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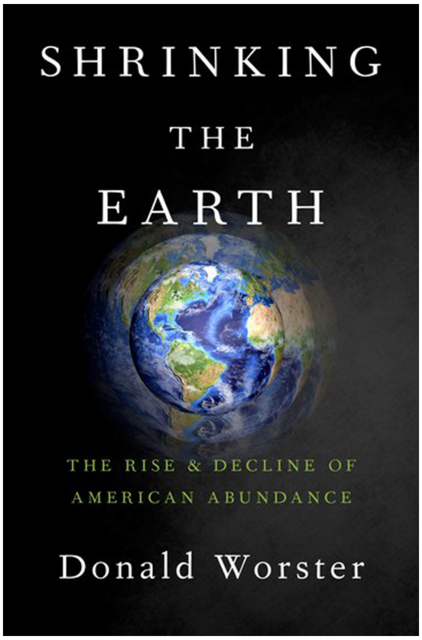
Book Review

The Rise and Fall of the Cornucopian Empire

Jeffrey C. Nekola*



The mathematics of the statement, 'Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist'–attributed to Kenneth Boulding, one of the grandfathers of systems and complexity science–is simple and unquestioned. Yet it has been conveniently ignored, not only by most economists over the last century, but many politicians, social scientists, and ecologists as well. In his excellent *Shrinking the Earth*, Donald Worster makes the convincing case that this disconnect between simple mathematics and the ivory towers ultimately stems from the discovery of the western Hemisphere by Europeans, which essentially doubled their carrying capacity. Suddenly, seemingly limitless growth was possible in population, wealth, and culture. It has taken half a millennium for human society to appropriate these resources. And in the interim we came to see unending growth as the normal and expected outcome of human enterprise.

Worster demonstrates that this belief represents a privileged viewpoint predicated by the sudden increase in resource levels. Even the founders of economic thought fully understood that the resource load of Earth was finite, and that eventually economies must become 'stationary'. Their Cornucopian descendents saw this as simply too depressing and instead offered an alternative: that it was the infinite potential for human ingenuity - and not the New World's additional resource base - that had made uninterrupted growth possible. The expectation soon became that within an infinite universe humanity itself could grow forever.

The fallacies employed by this viewpoint are many and profound. Worster details that faith in a God-like human ability to surmount all obstacles has often been unrewarded. For instance, air pollution from steel production made Pittsburgh almost unlivable by the turn of the last century. Andrew Carnegie assumed that human ingenuity would easily find a cost-effective technological fix. But one never materialized, and he finally moved to Scotland to escape the problem. Pittsburgh's air quality did not recover until after most of the mills had closed.

While Worster suggests that the field of ecology has led the way in pointing out the inadequacies of the Cornucopian viewpoint, this analysis seems overly generous. The human macroecology research group to which I belong was initiated by our reaction to an Ecological Society of America position paper which implied that unlimited growth (also known as 'sustainable development') was an achievable goal (ESA Position Statement on Economic Activities, 2013[i]). Never once were the hard global resource limits facing humanity considered. Never once did it state, as did Adam Smith, that at some point growth must stop. We could not believe that our colleagues would produce such a document. Worster's careful, multifaceted analysis of the many complex factors influencing and driving human response to resource levels and limits is far more ecological in its approach.

I do have two quibbles with the book, however, one minor and the other less so. First, Worster's premise is that the doubling of human carrying capacity gave rise to all the scientific and cultural advancements that followed. While I have no doubt that there were positive feedbacks, I remain unconvinced that this was the sole driver. The throwing off of long-held dogma and the embracing of empiricism and scientific method during the Renaissance is what gave rise to European voyages of discovery in the first place. Without this philosophical revolution, the New World's resources would never have been tapped. It seems simplistic to suggest that its impact ended as soon as the explorers returned home with heavily loaded ships.

Second, and perhaps most importantly, Worster attempts to end on an optimistic note by stating that humanity is rapidly adapting to the reality of a filled world, and uses the decrease in fertility rates to make his point. However, population projections are not falling, with 9.5 billion humans still being anticipated by 2050 and 11.2 billion by 2100. A convincing case can be made that humanity exceeded the sustainable carrying capacity for Earth around 1980 when there were only 4.5 billion people [1]. Even if we are able to maintain current resource extraction rates, in 2050 humans will be required to live at a Ugandan standard of living [2]. If we wish to live at current Chinese levels we will need to increase resource production by more than fourfold. Current USA levels will require a 15-fold increase. The only way our culture will endure is by embracing these sobering statistics and beginning to fundamentally change the way we interact with ourselves and the planet.

Resources

[i] www.esa.org/esa/wp-content/uploads/2013/03/ESA-Statement-on-Economic-Activity.pdf

Shrinking the Earth by D. Worster, Oxford University Press, 2016. US$27.95/£18.99 (265 pp.) ISBN 978-0-19-984495-1

Department of Biology, University of New Mexico, Albuquerque, NM 87131, USA

*Correspondence: jnekola@unm.edu (J.C. Nekola).

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Letter

Incorporating Imperfect Detection into Joint Models of Communities: A response to Warton *et al.*

Steven R. Beissinger,[1,*]
Kelly J. Iknayan,[1]
Gurutzeta Guillera-Arroita,[2]
Elise F. Zipkin,[3]
Robert M. Dorazio,[4]
J. Andrew Royle,[5] and
Marc Kéry[6]

Warton *et al.* [1] advance community ecology by describing a statistical framework that can jointly model abundances (or distributions) across many taxa to quantify how community properties respond to environmental variables. This framework specifies the effects of both measured and unmeasured (latent) variables on the abundance (or occurrence) of each species. Latent variables are random effects that capture the effects of both missing environmental predictors and correlations in parameter values among different species. As presented in Warton *et al.*, however, the joint modeling framework fails to account for the common problem of detection or measurement errors that always accompany field sampling of abundance or occupancy, and are well known to obscure species- and community-level inferences.

Detectability often differs among individuals within a species and among species within a community, and typically varies among observers, sampling sites, and survey methods [2]. These differences in detectability create biases in estimates of abundance, occupancy, and dynamics derived from raw counts of multispecies surveys, which are the basis for the joint modeling framework and the examples given in [1]. Undetected individuals result in underestimation of population size when species are common and in false absences when species are rare. As a result, inferences concerning the explanatory power of ecological covariates [3] or community patterns across gradients [4] can be seriously affected, with important effects being masked or spurious ones detected when variation in detectability is not taken into account. The problem is ubiquitous across taxa, including both plants and animals [2]. Thus, imperfect detection is the rule rather than the exception. Fortunately, a class of models has been developed that specifically addresses this problem in the form of hierarchical, detection-based multispecies models, which treat species occurrence or abundance as an imperfectly observed (latent) state. For reviews with examples and the code to run these models, see Iknayan *et al.* [2], Royle and Dorazio (chapter 12 in [5]), and Kéry and Royle (chapter 11 in [6]).

The simple but powerful idea to model a community as a collection of single-species models linked by a mixture distribution was developed more than a decade ago by Dorazio and Royle [7] and Gelfand *et al.* [8]. These models typically include (i) an observation process that models detection, (ii) an ecological process related to abundance (or occupancy) and any covariates of interest, and (iii) a super-population process that models species as random effects from community-level distributions, using hyperparameters to model detection

Box 1. What is a Detection-based Joint Model for Abundance?

We extend the joint hierarchical model of species abundance in Box 1 of Warton *et al.* [1] by adding a layer to accommodate imperfect detection using measurements derived from repeated surveys over a period when the population is closed.

Let y_{ijk} be the number of individuals of species j detected for replicate k at site i. The only modification required is to treat true abundance N_{ij} as a latent state that is only partially observable and related to the observed counts (y_{ijk}):

$$y_{ijk} \sim \text{binomial}\,(N_{ij}, p_{ijk}) \qquad \text{\# Abundance measured with detection error}$$

Each individual of N_{ij} has a probability of being recorded or detected (p_{ijk}) in the count y_{ijk} [12]. The remainder is identical to models in Box 1 of [1], except we relabel their y_{ij} as N_{ij} to clarify that abundance is imperfectly observed and to distinguish true (N_{ij}) from measured (y_{ij}) abundance. For the latent variable model from [1] we have:

$$N_{ij} \mid \mathbf{z}_i \sim F(m_{ij}, \phi_j) \qquad \text{\# Model for latent abundance}$$
$$g(m_{ij}) = \alpha_i + \beta_{0j} + \mathbf{x}'_i \beta_j + \mathbf{z}'_i \lambda_j \qquad \text{\# Random effects, covariates and latent variables}$$
$$\mathbf{z}_i \sim N(\mathbf{0}, \mathbf{I}) \qquad \text{\# Model for latent variables}$$

To make the model identifiable, we need repeated abundance measurements (i.e., k>1) for at least some sites, and put some constraints on p_{ijk} (typically site-level covariates or random effects). Analogous models can be specified for occurrence instead of abundance [5–7].