). I assigned these samples mean dates based on the span of time the mounds were occupied, as determined by radiocarbon dating, obsidian hydration, and artifact typologies. Since many of the occupation spans were quite long (*i.e.* > 1,000 years), this is a very coarse-grained temporal scale as well. While regression analyses between the artiodactyl index and mean occupation dates for the region as a whole indicated a negative and significant relationship ($r = -0.60$, $P = 0.01$; Figure 5), time is clearly a poor predictor of this index of mammalian foraging efficiency. There is thus extensive spatial variability in the artiodactyl index values across the region at any particular point in time. However, as subregions were extracted and analyzed individually, highly significant negative relationships between time and the artiodactyl index were indicated. Figure 6, for instance, shows the distribution of the artiodactyl index just for sites located in the Coyote Hills or southeast portion of the San Francisco Bay region (including sites ALA-12, ALA-13, ALA-328, ALA-329; $r = -0.94$; $P = 0.006$). These data suggest that while the encounter rates with high-ranked artiodactyls were generally declining across the late Holocene occupational history of the San Francisco Bay shore, there was considerable spatial variation in the timing of this trend.

The Emeryville Shellmound

Analysis of the Emeryville Shellmound (CA-ALA-309; Figs. 4 and 7) vertebrate fauna was conducted to examine

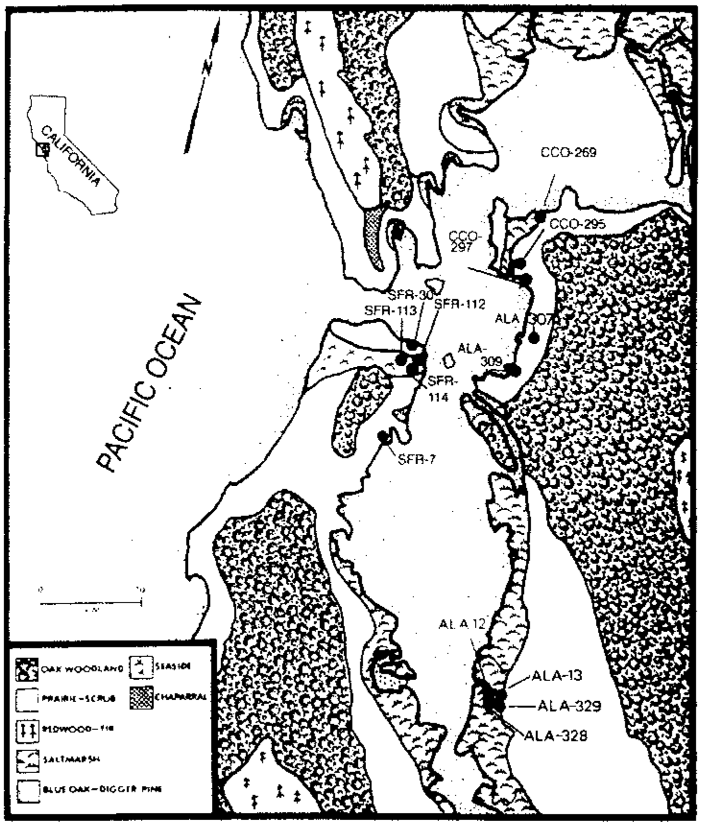

Fig. 4. Map of San Francisco Bay area indicating the location of archaeological sites and historic period vegetation (vegetation redrawn from Küchler 1977).

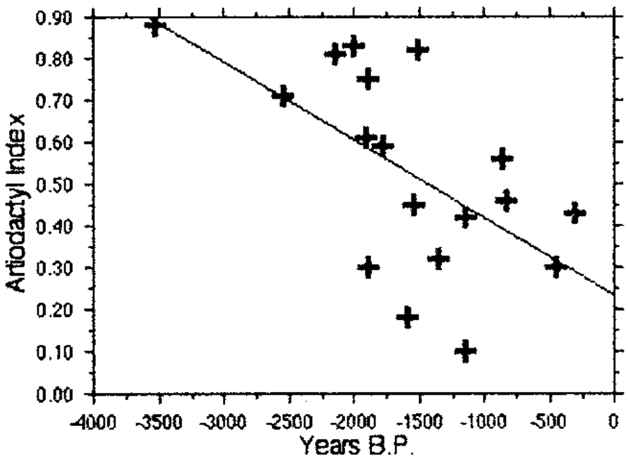

Fig. 5. The changing relative abundance of artiodactyls and sea otters (the Artiodactyl Index) through time for the San Francisco Bay area archaeological sites (all sites included). B.P. = radiocarbon years before present.

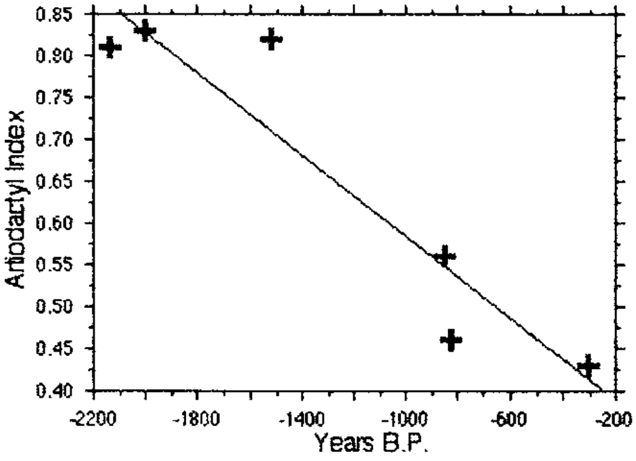

Fig. 6. The changing relative abundance of artiodactyls and sea otters (the Artiodactyl Index) through time for the Coyote Hills assemblages (sites ALA-12, ALA-13 [two dated components], ALA-328 [two dated components], ALA-329; see Figure 4 for site locations). B.P. = radiocarbon years before present.

Fig. 7. Demolition of the Emeryville Shellmound (ALA-309) by steam shovel, 1924. (Photo courtesy of the Phoebe A. Hearst Museum of Anthropology).

these issues on a finer scale while holding constant regional spatial variation in large prey abundances. The Emeryville site was located on the east shore of San Francisco Bay, California, before it was destroyed in 1924. The stratified mound, measuring 100m x 300m in area and extending to a depth of over 10m., formed through the accretional build-up of *c.* 1,900 years of human occupation and the deposition of shells, animal bones, and other sediments. The site was situated in a complex mosaic of terrestrial and aquatic habitat types, including open estuary, tidal mudflats, freshwater marsh, salt marsh, oak woodland, grassland, and redwood-fir forest.

Prior to its destruction, three different excavations at three different locations were carried out at the Emeryville Shellmound. Most of these excavations were conducted stratigraphically and ten primary strata were documented. Fourteen radiocarbon assays have recently been provided for bone and charcoal specimens recovered from the ten strata; the dates range between *c.* 2600 and *c.* 700 B.P. There are no inconsistencies in the stratigraphic ordering of the dates from these excavations; the oldest dates are from the bottom and the youngest dates are from the top. These excavations at Emeryville provided 17 faunal samples that could be placed into stratigraphic context. Collectively, about 25,000 fish, bird, and mammal specimens, representing 102 different species, have been identified from these samples. The Emeryville deposits thus allow a fairly high-resolution, ordinal-scale analysis of change in human foraging behavior over much of the late Holocene. (For a full reporting of the mammal and fish data summarized below see Broughton 1995; 1999; for the birds see Broughton 2003).

Among the fishes, four taxa comprise over 99% of the identified specimens at Emeryville: requiem sharks (Carcharhinidae), bat ray *(Myliobatis californica)*, salmon (*Oncorhynchus* spp.), and white sturgeon. All of the identified fishes presently inhabit the open estuary of San Francisco Bay, directly west of the site. White sturgeon, formerly reaching lengths of up to 6.1 m and weights up to 816 kg (Wydoski and Whitney 1979, 17), are by far the largest species represented in the Emeryville fish fauna.

Sturgeon possess no defense mechanisms that would disproportionately elevate their capture costs; they are lethargic benthic browsers, easily captured by a variety of methods (Kroeber and Barrett 1960, 87; Moyle 1976, 95). Sturgeon almost surely represent the highest-ranked fish taxon available to the Emeryville foragers. The changing proportions of sturgeon remains across the Emeryville strata are shown in Figure 8. While strurgeon bones dominate the early history of site occupation, they are rare in the upper, later strata of the mound.

If increasing human harvest rates caused absolute reductions in the densities of sturgeon, the exploited populations should exhibit demographic indications of harvest pressure. Specifically, the harvest rates of vertebrate populations are systematically reflected in the age composition of individuals in a population. An increase in the harvest rate of a population can cause reductions in the mean and maximum ages of individuals. Reductions in the mean and maximum ages of individuals in vertebrate populations as a result of increasing harvest rates have been documented empirically for a number of modern species (see the review in Broughton 2002a).

To estimate change in sturgeon age and size, maximum widths were measured for the sample of sturgeon dentaries collected from Emeryville. Both the mean and maximum age/size of the exploited sturgeon declined significantly across the history of mound occupation (Figure 9; mean width by stratum: $r_s = -0.762$, $P < 0.05$).

These changes are not correlated with late Holocene variation in estuarine salinity or freshwater inflow

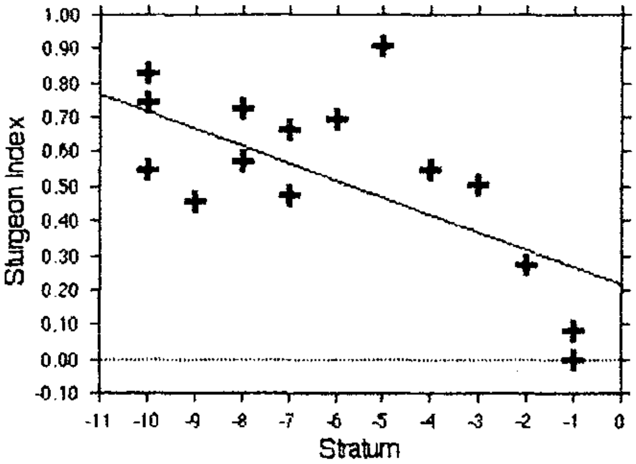

Fig. 8. The distribution of the Sturgeon Index (ΣNISP Sturgeon / Σ (NISP (Estuarine Fishes)) by stratum at the Emeryville Shellmound ($r_s = -0.49$, P = 0.05). A least-squares regression line highlights the direction of the trend.

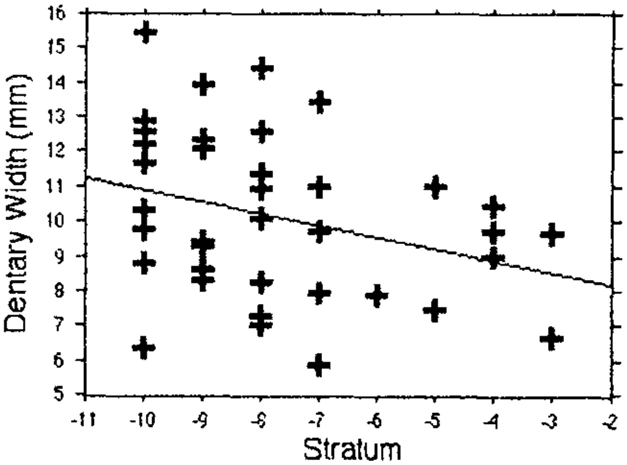

Fig. 9. Sturgeon dentary widths by stratum at the Emeryville Shellmound. A least-squares regression line highlights the direction of the trend.

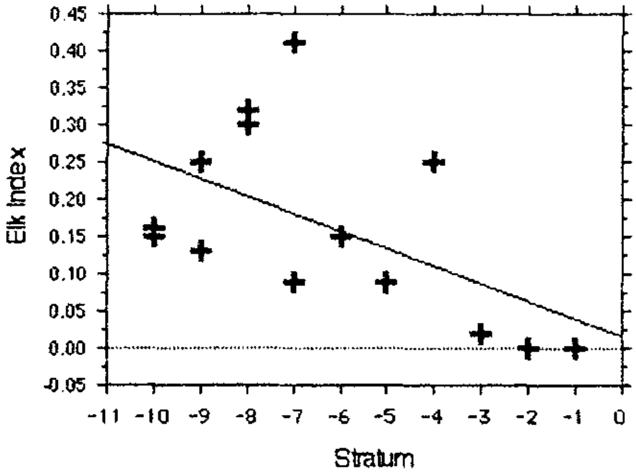

Fig. 10. The distribution of the Elk Index (ΣNISP Elk/Σ (NISP Terrestrial Mammals)) by stratum at the Emeryville Shellmound ($r_s = -0.658$, P < 0.01). Does not include the potentially intrusive rodents and lagomorphs. A least-squares regression line highlights the direction of the trend.

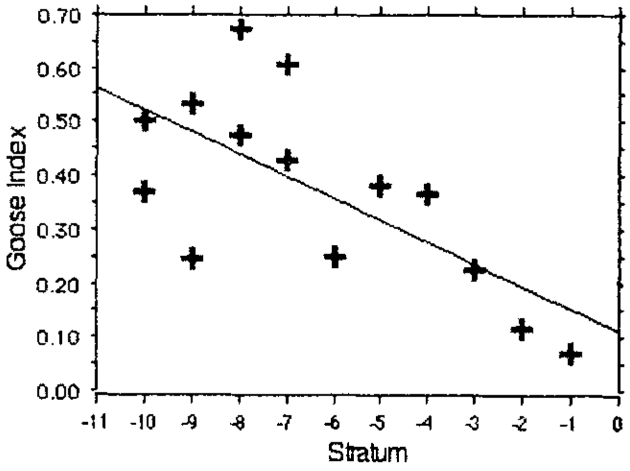

Fig. 11. The distribution of the Goose Index (ΣNISP Medium + Large Geese/Σ (NISP Anatids)) by stratum at the Emeryville Shellmound ($r_s = -0.62$, P = 0.02). A least-squares regression line highlights the direction of the trend.

(Benson *et al.* 2002; Byrne *et al.* 2001; Ingram *et al.* 1996), the most influential variables that currently limit the density of sturgeon in San Francisco Bay (Broughton 1997). The decrease in the relative abundance of sturgeon provides evidence for a significant decline in the density and encounter rate with this taxon. The decreasing mean age suggests that the decline in sturgeon abundances was due to an increasing harvest rate of this resource by the inhabitants of Emeryville as well as other human groups occupying the San Francisco Bay margin.

Similar conclusions were reached from analyses of the mammal and bird materials from this site. Considering terrestrial mammals, elk are by far the largest species to occur in the region. Figure 10 shows the relative abundances of elk, compared to all other smaller terrestrial mammals across the occupational history of Emeryville. Although there is considerable noise here, there is nonetheless a significant decline through time; tule elk virtually vanish from the fauna at Emeryville after the deposition of stratum 4.

Figure 11 shows the relative abundance of geese (*Anser, Chen, Branta*) compared to the smaller ducks across the occupational history of Emeryville. Again, a significant decline through time is documented. Geese overwhelmingly dominate the anatid fauna in the early years but ducks dominate the waterfowl sample in the upper layers of the deposit.

A variety of other data derived from the mammal and bird materials recovered at Emeryville support the general hypothesis that local densities of large, high-return resources declined across the occupational history of the site. For example, patterns in cut-mark frequencies and fragmentation patterns of the mammal bones at Emeryville all strongly suggest that processing intensity – to extract grease and marrow from bones – increased steadily across the history of site inhabitation. That is, people were working harder and harder to squeeze the maximum yield out of the mammalian resources that were becoming increasingly difficult to obtain (Broughton 1999). Patterns in age structure of birds and mammals, as well as artiodactyl anatomical part representation, also support this hypothesis (Broughton 2002a; but see also Rogers and Broughton 2001).

In sum, a number of independent tests involving the fish, bird, and mammal faunas from Emeryville provide support for the hypothesis that expanding forager densities depressed local vertebrate populations. Hardest hit were the largest, most attractive resources, such as sturgeon, tule elk, and geese. None of these trends are correlated with changes in late Holocene temperature and precipitation, to judge from detailed analyses of paleo-environmental records (Broughton 1999).

High-elevation Alpine Tundra: The White Mountains

Strong evidence for declines through time in the abundances of large vertebrate prey species also exists among late Holocene archaeological sites in the White Mountains of east-central California (Grayson 1991; 2001; see also Broughton and Grayson 1993; Madsen 1993). In this region, archaeological faunal remains were collected from thirteen sites located in high elevation (3000 and 4000 m) alpine tundra. Many of these sites contained rock rings that served as foundations for small structures, storage facilities, abundant seed grinding stones and arrowpoints, and deep accumulations of human occupational debris. These sites appear to reflect the construction and use of small alpine settlements and have been termed 'villages' (Bettinger 1991, Grayson 1991).

Five of these White Mountains village sites were, however, preceded by human occupations that lacked the foundations for structures, storage facilities, and grinding stones. These 'previllage' occupations are probably related to the use of hunting features such as blinds and drives that are abundant in the White Mountains. Based on radiocarbon and a variety of other dating methods, the previllage occupations date to between 3500 and 1400 B.P., while the villages were occupied from about 1400 B.P. to early historic times (Bettinger 1991; Grayson 1991).

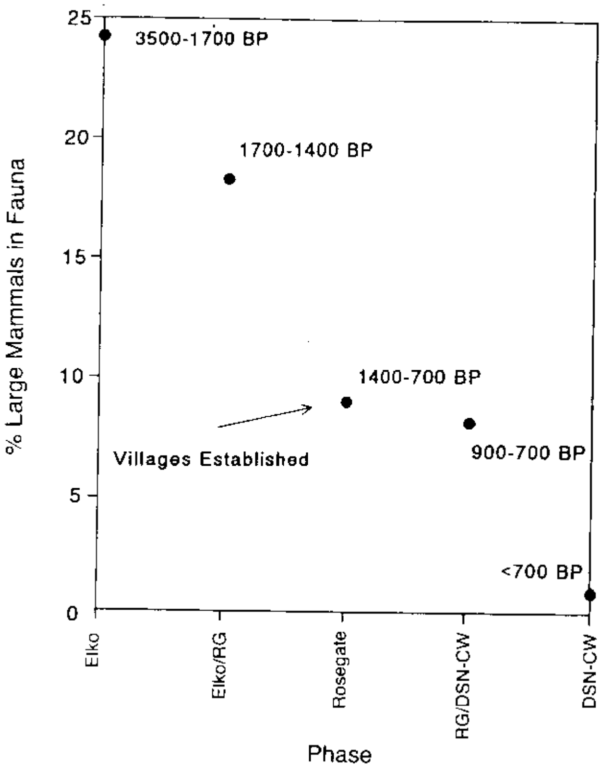

Fig. 12. The changing relative abundance of artiodactyls and small mammals through time for high elevation sites in the White Mountains. B.P. = radiocarbon years before present; "phase" refers to archaeological sites grouped on the basis of the time sensitive projectile point styles they contain, named on the X-axis (RG = Rosegate; DSN = Desert Side-notched; CW = Cottonwood). From Grayson (2001).

Although as many as 15 different, mostly small, mammal species are present in any given White Mountains site, yellow-bellied marmots (*Marmota flaviventris*) and mountain sheep (*Ovis canadensis*) comprise 89.1% of the mammal specimens identified from these faunas. The relative abundances of these animals does however change dramatically through time. In particular, the abundance of large mammals (mountain sheep) decline sharply across the occupational history of the area (Figure 12; $r_s = -1.0$, $P = 0.04$). Mountain sheep bones represent about 25% of the mammalian materials in the earliest occupations, but plummet to less than 1% of the specimens by the end of the sequence.

Such a pattern could, of course, be driven by any climatic change that would cause mountain sheep populations to steadily decline, but paleoclimatic records for this region, again, reveal no uni-linear changes in precipitation or temperature across this interval of time (see Stine 1994; Lloyd and Graumlich 1997). Grayson

(1991, 503; 2001) argues that the intensive use of these high-elevation alpine settings during village times may have been a response to increasing human population densities in the adjacent lowland and the impact of those increases on low elevation resources. He further suggests that the decreasing relative abundances of mountain sheep through time in the White Mountains assemblages reflect the local depletion of those mammals by prehistoric human hunters (Grayson 1993, 299–300; 2001).

Conclusions

While the particular species and ecological settings involved vary widely - from sturgeon of the San Francisco estuary to mountain sheep in alpine tundra of the White Mountains – the archaeological vertebrate evidence summarized above documents significant declines in the relative abundances of large-sized vertebrate taxa throughout the late Holocene. Similar conclusions have been reached from the analysis of archaeological faunas in other regions of California, such as coastal southern California (Raab and Yatsko 1992; Raab *et al.* 1995; Glassow 1996; Porcasi *et al.* 2000) and the Pit River region of the northeastern part of the state (Bayham and Valente 1997). This pattern thus appears to be a very general one, albeit one characterized by considerable temporal and spatial variability. Yet, in no case has the documented declines in large vertebrates been found to correlate with late Holocene environmental change. Given the ubiquitous evidence for human population growth over this period, the broad scale pattern of declining abundances of large vertebrate taxa is consistent with the hypothesis that expanding human forager densities led to the near-depletion of large, 'high-ranked' species. It has been suggested that the foraging strategies of native Americans 'in some times and places maintained animals at levels we might declare worthy of endangered species status today' (Simms 1992, 189); the late Holocene of California was almost surely one of those times and places. Collectively, these data have far-reaching implications concerning not only how we think about environmental 'benchmarks' but the potential role of indigenous populations in conservation management as well.

One of the fundamental goals of modern conservation biology is to promote the management of ecosystems so as to 'maintain or restore their natural structure and function' (Hunter 1996, 695). Conservation biologists have thus sought to establish benchmarks for what the 'natural' or 'original' conditions of a region are so that management can be directed toward restoring and maintaining those conditions (Hunter 1996, 695). This approach is clearly 'aimed at a flickering target' (Martin and Szuter 1998, 36) and the California example provides an excellent case in point.

In California, as recounted above, early historic records unanimously describe a land of 'inexpressible fertility' (Margolin 1978, 11) teeming with a wide variety of large, tame vertebrates. However, the vast herds of 'fat deer' that may have darkened the California landscape for miles during the early historic period, appear to have been anything but abundant during late prehistoric times. Prior to the disease-based near decimation of the California Indians, beginning perhaps as early as the 16th century, those peoples had reached extremely high densities and appear to have nearly eaten their way through many populations of large-sized fishes, birds, and mammals. The early European explorers, it now seems, had 'traversed and Edenic blip' on the California landscape (Grayson 2001, 8): the region was characterized by Indian-induced faunal poverty only decades before and would soon return to that condition with the wave of human consumers that came with the Gold Rush in the 1850s. Earlier periods in California prehistory were characterized by dramatic faunal changes as well, although these were driven by climatic-based environmental shifts (Broughton 2002b; Broughton and Bayham 2003). This extreme variability certainly makes it difficult to imagine just what a 'pristine' benchmark for the California faunal landscape might be.

Whether or not these very different benchmarks and the processes that created them are recognized may have more specific implications for how the restoration and maintenance of wilderness areas will be most effectively carried out. Recent arguments concerning the potential effects of the management of national parks by native Americans practicing 'traditional' foraging strategies provides an illustration of this point.

Based on ethnographic data from California – a record detailing Indian lifeways that pertain primarily to the mid-19th century – Blackburn and Anderson (1993,19–20) suggest that the harvesting of resources by native peoples 'was controlled by a complex web of social, political, and ideological regulatory mechanisms that ensured native groups of a sustained, reliable yield generation after generation.' While they emphasize that native peoples had substantial influences on California ecosystems, those influences are always viewed to have promoted game abundances and biodiversity; large vertebrates were maintained at high densities as a direct result of human activities. Thus, the superabundances of large vertebrates chronicled by the early explorers in California are mistakenly taken as characteristic of prehistoric conditions and are viewed as having resulted from the careful, deliberate, and efficient manipulation of the landscape by environmentally friendly native peoples. Finally, following this interpretation, it has been suggested that native exploitation strategies be implemented to manage wilderness areas or national parks in western North America to duplicate the 'balance and plenty' recorded in historic times (Anderson *et al.* 1998; Anderson 1993; Blackburn and Anderson 1993; Lewis 1993). Lewis (1993, 398), for instance, has advocated that the management of such parks as Banff, Yellowstone, and Yosemite, should be carried out by native peoples using 'indigenous management practices...carrying on the day-to-day subsistence activities of harvesting traditional foods, hunting and trapping animals'. Similar proposals have been made to preserve biodiversity in many other areas of the world (see examples in Anderson 1993; Lewis 1993; Alvard 1994).

So, the belief or perception that indigenous peoples maintained a harmonious relationship with animals that was 'sustained by human respect, mutual accomodation, and spiritual empathy' (Preston 2002, 111) is set up as an important reason *why* traditional hunting and harvesting methods should be used to manage wilderness areas and national parks today. The California zooarchaeological record makes it clear, however, that the degree of human impact on animal populations is *extremely* variable. When human populations were small, such as in ethnographic and historic times, aboriginal hunting methods may indeed have had little, or perhaps even limited positive, impacts on vertebrate populations. An analogous situation may even have characterized the early part of the late Holocene (*c.* 4000–3000 B.P.), as human populations appear to have been substantially depressed by the preceding prolonged drought of the middle Holocene period between 8000 to 4000 B.P. (Broughton and Bayham 2003). But the affects of the huge late prehistoric human populations were very different with the intense harvest pressure causing substantial declines in a host of large sized vertebrate prey from pinnipeds to geese.

Zooarchaeological data has not only shown us that indigenous human impact on animal populations is highly variable, but it gives us guidance in thinking about what demographic-ecological factors influence that variation. For instance, it may be telling that the California case represents one of the best-documented, most taxonomically comprehensive, and severe examples of hunter-gatherer impacts on animal populations, outside of oceanic island settings. Much of California is also characterized by extremely rich environments, and it is in such contexts, blessed with a cornucopia of lower-return resources (acorns, molluscs, rodents, smaller fishes), that may permit human predator densities to continually expand, even as the most attractive prey taxa are being severely depressed (see Winterhalder and Goland 1993, Winterhalder and Lu 1997). Regions where human populations are subsidized by intensive agriculture may provide analogous patterns.

Because the nature of human impact on the landscape is fundamentally dictated by demographic and ecological processes, not cultural affiliation or ideology, we may be led astray by explicit emic-based conservationist attitudes and philosophies. And for these reasons, it is inaccurate to characterize indigenous Californians, or any peoples for that matter, as fixed types with respect to the influences they may have had or, most importantly, will likely have on faunal environments. However, as noted above, this fallacy continues to underlie many arguments and assumptions about the management and stewardship of national parks and wilderness areas in North America.

This analysis of the aboriginal human impact on California faunas should in no way be construed as providing support against indigenous land claims or other rights. As Kay (2002, 261; see also Smith and Wishnie 2000, 516) has recently noted, conservation, or lack thereof, is clearly not a criterion for land ownership that is used by any modern state and it should not play any role in the politics of land claim issues for native peoples today. Indeed, if native land claims are predicated on naive or mistaken views about indigenous conservation, they are vulnerable to be undercut by any documentation of negative human impact on the landscape.

In the end, wherever we set our benchmarks and whichever wilderness or wildernesses we decide are the most desirable ones, a detailed understanding of the processes that created them is required if we want to successfully restore and maintain them. Because zooarchaeology provides a critical source of information on *long-term* dynamics of past faunal landscapes, it can and should play a more important role in the future of conservation biology.

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