From the archive

Insect development, and an economist's will offers financial incentives for university reform.

50 years ago

Developmental Systems: Insects. Edited by S. J. Counce and C. H. Waddington — Insects have provided and will continue to provide ideal material for the study of all the processes of growth and development. Their size is such that the relations between the final form and the cells by which it is built are often wonderfully clear to the observer. This does not make the process of growth intelligible — but it constantly inspires the investigator with the feeling that given a little more knowledge everything could be understood ... Volume 2 opens with a 150-page chapter in which S. J. Counce reviews in detail "the causal analysis of insect embryogenesis" ... The succeeding section by P. A. Lawrence is less concerned with completeness than with ideas. It provides a stimulating discussion of gradients in relation to differentiation. C. M. Child battled for years for recognition of the importance of gradients — but without much success. Gradients of what? As ... Lawrence makes clear, it is possible to define the laws of gradients without knowing the true nature of the phenomenon. To discuss gradients of an imaginary something is no more and no less an invocation of the occult than is the idea of gravity — which, after nearly four hundred years, is still a useful concept.
From *Nature* 7 September 1973

150 years ago

The late Mr. John Stuart Mill has left property to the amount of 14,000*l* [£14,000]. Of this he has left to any one university in Great Britain or Ireland that shall be the first to open its degrees to women, 3,000*l*; and to the same university a further sum of 3,000*l* to endow scholarships for female students exclusively. His copyrights he bequeaths in trust to Mr. John Morley, to be applied in aid of some periodical publication which shall be open to the expression of all opinions, and which shall have all its articles signed with the names of the writers.
From *Nature* 4 September 1873

but for a pattern with a rapid acceleration followed by a gentler deceleration and a rest phase, Scarselli and co-workers reported a substantial power saving of 9% compared with steadily driven pipe flow. Considering that the pumping of fluids has been estimated to account for almost 15% of the total energy consumption in the European Union (see go.nature.com/3sfiygz), a 9% reduction in pumping power could make a considerable contribution to improving energy efficiency.

There is, however, work to be done before such savings can be realized. Scarselli *et al.* considered Reynolds numbers that are moderate compared with typical values in many industrial pipe-flow applications. Thus, it needs to be established whether their approach can be extended to higher Reynolds numbers. Furthermore, Scarselli and colleagues' study focused on flow in a straight pipe section, which is the standard configuration for investigating the fundamental properties of pipe flow. However, pipe systems contain many other elements, such as bends, branches, junctions, expansions and contractions. Similar elements also occur in the human cardiovascular system. Therefore, it would be of high interest to investigate whether Scarselli and colleagues' optimal pulsating waveforms could yield similar benefits for more complex configurations, representative of full industrial and biological applications of pipe systems.

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Ecology

A drowned future for coastal ecosystems

Qiang He

Tidal marshes, mangroves and coral reefs support the livelihoods of millions of people. Most of these ecosystems will be vulnerable to submergence owing to rapid sea-level rise if global warming exceeds 2 °C above pre-industrial levels. **See p.112**

Humans have gravitated towards coastlines for millennia and depend on coastal ecosystems such as tidal marshes, mangroves and coral reefs for fisheries, storm protection and recreation[1]. On page 112, Saintilan *et al.*[2] shed light on what the future under climate change might mean for these ecosystems.

The Kunming-Montreal Global Biodiversity Framework, an agreement on biodiversity conservation adopted during the 2022 United Nations Biodiversity Conference (www.cbd.int/gbf), outlines a global goal to protect at least 30% of coastal ecosystems. However, these ecosystems are increasingly threatened by rising seas, owing to global warming. Since the 1900s, the global mean sea level (GMSL) has risen by 0.20 metres, with rates reaching 3.7 millimetres per year between 2006 and 2018 (ref. 3). According to the Intergovernmental Panel on Climate Change's Sixth Assessment Report (IPCC AR6), the GMSL is projected to rise further by 2100 under global warming scenarios of 1.5–5 °C of temperature rise above pre-industrial levels, probably with a mean rise of between 0.44 m and 0.81 m above the GMSL of the 1900s and a mean rate of rise of between 4.3 mm and 11.7 mm per year[3].

How would coastal ecosystems fare in such rising sea levels? Saintilan and colleagues provide a comprehensive global-scale assessment of this crucial question and find that the thresholds beyond which sea-level rise would lead to widespread 'drowning' of coastal ecosystems might be much lower than were previously thought.

Tidal marshes, mangroves and coral reefs are ecosystems in which plants and corals accelerate the deposition of substrate material (accretion) – by affecting sediment and the accumulation of organic matter and calcium carbonate – and thus lower the depth and duration of water inundation, which in turn enables these ecosystems to persist when they encounter sea-level rise[4]. Without considering these biophysical feedback processes, early modelling studies[5,6] predicted large losses of tidal marshes as a result of future sea-level rise. Studies[7,8] that integrate these processes, as well as considering potential landward migration of coastal wetlands, however, suggest that these ecosystems could survive high rates of relative sea-level rise (RSLR; the rise in sea level relative to the adjacent land that might rise or subside) of 10–50 mm per year. But whether there are threshold RSLR rates beyond which coastal ecosystems will 'drown', owing to increasing depth and duration of inundation, remains an open question.

To determine whether there are such thresholds, Saintilan and colleagues compiled comprehensive data sets on ancient (after the Last Glacial Maximum ended 19,000 years ago) and contemporary coastal ecosystem changes. Their ancient data included palaeo-records of tidal marsh drowning and mangrove formation. The contemporary data included field observations of accretion, subsidence and elevation gain (accretion minus subsidence) from a global network of survey benchmarks covering 477 tidal marsh stations and 190 mangrove stations. The authors also included remote-sensing-based interpretations of the change in tidal-marsh extent and conversion to open water at the same 477 stations and surveys of size changes of 872 coral-reef islands. These data sets enabled the authors to identify threshold RSLR rates at unprecedented temporal and spatial scales.

Saintilan *et al.* found that changes in coastal ecosystems often had a nonlinear relationship with RSLR. This is an important but unsurprising finding. Biophysical feedback processes are known to cause nonlinear, even abrupt, changes in coastal ecosystems[4]. Crucially, the authors found that tidal marshes and mangroves would most probably ($P > 0.90$) drown if RSLR exceeded approximately 5–7 mm per year. This finding was largely consistent between palaeo-records and contemporary observations of tidal marsh and mangrove changes. For coral-reef islands, submergence of reef crests, the highest point of a reef, would increase and the size of islands would probably ($P > 0.66$) contract if RSLR exceeded 6.2 mm per year. These findings highlight the risk that coastal ecosystems might drown at rates of RSLR that are much lower than those previously predicted[7].

What might explain this difference? Although substrate accretion generally increases with rising rates of RSLR, other research has found that subsidence increases nonlinearly with accretion, and it does so more rapidly as RSLR rises from 5 mm to 10 mm per year[9]. This suggests that elevation gain would fall behind RSLR at high rates of RSLR. Incorporation of this nonlinear relationship between accretion and subsidence will probably lower future predictions of threshold RSLR rates for the persistence of coastal ecosystems, although this was not part of the authors' work and remains missing even in the most advanced process-based and integrated models.

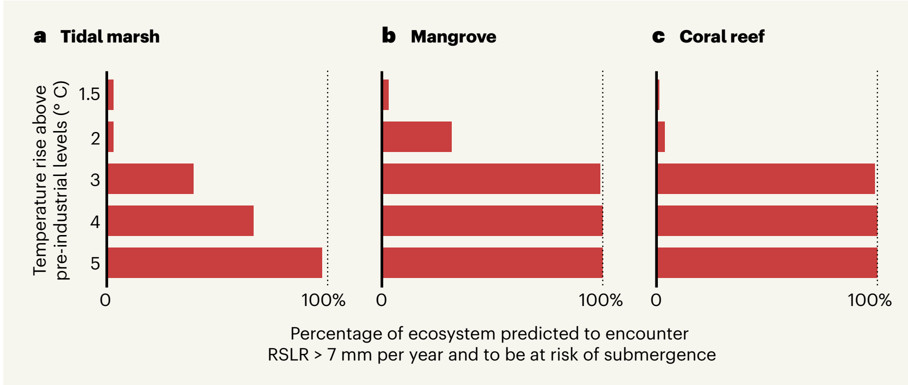

Figure 1 | Global warming and the risk of submergence of coastal ecosystems because of sea-level rise. Saintilan *et al.*[2] estimated the proportion of mapped tidal marshes (**a**), mangroves (**b**) and coral-reef islands (**c**) that would be exposed to a relative sea-level rise (RSLR) — the rise in sea level relative to the adjacent land that might rise or subside — of more than 7 millimetres per year under different scenarios of global warming above pre-industrial temperatures. With RSLR on this scale, it is predicted that tidal marshes and mangroves would most probably ($P > 0.90$) and coral-reef islands probably ($P > 0.66$) fail to handle RSLR and eventually 'drown'.

What would RSLR rates of more than 7 mm per year mean for coastal ecosystems in future climates? By modelling the exposure of the world's existing coastal ecosystems to the RSLR projections of IPCC AR6, Saintilan and colleagues found that the proportion of the world's mapped tidal marshes, mangroves and coral reefs that would be exposed to such RSLRs remained small under median projections of 1.5–2 °C warming above pre-industrial levels (Fig. 1). However, with 3 °C warming, nearly all the world's mangroves and coral reefs and 39% of mapped tidal marshes would be exposed to this level of RSLR. This percentage for tidal marshes would rise substantially at higher levels of warming.

Limiting global warming to less than 2 °C above pre-industrial levels is the central ambition of the 2015 Paris climate agreement. Saintilan and colleagues' findings suggest that the RSLR boundaries of the safe operating space of coastal ecosystems — in which the risk of catastrophic ecosystem collapse remains low[10] — might be rapidly approaching. Uncertainties remain, however. Besides RSLR, coastal ecosystems are greatly affected by a number of impacts associated with human activity, such as thermal stress, hydrological modification, nutrient enrichment and altered interactions between species[11]. These factors can raise or lower threshold RSLR rates[12].

Also, the authors focused on global-scale patterns, but threshold RSLR rates might vary substantially from place to place. Future studies should determine whether threshold rates are smaller or greater when assessed locally and identify the human-associated or natural drivers.

Could widespread drowning of coastal ecosystems be avoided in future climates? Saintilan and colleagues' findings remind us how profoundly necessary it is to achieve the Paris agreement's goals through global actions. Local actions, including protection and restoration, can also make a difference and enhance the persistence of coastal ecosystems with rising seas, especially in regions where coastal development restricts the possibility of landward migration for wetlands[8]. This would also offer more time to innovate technologies to transform the energy sector and mitigate carbon emissions. In a warming world with rapidly rising seas, combining local and global efforts and taking immediate actions would be our best hope to save coastal ecosystems from potentially catastrophic levels of drowning.

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