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Importance of the historical dimension in policy and management of natural resource systems[a]

by

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Abstract

Scientific knowledge – however defined – does grow cumulatively when not impaired by external crises, in contrast to fashionable beliefs of about 'paradigm shifts' that fail to account for the increasing empirical contents of new, over old, paradigms.

On the other hand, crises of science generated externally e.g. by drastic funding cuts, or the loss of the institutional basis of entire disciplines by wars (civil or not) do lead, at least locally, to loss of knowledge, especially in disciplines (such as taxonomy) which rely on archived specimens, and on explicit transfer of arcane skills from one generation of specialists to the other.

Various disciplines, such as e.g. physical oceanography, have data recovery programmes dedicated explicitly to recovering the earlier data sets that, because of such crises, failed to become incorporated into their mainstream.

Taxonomy and the biological disciplines depending on proper identification of numerous specimens, did not until recently have any vehicles for such explicit recovery programmes. Relational databases, such as e.g. FishBase for fishes, can be used as hubs for data recovery programmes in both developed and developing countries.

Such programmes are important because the concept of 'sustainability', is meaningless unless it implies reliance on accurate estimates of initial baselines or reference points. Without reference points, biodiversity will suffer from the "shifting baseline syndrome".

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Introduction

Science proceeds by accumulation of knowledge. This truism brings to mind a smooth process, the naïve view represented in Fig.1A. Different shapes for the curves result from whether knowledge is thought to be reflected by the amount of 'data', or the number of new publications, both usually exponential (a), or whether knowledge growth is defined by increase of well corroborated integrative concepts and theories, which may imply a gradual slowing down (b). In either case, an increase of knowledge occurs. This contrasts with what may be called the 'Standard Social Science Model', where, based on crudest reading of Kuhn (1960), the process of natural sciences science is viewed as dominated by sequences of 'paradigm shifts', or by different 'discourses', each reflecting mainly the vested interests of a currently elite group (Gross & Levitt, 1994). 1B gives a schematic representation of this view.

Yet, in the natural sciences, we do know *more* about the Earth since Plate Tectonics replaced earlier, static representations of global geological processes, and we know *more* about biology since Darwin's selectionist paradigm replaced its creationist predecessor. In both examples, the new paradigm not only explained more than did its predecessors, but spawned new opportunities and methods of investigations.

Thus, a key criterion for a true advance is that the new model or explanation should explain more than its predecessor(s), i.e., provide a context for incorporating into a coherent body of knowledge more of the empirical evidence established by previous generations of researchers. Thus, even when acknowledging that paradigm shifts do occur, an overall increase of knowledge occurs as well. Thus, the naïve view of science operating in cumulative fashion is vindicated, though perhaps in form of a slightly more complex representation (Fig. 1C).

What is required for the cumulative process of science to break down are crises external to science itself (Fig. 1D).

Crises and challenges

Crises capable of interrupting scientific growth are, for example, those caused by unstable research support, in both developed and developing countries.

In developed countries, examples of such crises were induced, starting in the early 1970s, by failing support for institutions devoted to taxonomy (mainly museums), once a vibrant area of biological research. As a result, a large fraction of the knowledge held by the last working generation of taxonomists is not being passed to successors.

In many developing countries, the same period has seen, in relative terms, even sharper declines in support, often reducing research institutions to shadows of their former selves – even when acute conflicts such as civil war did not lead to scientists having to flee their jobs, and valuable archives and specimens being burnt or looted.

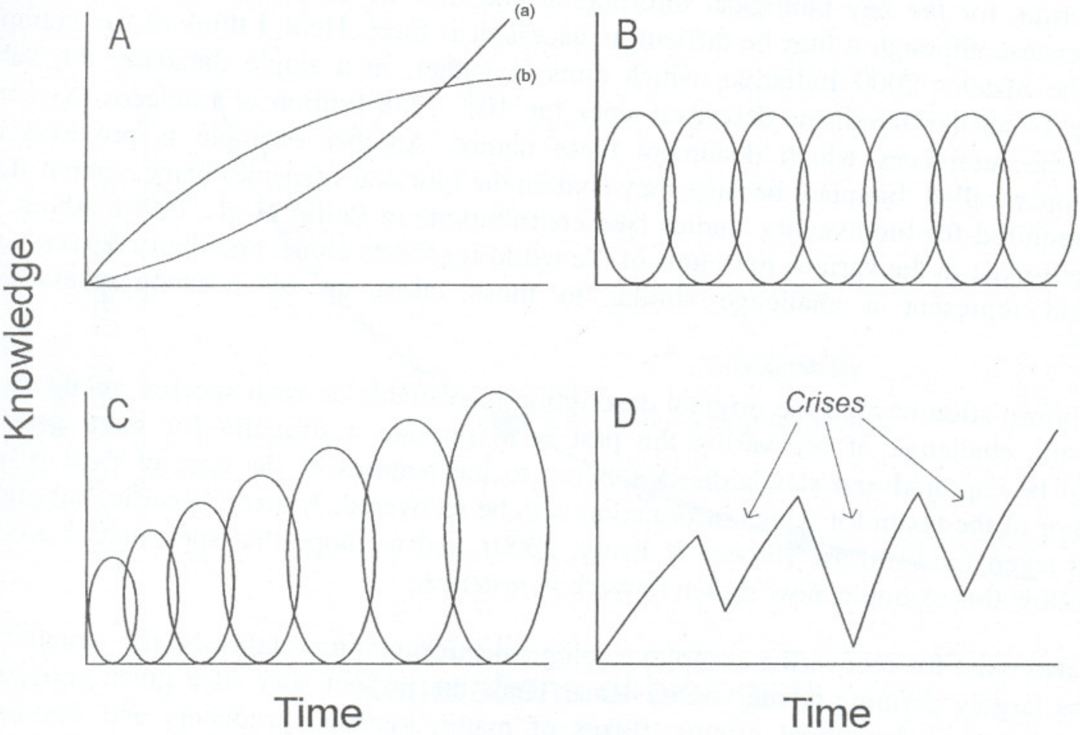

Fig. 1. Aspects of the growth of scientific knowledge. A: Naïve models, assuming that growth does occur. Different view may exist as to whether this growth accelerates (a) or not (b), depending on how 'scientific knowledge' is defined. B: The Standard Social Science Model, wherein paradigms (the ovals in the graphs) are successively replaced, without net increase of knowledge. Note that this model may well apply to literature, in that early work by say Aeschylus or Homer's was not subsequently 'improved'. C: While paradigms, in the natural science, do replace their predecessors, they will do this only if they can accommodate an increased empirical content, i.e., explain more 'facts', and lead to more knowledge. Hence the naïve view in A is largely validated. D: Crises (slashed funding, or failures in knowledge transmission from one generation of scientists to the next) can, however, impair the growth of scientific knowledge, and hence the need for data recovery programs and databases dedicated to overcoming the effects of such crises.

In some disciplines, notably oceanography and meteorology, vast programmes of data recovery have been initiated, often triggered by the need for the proper baselines required by global climate models. Here, the cumulative process is restored *post hoc*, to bridge the gaps caused by institutional crises. For example, programmes presently exist to recover oceanographic and weather data pertaining to areas held by the Axis powers during the Second World War (the ultimate institutional crisis), and previously available in global databases.

Similar efforts are exceedingly rare in the biological sciences. Many colleagues believe that this is due to the complex nature of biological data, compared to the straightforward formats required for oceanographic (mainly salinity, temperature) or meteorological information (mainly wind direction and strength, and air pressure).

However, one could argue if there is a will, there will be a way. One way, for example, is to define a minimum format for *the* key biological information and then do an all out effort to get that information, because although it may be difficult to access, it *is* there. Here, I think of the example provided by the Species 2000 Initiative, which aims to gather, in a single database, the valid scientific name of all the organisms described since the 10th, 1758 Edition of Linnaeus' *Systema Naturae*, and the references which document these names. Another example is provided by occurrence records, called 'bioquad' because they contain the four items (species name, source, date and locality) required for biodiversity studies (see contributions in Pullin *et al.*, 1999). About 10 million bioquads exist in the various museums of the world for fishes alone, and their recovery and analysis should represent a challenge similar to those taken up by oceanographers and meteorologists.

Where some information beyond the original description is available on each species, another way to deal with the challenge of recovering the past is to provide a structure for more detailed information to be captured and standardised, tailored to the features of the type of field survey (Pauly, 1996) or of the taxon for which information is to be recovered. A taxon-specific, but global approach was taken for FishBase (Froese & Pauly, 2000), and we hope that specialists for other groups will follow this example, now shown to work *in practice*.

Approaches also exist for recovering complex ecological information, notably on the structure of the food webs largely defining aquatic ecosystems. Thus, the present state of a given ecosystem (biomass of its various functional groups, fluxes of matter between producers and first-order consumers, predatory fluxes from the latter to higher-order consumers, etc.) can be represented in standardised fashion using Ecopath models (see software and documentation on www.ecopath.org). Then, the data recovered from the past can be used to modify the contemporary model such that it will tend to represent an earlier state of the ecosystem, e.g. before the biomass of major resource species was reduced by industrial fishing. Numerous application cases documenting the practicality of this approach also exist (see www.ecopath.org).

This establishes that approaches are available for digitizing, documenting and analysing, on a global basis, the aquatic species that have so far been identified, the occurrence records that document their distributions in space and time, and their interactions with other species. Moreover, approaches similar to the Ecopath software can be easily conceived which would allow the validity of this statement to be extended to terrestrial ecosystems as well.

Using recovered knowledge to prevent baseline shifts

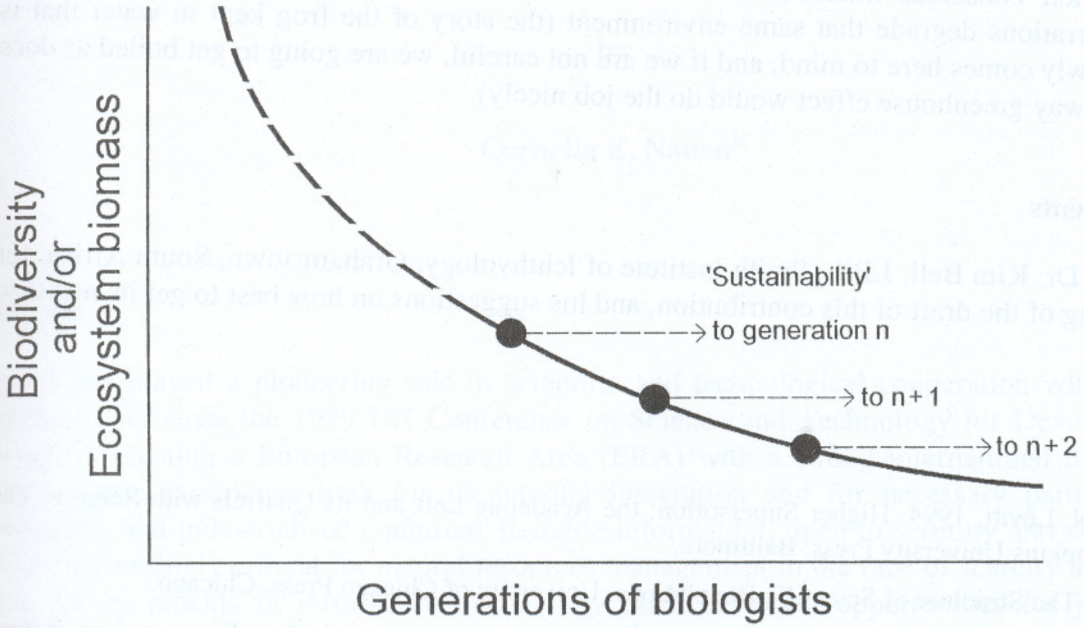

Fig. 2. Human exploitation of newly accessed ecosystem typically implies that the animals that are largest and most valuable (in the nutritive or commercial senses) are taken and depleted first, often with simple methodologies. Smaller, less valuable animals are then the next to be taken, with improved technologies. Early serial depletions of this sort (thick dotted line) are not documented in the literature with the standards now prevailing, and thus often dismissed. Moreover, successive generations of biologists will tend to use the ecosystem state at the start of their career as baseline for what biodiversity and abundances 'ought to be'. This leads to shifting baselines, with each generation aware of less that ought to be sustained. This undermines the concept of sustainability, which becomes generation-specific. Countering this 'shifting baseline syndrome' (Pauly, 1995) requires recovering and synthesizing historic information, i.e., data on earlier ecosystem states, as can be achieved by the tools also useful to address the crises in Fig. 1D.

The question, which now emerges is why we would want to do this? After all, this work covers much of the agenda proposed for the U.S. based *Census of Marine Life*, an initiative initially costed at 10 billions US \$ (10^{10} \$), a rather large sum. However, we may wish to compare this with the sum spent annually by governments to subsidise already overcapitalised fisheries: 50-70 billions \$ *per year*. As every fishery economist will confirm, subsidies encourage overfishing and resource depletion. Thus, all of a sudden, the *Census of Marine Life* does not look so expensive any more, at least compared with the support to forces that are presently contributing to reducing biodiversity, and of which fisheries are but a small part (Pullin *et al.*, 1999).

However, the real reason why we would want to get proper baselines of the marine life we have now, or once had, is because it is only when it is based on well established baselines that the concept of sustainability, otherwise nothing but a feelgood concept can be made to mean anything.

Indeed, without firmly rooting in scientific, quantified knowledge of what we now have, or had, we will experience what I called the "shifting baseline syndrome" (Pauly, 1995). Herein, successive generations of naturalist, ecologists, or even nature lovers use the state of the environment at the beginning of their conscious interactions with it at 'the' reference point, which then shifts as successive generations degrade that same environment (the story of the frog kept in water that is heated very slowly comes here to mind, and if we are not careful, we are going to get boiled as does the frog: a runaway greenhouse effect would do the job nicely).

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References

Gross, P.R. & N. Levitt, 1994. Higher Superstition: the Academic Left and its Quarrels with Science. The John Hopkins University Press. Baltimore.

Kuhn, T., 1962. The Structure of Scientific Revolutions. University of Chicago Press, Chicago.

Froese, R. & D. Pauly (eds.), 2000. FishBase 2000: Concepts, Design and Data Sources. Los Baños, Philippines, ICLARM, 346 p. (Distributed with 4 CD-ROMs)

Pauly, D., 1995. Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution*, 10(10):430

Pauly, D., 1996. Biodiversity and the retrospective analysis of demersal trawl surveys: a programmatic approach. pp. 1-6 *In:* Pauly, D. & P. Martosubroto (eds). Baseline studies in biodiversity: the fish resources of western Indonesia. *ICLARM Studies and Reviews*, 23.

Pullin, R.S.V., R. Froese & C.M.V. Casal (eds.), 1999. ACP-EU Fisheries Research Initiative. Proceedings of the Conference on Aquatic Biodiversity: Data, Tools and Cooperation. Lisbon, Portugal, 3-5 September 1998. *ACP-EU Fish.Res.Rep.*, (6):70 p. + CD ROM