Aboriginal fires modify an ideal free distribution

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Optimality and game-theoretic models grounded in behavioral ecology have enjoyed increasing popularity in anthropology and prehistoric archaeology over the last three to four decades. They have been especially important to prehistorians in fostering the development of comprehensive, theoretically well-grounded expectations about past human behavior and in helping to identify testable explanations for its variation across time and space. Bliege Bird et al. (1) provide an example of this approach in their discussion of two game-theoretic models in an Australian ethnographic context. The results have important implications for reconstructing the process of hunter-gatherer dispersal across Sahul (Pleistocene Australia–New Guinea) and about changes in human subsistence during the Late Pleistocene and early Holocene.

One of these models describes the ideal free distribution (IFD) of a population as it grows and spreads in an ecologically heterogeneous habitat (2). Applied specifically to hunter-gatherers, it assumes that patches within the habitat contain different sets of plant and animal foods offering different nutrient return rates to potential consumers. The model predicts that incoming population members will first occupy the patch where resources offer the highest aggregate rates, allowing them to gain the best overall return in the time available for collection. If resources are finite, consumers may deplete them. If returns from exploiting them fall below those available in other patches, some consumers will move to those patches. The process may continue until all patches are occupied and return rates across all are equal. It will be accelerated by population growth: Increasing numbers of consumers means more rapid resource depletion and related consumer dispersal across the overall habitat—a negative density-dependent scenario. In some situations, the opposite pattern may be apparent: Consumer presence may increase resource availability, an example of the Allee effect (3). Although the end result may be the same as in a simple IFD, interpatch dispersal will be slower and consumer population density higher across the overall habitat—a positive density-dependent outcome.

Fig. 1. Martu women observing a recent controlled burn. Image credit: Douglas W. Bird (Pennsylvania State University, University Park, PA).

Bliege Bird et al. (1) explore the application of these models in their study of Martu (Aboriginal) hunting and gathering in the Australian Western Desert (WD) (4, 5). This is an austere setting: highly arid, with widely dispersed, often ephemeral water sources and few plant and animal foods attractive to humans. It was partly occupied by 45 ka (6), repeatedly abandoned and reoccupied over the next 35 ka owing to high-amplitude climate changes, then settled at maximum pre-European densities after 5 ka when climates had become relatively stable (7). At late-19th-century European contact, populations were still low, about one person per 100 to 200 km^2, concentrated seasonally around reliable water sources (8).

The situation was subsequently disrupted by increasing European presence in the form of government-supported ration depots, mines, cattle stations, religious missions, nuclear missile drop zones, and improved transport routes, most creating opportunities for Aboriginal access to wage labor, food, and clothing on the margins of the WD and elsewhere. By the mid-1960s, the region had effectively been abandoned by Martu and other

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indigenous groups. An important result was the suspension of traditional landscape burning practices, which led to the widespread reestablishment of spinifex grassland, an unproductive ecological community for foragers (9). The process was reversed in the wake of a 1992 Australian court decision that recognized Native land rights and established the basis for formal claims. A Martu petition for a 136,000-km^2 parcel was granted in 2002. Three small, permanent settlements were established and Martu moving back began to pursue part-time hunting and gathering and related landscape burning. Bliege Bird and colleagues were involved in the process from the start: recording preburn resource availabilities, observing controlled fires designed to eliminate spinifex and improve hunting opportunities (Fig. 1), and tracking subsequent changes in resource availability and their effect on foraging success. The overall exercise mimics on a small scale the initial occupation of the arid zone and in a broader sense the Pleistocene colonization of the continent.

Interpretation of results pertinent to questions about patch choice is aided by reference to a series of aerial photographs taken in 1953 covering >353,000 km^2 of the WD, including the Martu land claim. Analysis of imagery for a 35,000-km^2 portion of the claim identified about 2,300 anthropogenic fires set in the 6-mo cool/dry season preceding image capture, an average of 92 fires a week or about 13 a day, set by an estimated 200 foragers, perhaps half the number that would have been present before recent regional abandonment began. Assuming a late-19th-century population of 400 implies an average of at least 4,600 fires set seasonally. At a median 2.6 ha per burn, coverage would have been about 12,000 ha (120 km^2), roughly 0.3% of the region monitored by the analysis, concentrated within a day's 10-km foraging radius around each reliable water source. In an area where those waters are few, this implies a significant, if highly localized, ecological impact. Assuming constant relocation of burns over the 5 to 7 y needed for spinifex to recover to the point it could carry a fire, the impact would have been even more substantial, on the order of 20,000 to 30,000 small fires covering 60,000 to 84,000 ha (600 to 840 km^2)—2% of the analyzed tract, again spatially concentrated.

Bliege Bird et al.'s recent work (1) on the recreation of the traditional fire regime adds further perspective. Burning not only yields an immediate increase in hunting returns but also initiates after the next rain recolonization of each burned patch by a succession of economically useful plants such as fruit, geophytes, and grass seeds. Controlled fires set over several years create a pattern of relatively small, heterogeneous resource arrays around each water source. The contrast in ecological scale with the extensive, nonanthropogenically modified landscapes of climax-stage spinifex, broken only by sizable open tracts produced by lightning fires, most of them far from dry season water sources, is striking.

To investigate patch choice, Bliege Bird et al. (1) calculated foraging returns available in different plant communities based on their assessment of potential resource types, associated return rates, and the degree to which these are modified by fire. They found that distance to reliable water was an important predictor of occupation, but that evidence of previous controlled fire counted strongly in the 1953 dataset as well. They inferred that what drew people to particular patches was first the reliability of the nearby water source but over a longer term the impact of related burning, which created not only an ecological but also a social magnet, offering opportunities to pool labor in various ways and pursue mating arrangements, all aspects of an Allee effect. Once population began to fall through the first half of the 20th century the level of habitat modification and related social affordances declined, so that by the late 1960s the region had to be abandoned.

The results of this study speak to questions about the process of Sahul colonization. Radiocarbon and luminescence dates from nine archaeological sites show human occupation of widely scattered locations across what are now New Guinea and Australia 45 to 50 ka. The earliest reliable dates in northwest Australia, a presumed point of entry, fall at 48 to 50 ka; those in eastern New Guinea and southern Australia, at the opposite ends of the 11-million-km^2 Pleistocene landmass, are at 45 to 46 ka (6). A simple IFD model (10) posits rapid movement south and east along the coasts and major river systems, focused on the most productive habitats and driven by immediate fire-related resource depletion of the sort described by Bliege Bird et al. (11) in one of their earliest reports on WD fire. The model assumes that subsequent, rain-initiated improvements in habitat quality developed too slowly to support colonizing groups in real time, which meant little opportunity-cost for moving on to the next attractive patch where the same process was repeated.

Bliege Bird et al.'s (1) recent results challenge this picture by suggesting less rapid resource depletion associated with initial burns around early occupied sites, allowing more time to gain the benefits of resource regeneration. A 10-km daily foraging radius around a permanent water source contains thousands of potential 3-ha burn locations. It would take a group of 50 people setting 10 fires a week over several 6-mo burning seasons to cover a significant fraction of that catchment, long enough for burned areas to begin to display the enhanced foraging returns associated with a serial recovery process. This would reduce the incentive to move away from the improving patch and the social networks it supports. Understanding constraints like this should aid the development of increasingly realistic, archaeologically testable models of the pattern and pace of continental colonization and its ecological consequences (12).

The study also speaks to the expansion of hunter-gatherer diet breadth in many parts of the world across the terminal Pleistocene and early Holocene (15 to 8 ka). One view sees this as a product of human population growth that forces increased use of resources that are costly in time and effort to exploit, like small grass seeds and toxic geophytes (13). Another styles the change as a result of habitat management that increases the abundance of these resources and favors greater efficiency in their exploitation, ultimately leading to the domestication of some, independent of human population density (14). Bliege Bird et al. (1) reckon that the results of their study support the latter view: that resource availability can be enhanced by human action even with simple technologies at low population densities. However, the opposite reading is also possible: Widespread Aboriginal application of fire and increased use of marginal resources like grass seeds only begins in the WD during the late Holocene when human population densities are an order of magnitude higher than at any earlier time (15).

Finally, on a different note, a crucial lesson emerging from this and earlier studies is that traditional fire-aided land-use practices reduce the likelihood of catastrophic wildfires by stalling the development of highly flammable climax plant communities and increasing habitat heterogeneity. Media reports on recent, large-scale fires in Australia and western North America suggest increasing public recognition of the importance of those practices and the potential benefits of reinstating them on whatever scales are possible.

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