BILBIES AND BETTONGS AS ECOSYSTEM ENGINEERS: PRELIMINARY RESULTS FROM ARID SOUTH AUSTRALIA

Alex I. James [1], *David J. Eldridge* [1] *and Brydie Hill* [2]

[1] School of Biological, Earth and Environmental Sciences, University of NSW, NSW 2052
[2] Arid Recovery, P.O. Box 150, Roxby Downs, SA 5725

BACKGROUND

Australia has experienced the highest recorded rate of recent mammal extinctions and range declines, and losses from the arid zone have been significant (Morton 1990). The Burrowing Bettong (*Bettongia lesueur*) and the Greater Bilby (*Macrotis lagotis*) are two species that were once widespread across arid Australia, and their foraging pits may have acted as resource traps that could be essential for maintaining landscape heterogeneity, nutrient cycling and vegetation productivity (Whitford and Kay 1999). Comparing the impact of these pits to those created by the Sand Goanna (*Varanus gouldii*) and the European rabbit (*Oryctolagus cuniculus*), an introduced herbivore, may explain if the ecosystem engineering role of these locally extinct species is still being maintained.

METHODOLOGY

The study was undertaken within a 60 sq km feral animal-proof exclosure near Roxby Downs in north-central South Australia. The landscape is characterised by parallel sand dunes and ridges, with intervening gibber flats. We selected three paddocks to examine the impact of animals on soil processes: 1) Main Exclosure, containing only native animals (e.g. bettongs, bilbies, goannas etc.), 2) First Expansion, where native mammals have not been introduced, and 3) adjacent mine sites containing rabbits but no bettongs or bilbies. Within each of the three paddocks three habitat units were sampled (dune, gibber, dune-gibber ecotone) and replicated three times, resulting in 3 paddocks x 3 habitat units x 3 replicates (n=27 locations). The density of diggings was assessed at each location along 50 – 150 x 2 m transects (depending on density). Animal digs were characterised according to shape and type of animal responsible, and measurements made of width, depth and length of each dig.

Within the Main Exclosure we collected soil from three microsites associated with each of 10 digs (within the pit below litter, adjacent to the pit, at the surface) resulting in 270 soil samples. Total carbon, nitrogen and sulphur were determined using a high combustion LECO CNS-2000 CNS Analyser. Finally, the relationship between dig size and the mass of excavated soil was determined by measuring 94 holes of differing size excavated by different animals (goannas, rabbits, bilbies and bettongs), calculating the volume of soil excavated, and correcting this using bulk density readings. Water infiltration was measured on disturbed and undisturbed soils in each habitat. General linear models with multiple error terms were used to examine differences in soil nutrients and dig densities across paddocks, habitats and microsites.

RESULTS

There were substantially more digs in the ecotones, followed by the dunes, and least numbers in the gibbers (Figure 1). The high degree of variability between replicate locations meant that only gibbers were significantly different from the other habitats. In general, most of the digging in the Main Exclosure were attributed to bilbies and bettongs (1600 – 19,400 digs/ha) compared with goannas (50 – 1,000 digs/ha). The simple product of hole width by length by depth, irrespective of the type of dig or animal creating it, explained 91% of the variance in mass of soil excavated ($F_{1,92}$=935, P<0.0001, Figure 2). Pits had major impacts on soil nutrients. Across all habitats, pits contained significantly more total carbon and total nitrogen compared with adjacent or surface soils ($F_{2,4}$=27.8 – 37.4, P<0.003). Pooled across microsites, gibber soils had significantly more carbon, nitrogen and sulphur compared with dune or ecotone sites ($F_{2,174}$=22.4 – 78.2, P<0.001). Disturbing the soil by digging increased the rate at which water moved into the soil.

DISCUSSION

Our preliminary results clearly reveal marked differences in soils created by the activity of semi-fossorial native animals. Bilbies and bettongs create a large patchwork of diggings while foraging for insects, plant roots and subterranean fungi. Our results indicate that the coarser-textured soils on the dunes and ecotones are preferred digging sites, though the data were highly variable. This level of activity may not reflect pre-European levels, as animal numbers in the Main Exclosure were artificially high, and under natural conditions animals would probably disperse to other areas.

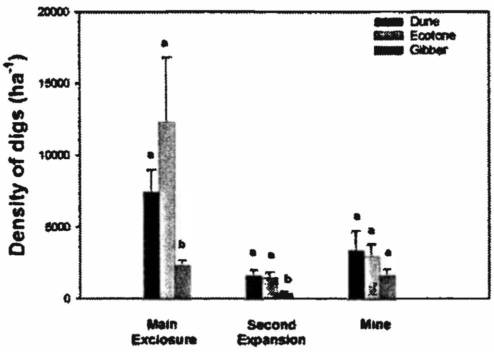

Figure 1. Density of digs (per ha) in relation to habitat and paddock. Different letters indicate a significant difference in density at P=0.05.

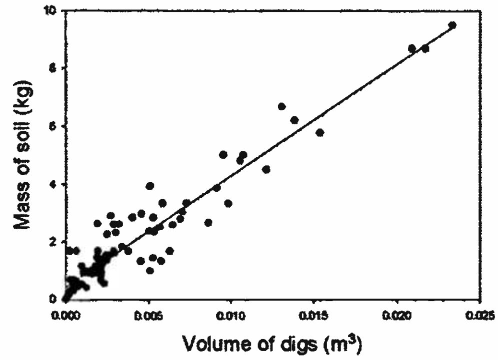

Figure 2. Mass of soil removed (kg) in relation to the volume of digs (per cubic m)

The second major impact of our study was that digs are acting as efficient resource traps ('fertile patches'), trapping litter and wind-blown sediment where it is broken down, enhancing soil carbon and nitrogen. Bilby and bettong digs are known to trap litter, particularly plant seeds, and the digs are likely to become safe sites for germination of vascular plants (Guttermann *et al.* 1990, Sparkes 2001). When the soil is disturbed by digging, the thin surface crust is destroyed, allowing water to run into the pits. On the gibber soils where soil clay contents are substantially higher (35-40% compared with 5-10% on the dunes), water is likely to pond, resulting in substantial benefits to seeds germinating in the pits. Our infiltration measurements confirm that water ponds on disturbed gibber soils for longer periods of time. Water infiltrating into the dunes may not be sufficient to initiate germination, but may stimulate the activity of litter-borne fungi associated with the pits. Further work will examine soil seed banks in the pits and the impact of these ecosystem engineers on soil surface health.

REFERENCES

Gutterman, Y., Golan, T. and Garsani, M. (1990). Porcupine diggings as a unique ecological system in a desert environment. *Oecologia* 85: 122-127.

Morton, S.R. (1990). The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proceedings of the Ecological Society of Australia* 16: 201-213.

Sparkes, S. (2001). A comparative study on the impacts of greater bilby *Macrotis lagotis* (Peramelidae) and the European rabbit *Oryctolagus cuniculus* (Leporidae) digs on vegetation structure in arid South Australia. BSc (Hons) thesis, University of Adelaide.

Whitford, W.G. and Kay, F.R. (1999). Biopedturbation by mammals in deserts: a review. *Journal of Arid Environments* 41: 203-230.