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Malaysia Program

Using signs to estimate animal densities

stats main page

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Relating sign density to animal density

On this page:

- Relating signs to animals
- Rate of production
- Retrospective estimate of decay
- Steady-state estimate of decay
- Signs as indices
- Main points

Great apes make nests to rest and ungulates produce clearly-visible dung piles: both of these are used to estimate the density of animals. There have also been attempts to use tracks (ie. footprints), generally as an index of density rather than absolute densities.

Signs are much easier to count than animals. There are more of them, and they don't run away or hide when you approach.

If each animal produces *p* signs per day and signs remain visible for *t* days, then sign density will be:

$$S = D \times p \times t$$

where *D* is the density of animals. If we can estimate *p* and *t*, we can calculate *D* from *S*.

Estimating rate of production

Ideally, this is based on data for wild animals in the study area.

Nest construction rates for apes are usually based on studies of habituated animals. This requires a lot of effort, and can't be repeated for each survey. Nest construction rates are usually extrapolated from one or two studies. Broad-scale variation exists - in Borneo, adult orang utan built one nest per night (so p = 0.9 to 1.0 nests per day, depending on the proportion of juveniles), but in Sumatra they frequently construct a nest for a day-time siesta as well (p = 1.6 to 1.9).

Dung production rates are likely to vary with the quality of the forage consumed, so will differ among habitats and with seasons. Observations of domestic elephants foraging freely in natural habitat have been used to get defecation rates. For ungulates, captive animals in a 'natural' habitat with minimal supplementary feeding are generally used.

In practice, bias due to production rates is likely to be less of a problem than biases in decay rates.

Retrospective estimation of decay rate

Retrospective estimation of decay rate

There are several ways of dealing with estimation of decay rates. The 'retrospective' method involves the fewest assumptions; we'll look at that in some detail and then deal with the other methods more briefly.

When we have a figure for the density of nests or dung piles, we need to know the number of days over which these were constructed or deposited, ie the maximum age of the signs. The retrospective method estimates this by monitoring signs during the months **before** the main survey.

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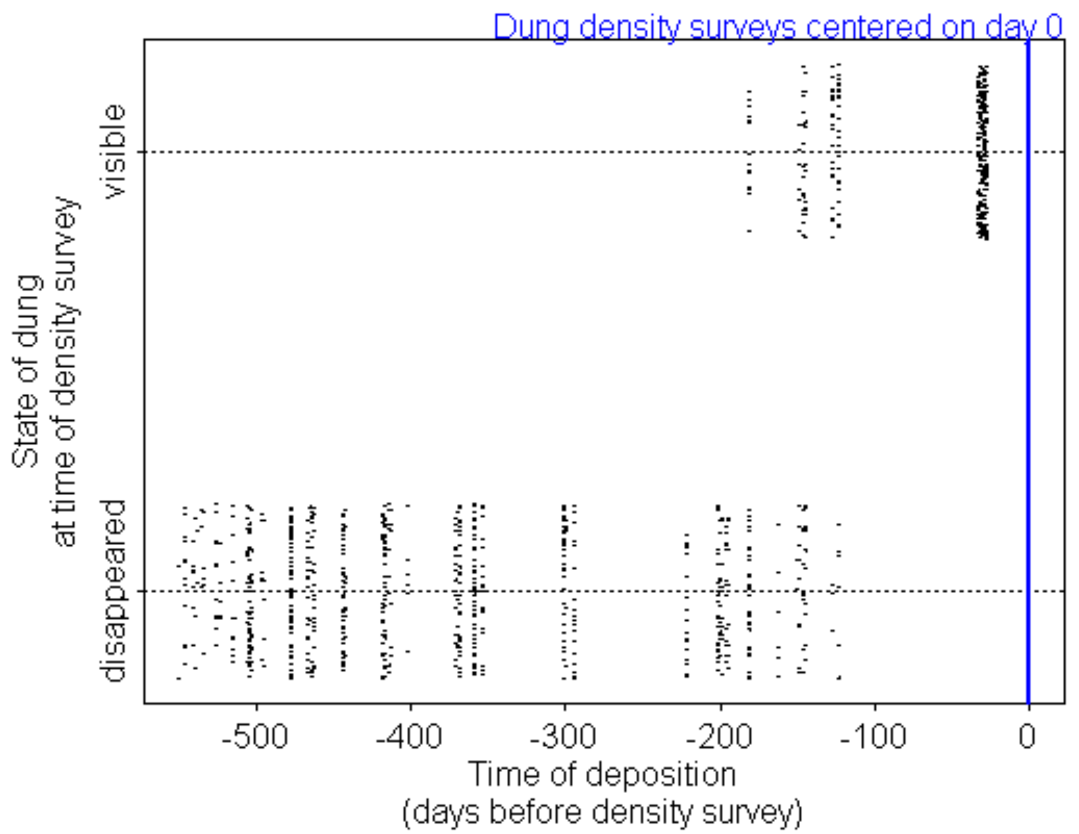
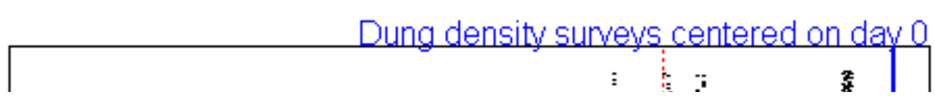
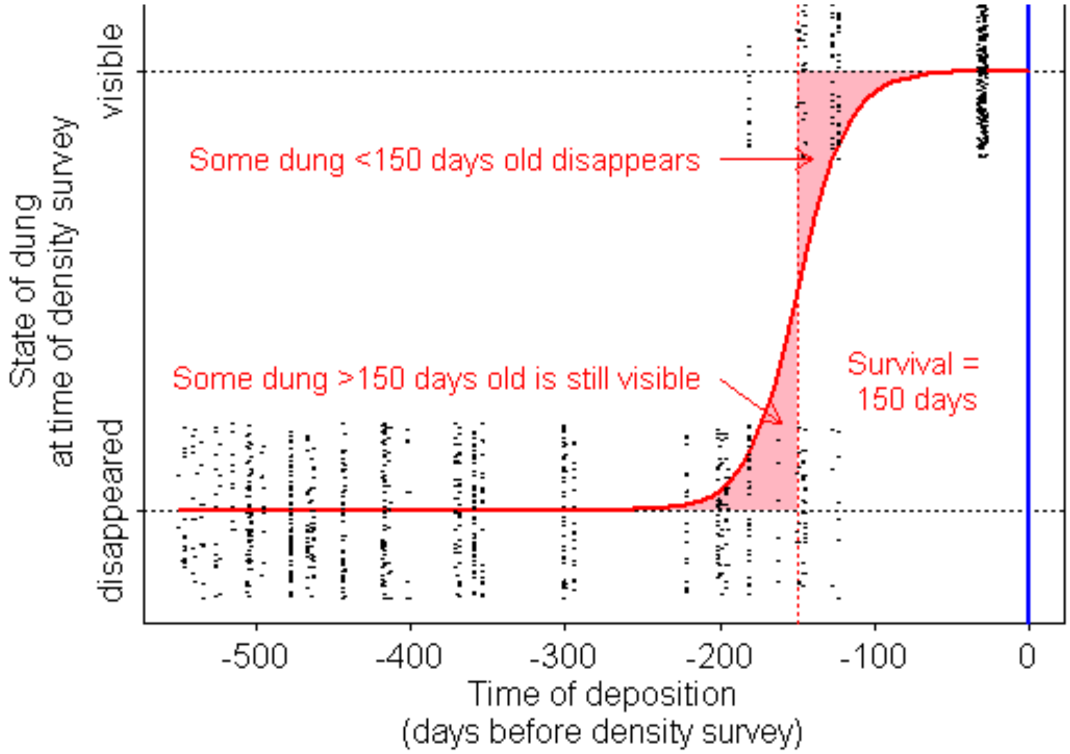
Dung density was used to estimate the elephant population of the Nakai area in Lao PDR. The survey of dung density took place in a short period around 26 March 2006. Beginning on 24 September 2004, fresh elephant dung piles were located and carefully marked; in the following 18 months, over 1000 dung piles were recorded. At the time of the survey, these dung piles were checked to see which had disappeared and which were still visible. The results are shown in the graph below. (Note that the dung piles are either visible or not, but have been spread out above and below the respective horizontal line for display purposes.)



The graph shows that all the dung piles deposited more than 200 days prior to the surveys had disappeared, while those deposited in the last 40 days were still visible. Between those limits, some were visible, some not. We now fit a logistic (S-shaped) curve to the data - the red curve in the diagram below - which is an estimate of the survival probability of dung deposited at a particular time.





The effective survival period in this case is estimated to be 150 days. Some older dung piles are expected to survive, and some newer ones will disappear, but the two should balance out.

So far we have used 'visible' vs 'disappeared' as the criterion for survival. The method works equally well for any age criterion. For example, you could classify dung piles with no boli intact as 'disappeared', even though the dung pile is still recognizable. Similarly, orang utan nests could be designated 'disappeared' when daylight starts to show through holes in the bedding. Cut-off points like these are often easier to identify reliably; whether a nest or dung pile is recognizable or not depends on the skill and experience of the observer.

Note that the retrospective method uses data on the decay of signs during the period preceding the density survey. No general assumptions about decay rates are needed.

Steady-state estimation of decay rate

The 'steady-state' or 'standing crop' method assumes that the rate of disappearance of signs is constant and equals the rate of production. Dung piles or nests are divided into age classes and transitions from one class to the next between two visits, typically 30 days apart, are recorded. These data are used to calculate the time a dung pile or nest spends in each class, and these times are added up to give the overall decay time. (Note that the method used in several published papers to calculate this is flawed and results in spurious values. See here for details.)

Decay rates are unlikely to be constant in reality, but will vary depending on local weather conditions and probably also the forage consumed or the tree used for nest construction. Walsh and White (2005) investigated the effect of rainfall on gorilla nest decay in Africa and concluded that the steady-state assumption led to substantial biases, in particular in the estimation of trends, which reflected rainfall-related changes in decay rates rather than changes in gorilla population.

The idea of a single decay rate, applicable to all sites and all seasons and measurable with two surveys at one-month intervals, is seductive, but rarely realistic. The retrospective method requires more effort over a longer time period, but avoids this doubtful assumption.

Signs as an index of animal density

Sign density is often used as an index of animal density. Animal density is assumed to be proportional to sign density, $D \propto S$, implying in turn that the rate of production of signs (p) and the period that they remain detectable (t) are constant.

Such an assumption may be plausible in the case of sign surveys conducted close together in space and in time, ie. subjected to similar weather conditions. In general, comparison between different seasons or years or different habitats is questionable.

While production and decay times have been estimated for dung and nests, this has not been done to my knowledge for tracks (footprints). Estimation would be difficult, as decay occurs over a matter of days or hours rather than months, and will depend heavily on local rainfall. Over a scale of hours, track production rates too would be highly variable and difficult to estimate. Assuming that production and decay rates are *constant* seems overoptimistic! Those are, however, the assumptions behind the use of track density as an index of animal density.

Main points

- Animal densities can be estimated from the density of signs (usually dung piles or ape nests) if rates of production and decay are known.
- Production rates are usually obtained from habituated or captive animals in natural habitat, as far as possible.
- Sign survival is best estimated by monitoring signs in the study area in the months preceding the sign density survey (the retrospective method). The assumption that decay rates are constant across sites and seasons is not supported by the evidence.
- Using sign density as an index to compare animal density between two sites or time points relies on the assumption that sign production and decay rates are the same at the two sites/times. This assumption is rarely plausible.

Further information

The "Dung survey standards" produced by the CITES MIKE programme (Hedges and Lawson, 2006) provide a thorough description of the method. Laing et al (2003) describe the retrospective method for decay estimation with details of analysis methods.

Marques et al (2001) and Hedges et al (2005) describe dung counts for deer in Scotland and elephants in Sumatra respectively.

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Text by Mike Meredith, updated 18 September 2007