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Land sparing or land sharing: context dependent

We were indeed limited by space in our editorial, and now, thanks to Scariot's letter, we have an opportunity to clarify some issues. We received several email responses from colleagues who expressed dismay at our simplistic suggestion that the tropics are better suited for land sparing whereas temperate regions are better suited for land sharing. A more accurate characterization of our idea would be that land sparing or sharing is not an either/or choice, but is highly context dependent, and should consider a whole suite of ecological, economic, sociocultural, and historical conditions. In our editorial, we alluded to a few important conditions, including the history of land use in the region, the current extent of intact forest, and the region's need for more food. Our tropics versus temperate regional dichotomy could be considered shorthand for deciding on land sparing versus sharing based on socioecological context. And we accept that both may coexist in some regions. The case of Brazil as elucidated by Scariot, with a mixture of land sparing and sharing, certainly makes sense to us.

Moreover, land sparing does not necessarily require that people be "fenced out" of forests. The greatest biodiversity loss occurs when a system is first converted from forest to agriculture, and even if forests are left to regrow this loss may never fully recover, depending on the degree and type of previous land use and the quality of the surrounding matrix. As such, preventing initial clearing is more important than preventing any use of forests. Spared land could thus be used (the 11.1% designated as "sustainable use" in Brazil being a good example), as long as the native ecosystem is still mainly intact, with the caveat that inhabited forests are often at risk of losing highly valued species to bushmeat and other practices.

Finally, although there are many successful examples of land-sharing systems, these typically involve agroforestry systems like shade-grown coffee. What is often forgotten in such arguments is that rice, wheat, and maize alone supply half of the world's calories. Can we grow these crops in sufficient quantities using land-sharing systems? The bottom line is this: to produce more food, we need to either clear intact habitat or intensify production on existing agricultural land (of course, whether we need to produce more food is the subject of an entirely different editorial…).

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Is accurate location information necessary for repeatability in field-based ecology?

Peer-reviewed letter

Repeatability of observations and experiments is necessary to formulate and test theories and to explain variation in ecological phenomena. Shapiro and Báldi (*Front Ecol Environ* 2012; **10[5]**: 235–236) scrutinized the repeatability of ecological field studies and found that ~27% of articles recently published in *Ecology* and *Oecologia* did not provide geographic coordinates and 16% of the remaining articles supplied incorrect geographic coordinates. Concluding that such inaccuracy hinders repeatability in ecology, the authors thus advocated the use of open geospatial and location standards (www.opengeospatial.org) as part of metadata requirements for published field studies. These standards facilitate more accurate representation of spatial study design as compared with a text-only site description or a single geographic coordinate.

The challenge of ecological study design is to obtain an unbiased sample of the target population sufficient for strong inference, given the unavoidable logistical constraints (eg cost and accessibility) that frequently accompany field sampling. An ecological sampling design can often be best described by the specific locations of sampling points. We therefore commend Shapiro and Báldi for their proposal to improve repeatability and agree that geospatial standards could enhance repeatability in some experimental designs. However, we argue that (1) providing accurate location information is not critical for ensuring repeatability in all field studies and (2) in some cases, releasing accurate location information can actually undermine experimental design.

To illustrate this point, we provide a hypothetical example following the sampling design of Kovács-Hostyánszki *et al.* (2011), which compared insect and plant diversity in crops, set-aside fields, and semi-natural grasslands. The alternative hypothesis is that diversity in set-aside fields is higher than that in crops. Crop and set-aside samples are paired, effectively accounting for confounding factors. The variable of interest is the effect size between set-asides (treatment) and crops (controls). The optimal design would seek a sample size that has adequate statistical power to detect a true effect against the null hypothesis (ie diversity in set-asides and crops is equal). The selected point locations are ideally a random, representative, and unbiased sample of the population, which consists of the crops and set-aside fields in the study area.

Now consider that we wish to repeat the experiment after 5 years and that our original findings had convinced farmers that set-aside fields promoted biodiversity, such that this practice had been implemented broadly. As a result, one-half of the original crop (control) areas were converted to set-asides. In this case, relying on the original experimental sample locations can lead either to suboptimal (unbalanced) design and smaller statistical power or to a biased control sample. Drawing a new random sample from the target population or replacing the converted locations would resolve this problem. Therefore, we argue that the key factors of repeatability in ecological field studies are not the exact sampling locations, but rather the definition of the statistical population and the sampling design.

Our second example focuses on Long Term Ecological Research (LTER) and monitoring systems designed to track ecological changes at large scales over long time periods in the face of changing human activities, natural disturbances, and climate (Haughland *et al.* 2010). The ability to accurately track change over time depends fundamentally on maintaining an unbiased and representative sample of the region of interest. If monitoring sites are permanently located, problems could arise if – by knowing the site location – managers can affect activities that occur there in the future. For example, suppose that a rare plant was discovered at certain monitoring sites. This could lead government officials to designate those sites as having some form of special management and/or protection, consequently rendering them unsuitable as part of an unbiased sample of the regional population in terms of human activities. In this way, accurate information on sampling location could in fact undermine the LTER goal of maintaining permanent unbiased survey locations. Similarly, LTER programs wishing to sample across a diversity of land uses may encounter property owners who are reluctant to provide access if the data can be traced back to their land (eg by identifying the location of an endangered species). Exclusion of this land-use stratum could bias the ecological sample, and thus represent another unintended consequence of making accurate location information widely available.

Such issues have been considered by the Alberta Biodiversity Monitoring Institute (ABMI; www.abmi.ca) in the context of its large-scale, long-term, cumulative effects monitoring program in Alberta, Canada. To ensure future access and representativeness of monitoring sites, the ABMI decided to "hide" their sampling locations by applying a relatively modest random offset to geographic coordinates released to the public. Precise coordinates are maintained in a secure location and may be retrieved by researchers following established guidelines. This compromise was designed to balance the need for accurate location data with the risk of inadvertently creating a suboptimal design and biased inference, as described in the above examples.

In conclusion, we feel that, where appropriate, accurate location information should be supplied for the sake of completeness, but that it is not necessary for the sake of repeatability or proper statistical design. We argue that location data are not the most important consideration for maintaining unbiased samples suitable for strong inference. The potential unintended consequences of releasing accurate location information, and the representativeness of a sample with respect to the experimental target population, should always be carefully considered.

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A reply to Sólymos *et al.*

In our letter (*Front Ecol Environ* 2012; **10[5]**: 235–236), we argued that applying open geospatial and location standards would link accurate geographical information to ecological studies, which may help improve experimental repeatability. We largely agree with Sólymos *et al.*'s arguments; their letter, however, highlights that our original message may not have been well articulated. Although we focused on the repeatability of ecological research, accurate location of samples has a much wider context, with applications that are useful beyond the narrow scope of the studies that we discussed. Here, we comment on several issues raised by Sólymos *et al.*

If an experimental treatment were applied in a temporally dynamic landscape and served as the focus of the study, then repeating the study should center on that treatment (instead of on the location) and would thus not require accurate spatial information. Nevertheless, satellite imagery and aerial photographs could help researchers choose sites with similar characteristics for conducting related research and substantially enhance our understanding of already published studies. For example, using Google Earth, the reader of a scientific article can "zoom in" on sample areas or points included in the study, thereby visualizing useful information such as the landscape context. This is especially important in regions characterized by habitat heterogeneity. Furthermore, because land use at a given study site may change over time, Google Earth can also assist in visualizing how a location has been altered.

