IDENTIFYING MALAGASY TREES

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The Integrity of US Ecosystems

The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. H. John Heinz III Center for Science, Economics, and the Environment. Cambridge University Press, Cambridge, United Kingdom. 2002. 288 pp., illus. $25.00 (ISBN 0521525721 paper).

Complex systems are characterized by multiple attributes with intricate interactions and emergent properties. For pragmatic reasons, it is often impossible and unnecessary to study such systems in all their dimensions. Rather, a subset of attributes is chosen for measurement, with the belief that these few variables sufficiently indicate the state of the system and allow inference to the whole. Examples of this approach include measurement of a small number of indicators to infer the state or behavior of economic systems or businesses and the health of individual human beings. However, even though these complex systems have obvious relevance to humanity, "no periodic comprehensive and reliable compilation of essential information about the overall state of the nation's environment" has been available. This void has now been partially filled, thanks in large part to a recent report on the state of major ecosystem types within the United States, commissioned by the Heinz Center for Science, Economics, and the Environment.

This ambitious undertaking identifies four broad categories of ecosystem characteristics (with accompanying indicator groupings): (1) system dimensions (extent and landscape pattern); (2) chemical and physical condition (key plant nutrients and chemical elements, selected contaminants, and physical features); (3) biological components (plant and animal species, biological communities, and ecological productivity); and (4) human use (food, fiber, water, and other goods and services provided by ecosystems). These broad categories of state variables, with accompanying indicators, are used to characterize the state of the nation as a whole, and of six major ecosystem types defined on the basis of major land-cover types (after Vogelmann et al. 2001). Indicator values specific to each ecosystem type are reported when data are available; otherwise, data needed to reliably characterize the state of a given ecosystem are scored as "indicator development needed." In total, of the 103 indicators reported on or proposed, only 58 currently have data available, and only 31 of these proved estimates of temporal trend.

The report has an extended section of technical notes, which describe the data sources, methods of data compilation, and data limitation. One of the many strengths of the report is the attention it draws to data gaps and to indicators that are needed but that lack data. For example, farmlands and grassland/shrubland ecosystems make up about 60 percent of the land area of the United States, yet full data on these ecosystems are available for less than half of the critical indicators. Urban and suburban areas are growing most rapidly of all ecosystem types and are home to about three-quarters of all Americans, but information on these areas exists for only 6 of 15 indicators.

It is not possible here to review all the insights provided by this report, but several are worth emphasizing because of their significance to human welfare and quality of life. At the scale of the entire nation, most pronounced are changes in the extent of various ecosystem types—consistent trends are shown for freshwater wetlands (downward) and urban and suburban areas (upward), implying some causal relationship. On the basis of available data, water resources and freshwater ecosystems appear to be the most threatened and degraded. Almost every stream sampled had at least one contaminant and over 25 percent of groundwater samples had at least one contaminant that exceeded current human health standards. Alterations of the nation's water resources are most pronounced in agricultural areas—75 percent of streams sampled in farm areas exceeded federal standards for phosphorus, and 83 percent contained at least one pesticide exceeding guidelines for wildlife protection. In parallel with more comprehensive reports on the status of biodiversity in the United States (Stein et al. 2000, Stein 2002), major threats and losses were also documented for most ecosystems. For example, currently about 20 percent of native animal species ($n \approx 1700$) in forest ecosystems are at risk; a similar percentage are at risk in grassland and shrub ecosystems ($n \approx 1700$ species); and about 20 percent of more than 4000 native animal species that depend on streams, lakes, wetlands, or riparian areas are considered imperiled or critically imperiled (classifications in Stein 2002). However, information on the status and trend of most species (even when restricted to animals and vascular plants) is unknown.

Given the documented dependence of human societies on the goods and services provided by ecological systems (e.g., Daily et al. 1997), perhaps the most important insights provided by this report are the gaps in what is known about the condition of the nation's lands, waters, and living resources. This information gap can only be filled by devoting significant resources to long-term monitoring and assessment programs. The absence of this information will exacerbate political controversies and perpetuate the current state of affairs. Unfortunately, those segments of society most likely to oppose funding to acquire this information, because they benefit from the status quo, are in positions of political influence. However, this issue is not directly addressed by the report.

The absence of essential information also implies that ecological systems are undervalued and poorly understood or perceived to be resilient to human use and transformation. This attitude is inconsistent with recent scientific reports that document extensive human alteration of ecological systems (e.g., Vitousek 1997, Sanderson et al. 2002, Wackernagel et al. 2002), the potential for loss of essential goods and services (e.g., Baron et al. 2002), and continuing broad-scale landscape transformations as human population and per capita consumption rates grow. Combining the number of indicators that have missing data with the reality of continuing human domination of ecosystems, the necessity of an accelerated program of environmental assessment becomes obvious.

An update to *The State of the Nation's Ecosystems* is expected in five years—an opportunity to see if federal and state environmental agencies respond to fill in the gaps of missing information. However, even better data, in my opinion, cannot substitute for a fundamental flaw in the reporting process. The Heinz Center has adopted a policy of not attempting to identify cause-and-effect relationships because this "can influence perceptions of the scientific credibility and political neutrality of both data and reporting efforts." This philosophy undermines the utility of monitoring data and allows only for retrospective investigations. To respond to environmental change before irreversible losses occur, it is important not only to identify or report on indicator values that trigger a critical evaluation of environmental policy but also to report on possible factors leading to such changes. As it now stands, the report relies on some unspecified individual or organization to interpret the report and assign culpability when it appears appropriate.

Other caveats, all of which can be addressed in subsequent updates, accompany this first report on the state of the nation's ecosystems. One consequence of environmental assessments conducted at broad spatial scales is the tyranny of the mean—that is, the failure to recognize significant declines in environmental quality on a local scale when broad-scale trends seem acceptable. An example is provided by forest ecosystems where the indicators of timber growth and harvest show that growth has exceeded harvest for more than 20 years. This indicator, viewed in isolation, suggests that harvest levels can be increased without adverse ecosystem effects. However, important information is masked by the value of this indicator: The density of large trees (> 73 centimeters in diameter at breast height) on public forests nationwide has decreased by 46 percent since 1952 (Powell et al. 1993); timber harvest is disproportionately focused on the largest trees; and many contemporary biodiversity issues are a consequence of the loss of large, old trees (e.g., northern spotted owls; Noon and McKelvey 1996).

Another limitation of the current report is the failure to explore the interactions among indicators. For example, in farmland ecosystems it would of interest to know the relationship between the values of the nitrates in groundwater, the phosphorus in streams, the pesticides in streams and groundwater, and the status and trends of freshwater organisms. Exploring such associations might provide insights to possible cause-and-effect relationships without sacrificing political neutrality. Finally, for indicators with inadequate data for a national assessment, the report discusses why the indicator cannot be reported at this time. However, the report does not take the next step and identify the agencies that should logically take the lead in collecting this information. As a consequence, critical information gaps may still exist when the report is reissued in five years.

Despite the caveats listed above, this report is noteworthy in initiating an essential and long overdue dialogue about the state of our nation's ecosystems. The Heinz Center and the authors of the report are to be commended for pursuing the project, documenting our current understanding of the state of the nation's environment, and attempting to insert the topic of ecosystem integrity into contemporary political discourse. Whether this report gets the attention it deserves remains to be seen.

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LIFE FROM THEN UNTIL NOW

The Story of Life. Richard Southwood. Oxford University Press, Oxford, United Kingdom, 2003. 272 pp., illus. $28.00 (ISBN 0198525907 cloth).

I have long looked for a book that describes life's record on Earth in a manner that covers evolutionary biology, paleontology, geology, genetics, and whatever other scientific fields pertain to the subject. Not being a card-carrying specialist in these dimensions of prehistory, I have wanted the book to be integrative across disciplines and accessible to a scientist who specializes in being a generalist. I have also wanted the book to highlight the remarkable array of life forms that have been generated by almost four billion years of evolution's powers. Above all, I have wanted it to be informed with a spirit that reflects the wonder of life's very existence from shortly after the emergence of the planet itself—what has been viewed as such an unlikely event that it has been described as the "impossible phenomenon." With the appearance of Richard Southwood's *The Story of Life,* I need look no further.

Southwood's account begins with the formation of Earth, followed by the primordial planet's suffering an asteroid bombardment, both intensive and extensive, for fully 100 million years. Eventually there emerged the first rudimentary flickerings of life. Then, after just 15 million years (a mere moment in evolutionary time), more complex life forms began to appear. After this biotic breakthrough, 3 billion years or more passed with few significant advances: Life's manifestations were largely a case of "the same as before, only more so." Then, around 540 million years ago, there was a sudden explosion of new species, arriving in huge numbers and with highly diversified forms: "Modern life" came into its own. From that point on, and for only the last eighth of life's history, Earth has featured animals with skeletons, jointed legs, a panoply of body plans, and numerous other major adaptations. This final phase rightly occupies three-quarters of Southwood's account.

In the main body of the book, Southwood takes us through one period after another, with extended accounts of life's development during the Permian, Triassic, Jurassic, Cretaceous, and Tertiary. During this last period, Southwood documents that "the main bands of vegetation, which we still have today, became clearly established: the tundra, coniferous forest, deciduous forest, grassland, and tropical rainforest." Most of our present plantscapes arose in less than the last 1 percent of life's history, and their associated animal communities arose during an even shorter time.

Southwood ends his account with detailed descriptions of the eruptions of new life forms during the Quaternary period, right up to the Holocene. This final phase, a mere 11,000 years, could be better termed the Homocene in light of the homogenizing impacts of *Homo sapiens*—for example, the grand-scale transformation of forests and grasslands to make way for agriculture. But the depauperizing debacle began rather earlier, notably during the late Pleistocene, with its mini–mass extinctions of "charismatic mega-vertebrates." Especially enlightening is Southwood's assessment of the debate on the predominant cause of the recent widespread extinctions: human hunters or climate change? Or both together, possibly working in conjunction to exert compounded impacts?

Whatever the cause or causes, the last few tens of thousands of years have seen a sharp end to the heyday of mammals and birds, and especially of their outsize creatures. Humans will never again set eyes on the Americas' mammoths, rhinoceroses, and camels, or on their saber-toothed cats, 16-foot-long ground sloths, and two-ton armadillos. Nor will they see Australia's 16-foot-high birds and 20-foot-high kangaroos, or similar giant species in Madagascar, New Zealand, and elsewhere. In all, two-thirds of the large mammals in the Americas have vanished, as have four-fifths of those in Australia.

Southwood confronts the reader with a series of basic questions. For instance, how did life ever emerge? Why did the dinosaurs go extinct at all, let alone so suddenly, after some 200 million years of dominance? Was their extinction caused entirely by an asteroid, or were other factors at work? Another key question that Southwood discusses at illuminating length: Are we humans precipitating another mass extinction, largely confined to a single century by contrast with the far longer periods for the five mass extinctions of the past? The "overnight" demise of the dinosaurs probably extended over thousands of years.

Southwood raises many other and more esoteric-sounding questions: For example, what was "snowball Earth"? Answer: an exceptionally glaciated planet with sea-level ice reaching far into the tropics. Also worth more than a page or two are such diverse and obvious topics as protists, algae, lampshells, tectonics, Gondwanaland, bipedalism, and Cro-Magnons. Less well-known phenomena, such as chemoautotrophs, pachycephalosaurs, conodonts, and cyanobacteria, are likewise covered in engaging detail. Not discussed, however, are certain central and controversial questions such as punctuated equilibrium: Do evolutionary processes proceed, generally speaking, in smooth progression (not the same as progress, if indeed there is any such thing in evolution)? Or is long-term stasis sometimes punctuated by phases of instant-seeming shifts to new stable morphologies?

Such, then, is the scope of this exhilarating account of life's record—exhilarating because Southwood himself can hardly contain his enthusiasm for his subject. Well might he write with such reader-friendly spirit: He has long served as chairman of zoology at Oxford University (and as head of the university), making him an expert's expert and an academic's academic. But he is more than that. He tells his story with scholarly passion, almost as if he were freshly acquainted with paleobiology rather than a cognoscente who has studied the field for half a century. His exuberant style is not surprising: The book is based on a first-year student course that Southwood taught for many years, attracting students in droves. He excels at presenting complex material in an eminently digestible fashion. His book is packed with abstruse findings, arcane theories, and authoritative viewpoints, but it is more immediately enlightening than a textbook. Moreover, it is admirably illustrated with numerous maps charting the movements of the continents, with line drawings of animals and plants both extinct and extant, and with graphs and tables in profusion. All of this goes to make the book both erudite and entertaining.

I would like to have seen more discussion of one aspect of the chemical processes that first sparked life. Given that the primordial soup was presumably to be found in many places, could life have first come into being, then been extinguished—it was long a fragile affair—before being generated a second time? And if more than one origin occurred, could several origins have existed side by side until they finally coalesced into the splendidly mongrel outcome we witness today?

As Southwood emphasizes, humans are the only species to have existed with the power to deliberately drive another species extinct; and humans are the only species with the power to save another species from becoming extinct. Janus-faced as we are, we need to decide whether we are to be regarded by our descendants millions of years ahead (supposing *Homo sapiens* persists that long) as the single generation in human history to have precipitated a mass extinction. All this is spelled out in graphic detail in the book's final chapter, in which Southwood urges *Homo* to be *sapiens* enough to safeguard the millions of fellow species that share the planet with us, albeit they may not view us as showing much fellow spirit.

Of course, and as Southwood repeatedly asserts, new species will eventually be generated by evolutionary processes of speciation. Unfortunately, we may eventually find we have depleted certain of these basic processes by destroying tropical forests and wetlands, which have served as the main sources of new species in the wake of mass extinctions in the prehistoric past. The loss of these evolutionary powerhouses could mean that the recovery time required for mass speciation will prove longer than the few million years of past bounce-backs. The future story of life may well turn out to be a tale of biotic impoverishment such as the planet has not known for 65 million years, since the dinosaurs and associated species were eliminated. As Michael Soulé and Bruce Wilcox stated, "Death is one thing, an end to birth is something else" (Soulé and Wilcox 1980, p. 8).

As scholarly as any textbook, the book would make a ready read on an airplane trip. It can be heartily recommended to the aficionado and the student alike. It should even appeal to that eclectic readership, the general public, so that people can gain an insight into the astonishing abundance and variety, and the pedigree, of our planet's chief feature.

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IDENTIFYING MALAGASY TREES

Generic Tree Flora of Madagascar. George E. Schatz (foreword in English by Peter R. Crane and Peter H. Raven; in French by Albert Randrianjafy and Philippe Morat). Royal Botanic Gardens, Kew, United Kingdom, and Missouri Botanical Garden, St. Louis, 2001. 477 pp., illus. $39.95 (ISBN 1900347822 paper).

The literature on the botany of Madagascar is quickly becoming as rich as the flora itself. For anyone with the least interest in this island 400 kilometers east of Mozambique, this is a wonderful development. While the richness and uniqueness of the Malagasy flora and fauna have long been appreciated, it may have been the French naturalist Philibert Commerson who conveyed these ideas most elegantly when he declared that Madagascar was the "promised land" for naturalists, so rich that Linnaeus would have to devote 10 editions of his *Systema Naturae* to the island (Lasègue 1845).

How rich is rich? It is estimated that 8500 to 12,000 species of vascular plants, 70 to 80 percent of them endemic, occur in Madagascar (Humbert 1959, Dejardin et al. 1973, White 1983). To place this in perspective, the island is slightly smaller in area than the state of Texas, which has 4800 species of vascular plants, a mere 8 percent of them endemic (Correll and Johnston 1970).

The most ambitious project to catalog the vascular plants of Madagascar has been *Flore de Madagascar et des Comores,* which was initiated in 1936 by Henri Humbert shortly after he became professor of botany and director of the Laboratoire de Phanérogamie at the Muséum National d'Histoire Naturelle in Paris. Modeled on his immediate predecessor's *Flore Générale de l'Indo-Chine* (1907–1951), which coverd another region colonized by France, *Flore de Madagascar* has dominated floristic work in Madagascar for almost 70 years. Issued in fascicles by plant family, its treatments are comprehensive, with keys to genera and species, lengthy descriptions, full synonymy, illustrations (including maps), citation of specimens examined, and lists of vernacular names. Perhaps 60 to 70 percent of the vascular plant species of the island have now been treated. Earlier fascicles are out of date, and there is no key to the 189 families that were projected originally to comprise the finished flora; however, for systematic botanists trained to recognize plant families and familiar with the extensive but scattered literature on plant identification, the lack of such a key is not an impediment.

For further assistance, some of us have turned to René Capuron's modest but insightful *Essai d'Introduction à l'Étude de la Flore Forestière de Madagascar* (1957). This mimeographed forest manual, virtually unknown outside of Madagascar, treats 95 families and about 450 genera. Those without systematic training or access to Capuron's forest flora, however, have had nowhere else to turn until now. The publication of *Generic Tree Flora of Madagascar* thus opens up broader access to the plants of Madagascar and gives not only botanists but also anthropologists, conservation biologists, ecologists, foresters, and zoologists an important tool for identifying Malagasy trees.

Defining a tree as "a woody plant at least (4–) 5 m tall, and/or with at least one vertical stem attaining 5 cm in diameter at breast height," George Schatz proceeds to treat 107 vascular plant families and 490 genera (161 endemic, 329 nonendemic) native to Madagascar. (These genera are represented in Madagascar by 4220 species, 96 percent of them endemic.) This is a major subset of the vascular flora, which the most recent fascicle of *Flore de Madagascar* indicates includes 224 families (but see below). After very brief introductory remarks, Schatz immediately cuts to the chase with a series of keys that emphasize vegetative characters. This is followed by several lists of genera exhibiting distinctive characters (presence of spines, color of exudate, presence of glands, etc.). By far the greatest portion of the book is then devoted to treatments of families and genera. The volume concludes with a glossary (partially illustrated) of botanical terms and with indexes to scientific names, vernacular names, and illustration sources (including some original illustrations). Each of the family treatments begins with a statement concerning global distribution and extent. A morphological description is provided for those families (54 of 107) that have two or more native or naturalized genera in Madagascar. References are cited to relevant fascicles in the *Flore de Madagascar* and, if available, to revisions and monographs of constituent genera. Dichotomous keys to genera are elaborated. Each generic entry in the tree flora includes not only the author and place of publication but also synonymy as it applies to Madagascar. Global distribution is indicated (for the nonendemic genera), and estimates or statements concerning the number of species are made. Following a morphological description based principally or wholly on Malagasy material, distribution within Madagascar is given in the context of the five bioclimatic regions recognized for the island: humid, subhumid, montane, dry, and subarid. Vernacular names are also recorded; these are not Malagasy names for genera, but rather Malagasy names for species in a particular genus.

Three families (Euphorbiaceae, Fabaceae, and Rubiaceae) account for one-third of the genera treated in *Generic Tree Flora of Madagascar.* Here Schatz's contribution is especially noteworthy, since of these three families only one has been described in *Flore de Madagascar* (in one part of a projected two-volume treatment of the Euphorbiaceae). Neither the Fabaceae nor the Rubiaceae has been treated in the same series, but soon after *Generic Tree Flora of Madagascar* was published, a monograph of the Malagasy Fabaceae by Du Puy and colleagues (2002) appeared.

Circumscriptions of vascular plant families are presently in a state of flux, changing with the accumulation of new molecular data. This presents enormous challenges to anyone writing a flora such as this one. Schatz made the wisest choice that he could and adopted the family concepts of the Angiosperm Phylogeny Group (Stevens 2003), which are not static. Consequently, serious users of the tree flora will have to begin penciling in corrections as soon as they purchase a copy of the book. As an example of how complicated this may become, the genera *Androya, Buddleja,* and *Nuxia* are placed in the Buddlejaceae in *Generic Tree Flora of Madagascar.* The same genera were treated as Loganiaceae in *Flore de Madagascar.* Now, in the Angiosperm Phylogeny Group system (Stevens 2003), *Androya* is allied with Myoporaceae, *Buddleja* is placed in Scrophulariaceae, and *Nuxia* is in Stilbaceae. Scrophulariaceae, but not Myoporaceae or Stilbaceae, is mentioned in *Generic Tree Flora of Madagascar.* Myoporaceae and Scrophulariaceae, but not Stilbaceae, are projected to be among the families treated in *Flore de Madagascar.*

Generic Tree Flora of Madagascar departs from Capuron's forest flora in associating 3000 vernacular names with the 490 genera treated. Capuron (1957) felt that while such names might give useful clues to identification, they just as easily could confuse, since one vernacular name could apply to more than one species. His example was the term *hazomena,* which was applied to any woody plant with reddish wood. Capuron (1957) cited three unrelated genera with this common name; Schatz lists nine! For most of us, Malagasy is not a familiar language, and providing lists of Malagasy names without explanation (as is also done in *Flore de Madagascar),* while it has some merit, is not especially useful. Apart from the possibility of confusing unrelated taxa, intriguing information can be lost by simply compiling lists of names. As an example, vavaporetaka, which is given in *Generic Tree Flora of Madagascar* as one of many common names of *Melanophylla* Baker (Melanophyllaceae), is in fact applied only to *M. alnifolia* Baker, and as reported by Dan Turk in *A Guide to Trees of Eastern Madagascar and Ranomafana National Park* (manuscript on file at the library of the California Academy of Sciences), it means "beak of the poretaka," which is a local name for the Madagascar brush warbler *(Nesillas typica).* The inside of this bird's mouth is said to be yellow, the same color as the wood of *M. alnifolia.* This admittedly has little impact on identifying or understanding the biology of these trees, but its omission does shortchange the linguist, the ethnobotanist, or the anthropologist who may want to delve into the folk taxonomy of the different ethnic groups residing in Madagascar.

There is no doubt that *Generic Tree Flora of Madagascar* is an extremely important tool for identifying the Malagasy flora and that it is likely to have a beneficial and lasting impact on the study of plants (and animals) in Madagascar. One hopes that as our knowledge of vascular plant phylogeny stabilizes and as scores of scientists and students use and test the keys and descriptions in Schatz's tree flora, these changes, corrections, and comments will be conveyed to the author. Important and useful works tend to have long lives and many editions, and *Generic Tree Flora of Madagascar* is certain to be one of them.

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NEW TITLES

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