Simulating vegetation dynamics and an observation process to support monitoring and evaluation of public investment in biodiversity: A case study from Australia's *Biodiversity Fund*

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Keywords: monitoring of biodiversity; survey design and analysis

Abstract: Each year governments commission habitat protection and restoration through a variety of programs, but routinely fail to adequately demonstrate the ecological benefits obtained. The need to improve the way we measure and report on the outcomes of environmental investments has been made very clear in the literature, and yet major initiatives continue to be released without a coherent strategy to do so.

We simulated vegetation dynamics, and observation processes, for two biographic areas from southern Australia to inform a monitoring strategy for Australia's "Biodiversity Fund". Our aim was to identify the sampling design, data collection, and analytical framework that provides an acceptably precise estimate of hypothesised "true" outcomes of the Biodiversity Fund investment at the lowest cost.

The simulation models, implemented in R and JAGS, are informed by existing data from similar sites and ecosystems. We placed particular emphasis on two dimensions of the problem where investors often seek to minimise costs: i) obtaining control and contrast sites, and ii) distinct observation models associated with quantitative and pseudo-quantitative field assessments. Both are known determinants of power in statistical inference, but decision makers rarely confront an explicit trade-off of cost and inferential benefit.

Plausible changes to species richness and vegetation condition measures arising from ecological restoration works are unlikely to be discernible over the 3-5 years of investment given background variance and the sampling replication possible within the nominated monitoring budget. Conversely, the data that the program Investors required participants to supply as a condition of funding is unlikely to yield statistically compelling insight.

Like any *a priori* power analysis, our investigation will enable the Government to make informed decisions about how to allocate monitoring resources across their portfolio of investments. Importantly, through model-based extrapolation and predictions of outcomes based on available data, the models should also provide the basis for a whole-of-program estimate of impact that explicitly represents uncertainty.