and climate drivers in the past, and tools such as species niche models that can link observed changes in distributions to particular environmental drivers. Although this approach has been advocated in earlier IPCC reports, the importance of multi-faceted empirical assessment has been recently de-emphasized in favour of model-based approaches[1,2,10,18].

Species' extinctions have already been linked to recent climate change; the golden toad is iconic, but the white lemuroid possum is a likely successor[11]. In this context, the most important information for biodiversity preservation centres around achieving better estimates of future biological impacts to begin constructing adaptation programmes. Understanding the roles of different climate drivers can be crucial, but it is likely that the true climate drivers of biological systems are metrics for which we do not have good future projections at present, such as complex patterns of extreme weather events and seasonal variability[20].

By over-emphasizing the need for rigorous assessment of the specific role of greenhouse-gas forcing in driving observed biological changes, the IPCC effectively yields to the contrarians' inexhaustible demands for more 'proof', rather than advancing the most pressing and practical scientific questions. This focus diverts energies and research funds away from developing crucial adaptation and conservation measures. To improve estimates of future biological impacts we need research focused on how other human stressors exacerbate impacts of climate change. Most importantly from a conservation standpoint, these other stressors are more easily managed on local scales than climate itself, and thus, paradoxically, are crucial to constructing adaptation programmes to cope with anthropogenic climate change.

We advocate striving for a richer understanding of interactions between multiple drivers of change through doing empirical research, emphasizing tractable questions and using model-based attribution approaches more as a tool for improving projections of biodiversity impacts than as an end in itself. To do so should clarify the dialogue between climate scientists, biologists and policymakers, and generate much-needed assessments of the current and future impacts of anthropogenic climate change on biota. ❐

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COMMENTARY:

Time to try carbon labelling

Michael P. Vandenbergh, Thomas Dietz and Paul C. Stern

A global private carbon-labelling scheme for consumer products could fill the climate-policy gap by influencing the behaviour of consumers and corporate supply chains.

Most analysts agree that the economically efficient way to reduce greenhouse-gas (GHG) emissions is by pricing them. However, such prices will not be in place globally or in the largest emitting nations in the near term. The climate system has substantial inertia. Difficult-to-identify nonlinearities and tipping points are also likely. Thus waiting for a 'best' policy may increase the likelihood of severe impacts[1]. The policy challenge is to develop near-term strategies that can bend the global carbon-growth curve to buy time, reduce costs and build support for more efficient approaches.

Bottom-up approaches are proliferating as many subnational jurisdictions adopt renewable portfolio standards, promote energy efficiency and develop climate-adaptation plans[2]. A private carbon-labelling programme for consumer products could help fill the policy gap by influencing both corporate supply chains and consumer behaviour. Through supply chains, a labelling programme can have cross-border effects, influencing incentives around the world.

The household sector generates a third or more of total greenhouse-gas emissions through direct use of energy in heating and cooling dwellings and water, lighting, appliance use and transportation (in the US it

is 38%)[3,4]. Although hard to estimate precisely, household purchases of both durable goods (such as appliances) and consumed goods (such as food) also generate substantial emissions[5]. Even modest changes in the household sector could significantly reduce emissions[4]. A carbon-labelling programme could reduce carbon emissions in two ways: by influencing consumer choices and by encouraging firms to identify efficiencies throughout the supply chain.

Ample evidence suggests that consumers do account for environmental impacts in their purchase choices even if such impacts are not the dominant influence. For some consumers the sustainability of goods is a major concern, for some it is part of the portfolio of features considered, and for some it matters not at all[6]. But a substantial segment of the population in many countries is motivated by climate concerns, and their preference for low-carbon products is a resource to draw on in the absence of international and national governmental action[7]. A 2008 survey in eight countries found that 33% of consumers are ready to buy green products or have already done so[8]. More than five million residential and commercial electric-utility customers in the US have participated in voluntary green-power programmes[9]. However, a major barrier to improved energy efficiency in households seems to be a lack of understanding of the impacts of various actions and products[10]. Providing information would lower this barrier, allowing consumers to make more informed choices without substantial effort.

Labels are a well-established method for providing information. For example, nutritional labels are used on food products in Australia, Canada, the European Union, India, Mexico, New Zealand and the US. Furthermore, a variety of labels also have been deployed to identify products as 'organic', 'fair trade', 'biodiversity friendly', 'sustainable', and so on, and organizations have formed to manage the label development, certification and verification processes[11].

A carbon label developed by the Carbon Trust. At present, little research is available to guide the design of carbon labels that are clear, accurate and effective at informing consumers and that can be adopted cross-culturally and across products with very different levels and profiles (for example, in production versus in use) of carbon emissions. Labels such as this one provide a starting point for that research.

Influencing choices

It is not reasonable to expect labelling to solve a complex problem by radically shifting the behaviour of most or all consumers. It is reasonable, however, to expect that labelling may improve a consumer's ability to make choices and may induce firms to change the mix of products offered to consumers. Nutritional labelling, for example, has not eliminated diet-related health problems, but labels do influence product selection and consumption in some cases[12,13]. For example, back-of-the-package labels required by the US Nutrition Labelling and Education Act (NLEA) of 1990 are correlated with healthier eating habits among those who report using them[14]. More recent work examining food intake in laboratory settings indicates that those who are exposed to menu labels consume fewer calories[12]. Similarly, evidence suggests that consumers have modified purchasing behaviour in response to non-nutritional labels such as 'dolphin-safe' tuna labels[13]. Nonetheless, more work is needed to clarify the impact of labels outside laboratory settings and of labels that provide information on a collective good, such as climate, rather than a private good, such as personal health. The purchase of low-carbon products may lead people to take additional 'green' actions or it may give them a sense of license to increase carbon emissions through other activities. In one study, participants who bought one unit of renewable energy production in an electric utility's carbon-offset programme increased their electricity use, but the carbon emissions from this increase were far less than the emissions avoided by the offsets purchased[15]. The net effect is key.

Of course labelling and certification systems do not always fully achieve their goals[16]. However, the existence of shortcomings does not obviate the value of such a programme. The relevant question for non-governmental carbon labelling is not whether it is better or worse than ideal but hypothetical alternatives, but whether it should be one of a cluster of viable private-governance options that are pursued in the absence of more efficient and comprehensive approaches.

Labelling also may induce firms to reduce their emissions in ways that lower their costs, enhance their reputations and make them more supportive of governmental policy measures that reinforce their emissions-reducing actions[17]. This easily overlooked effect of carbon labelling will occur to the extent that firms respond to generalized concerns about brand reputation even if consumers only demonstrate limited willingness to pay for lower-carbon goods. Indeed, it seems that many firms have overlooked supply-chain efficiencies, and are not acting on substantial opportunities to cut costs and reduce emissions[18]. Developing the data to underpin carbon labelling can identify and highlight these potential savings and spur changes in production and distribution throughout the supply chain; an effect that may be a more potent incentive than the immediate impacts of consumer choices. Industries have responded similarly in the past. For example, in the Netherlands food labels designed to identify healthier food options within a product category resulted in an overall reduction in sodium in some foods and an increase in dietary fibre[19].

There are, of course, a number of complexities that have to be addressed

in developing a system of carbon labels, especially one that would apply globally. Ideally the label would consider the climate effects arising from the full product life-cycle: production, transportation, use and disposal. The challenges of life-cycle assessment are substantial, but this is an active area of research. The value of the label comes not from providing perfect information, but better information than the consumer has at present. The information should not lead to perverse choices, of course, but the accuracy of the label can evolve over time. Efforts to generate open-source databases on the environmental implications of supply chains, such as that being spearheaded by the Sustainability Consortium (www.sustainabilityconsortium.org/), could facilitate the widespread availability of accurate information.

Going global

Much of the work to develop a global private carbon-labelling system has already been done, and several public and non-governmental carbon labels are in use, but the pieces have not been pulled together and propagated by an organization with global reach. The International Standardization Organization is developing ISO 14067, a carbon-labelling standard for products, with a target completion date of 2011 (http://go.nature.com/McUwRf). The British Standards Institution (BSI) is facilitating the development of Publicly Available Specification (PAS) 2050, a private standard designed to identify the requirements for life-cycle assessment of GHG emissions of goods and services (http://go.nature.com/6o8Vil). The Carbon Disclosure Project has focused on firm-specific, not product-specific emissions, but it has induced over 1,000 of the largest global firms to voluntarily disclose Scope 1 (direct) and 2 (energy-supply-related) carbon emissions using a common protocol, and it is encouraging firms to disclose Scope 3 (for example, supply chain and other) emissions using an accounting tool known as the Greenhouse Gas Protocol (www.ghgprotocol.org/). Several non-governmental carbon labels are used by single companies or targeted at a larger market, but none have a global reach at this point.

A credible, non-profit organization could manage and promote the adoption of the carbon label for the most important consumer products. This could involve knitting together and actively promoting existing initiatives or starting a new one. A common pattern for the formation of labelling systems has been for one or more non-governmental organizations to partner with a large firm or group of firms with incentives to develop a new system[11]. The non-governmental organization partners must establish their independence of interested parties. A number of international non-governmental organizations are well positioned to take on this role.

Carbon labels should incorporate existing knowledge garnered from previous labelling studies. The label design should be simple, and interpreting the label should not require any more mental mathematics than simple comparisons between products[20]. The inclusion of verbal descriptors and reference values also may improve the usability of labels[20]. The design should undergo empirical pre-testing to ensure that consumers will notice it, understand it and interpret it accurately. Major gaps still exist in our knowledge of how consumers understand and respond to labels. In particular, few studies examine the use of labels in natural settings where individuals are often distracted, under time constraints or exposed to different options than in laboratory studies. Empirical testing in natural environments could improve the chances for success before committing to a single approach. We need to learn from existing efforts as they evolve. But we also believe that it is time to both expand the private and public experiments into global pilot programmes, and to initiate the research programme that is needed to further develop the scientific basis for carbon labelling.

The initial products selected for the programme should be chosen based on their total carbon emissions and the likelihood of prompt and accurate label development and dissemination[21]. The labelling system also should be designed to take advantage of new technologies, including the ability of mobile phones to read product bar-codes to access additional data on the carbon profiles of a product and its alternatives. Examples include smart-phone barcode-scanner apps developed by SnowShoe Food (http://snowshoefood.com/) and the GoodGuide (www.goodguide.com/).

A concern is often expressed that private efforts to promote reductions will undermine more effective public measures. This argument is well taken, but the prospects for major national and international actions beyond the European Union seem poor. The opportunity cost for non-governmental organizations of a global labelling system also is remarkably small — in other words, the same amount of money spent on other carbon-reducing efforts is unlikely to yield greater benefits, at least in the near term. The Marine Stewardship Council seafood-labelling system operates on roughly £8 million per year of private funding[16]. A carbon-labelling system may have higher start-up costs, but not by more than an order of magnitude.

At this point, with the theoretically ideal measures (such as a carbon tax or cap-and-trade system) not under active consideration globally, it is appropriate to seek a portfolio of measures in the hope that a combination will enable us to avoid crossing important thresholds. As with renewable portfolio standards or policies to encourage energy efficiency, labels alone are not sufficient to meet frequently stated targets. But they can play an important role in the near term, and the information they provide can complement carbon-pricing approaches in the long term. The size of the consumer footprint suggests that only small shifts in purchasing behaviour could yield large emissions reductions. ❐

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