E-Letter responses to:

reports:
Edward B. Barbier, Evamaria W. Koch, Brian R. Silliman, Sally D. Hacker, Eric Wolanski, Jurgenne Primavera, Elise F. Granek, Stephen Polasky, Shankar Aswani, Lori A. Cramer, David M. Stoms, Chris J. Kennedy, David Bael, Carrie V. Kappel, Gerardo M. E. Perillo, and Denise J. Reed
Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values
Science 2008; 319: 321-323 [Abstract] [Full text] [PDF]

E-Letters: Submit a response to this article

PUBLISHED E-LETTER RESPONSES:

Response to N. Koedam and F. Dahdouh-Guebas's E-Letter
Edward B. Barbier, Evamaria W. Koch, Brian R. Silliman, Sally D. Hacker, Eric Wolanski, Jurgenne H. Primavera, Elise F. Granek, Stephen Polasky, Shankar Aswani, Lori A. Cramer, David M. Stoms, Chris J. Kennedy, David Bael, Carrie V. Kappel, Gerardo M. E. Perillo, Denise J. (2 October 2008)

Ecological Quality Changes Precede Changes in Quantity in Mangrove Forests
Farid Dahdouh-Guebas, Nico Koedam (2 October 2008)

Response to N. Koedam and F. Dahdouh-Guebas's E-Letter

2 October 2008

Edward B. Barbier

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Koedam and Dahdouh-Guebas raise the important issue that "there is a pressing need for in-depth investigation of the protection function of various mangrove formations and coast-geomorphological settings, various root types, and various species composition," and that "detangling the effect of such complexity under various

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Respond to this E-Letter:
Re: Response to N. Koedam and F. Dahdouh-Guebas's E-Letter

water-related impacts" is essential for "understanding the power of mangroves and other coastal vegetation as protective barriers."

We agree with their assessment, and consider our recent *Science* article (*1*) as a first step in a much-needed global research agenda for "detangling the effect" of the physical and vegetative properties that determine whether mangroves and other interface systems are effective coastal barriers against periodic, economically damaging storm events. We would like to make three additional points.

First, although understanding how the "complexity" of physical and vegetative properties contributes to the overall protective benefits of wetlands and other interface habitats is essential, ultimately it is important for coastal management decisions to estimate how these benefits are affected as habitat area changes. Our reasoning is straightforward; as stressed in our article, the sheer scale of the area of interface habitats lost, including marshes (50% lost), mangroves (35%), and reefs (30%), is intense and increasing worldwide (*2–4*). The immediate concern, therefore, is to determine what benefits are lost, including protection against storms, as sizeable areas of wetland and other interface habitat are converted to other uses as a result of coastal economic development and population growth.

Second, given the "complexity" of physical and biotic factors determining the protective benefits of wetlands and other interface habitat, it is also important to distinguish between attempts to restore (i.e., bring back to its original conditions) versus rehabilitate (i.e., restore some of the ecological services and functions) these degraded coastal ecosystems by a combination of engineering, ecohydrological, and vegetative measures such as dredging and hydrological modification, controlling inflow of pollutants and sediment, and replanting vegetation in flood plains, wetlands and tidal flats (*5–7*). The costs of the various rehabilitation or restoration schemes must be weighed

against the range of benefits, including coastal protection, which the schemes can deliver. In addition, we must take into account that restoration of certain interface habitats, such as near-shore coral reefs, is still largely impossible (*8*).

Finally, ecosystem functions such as wave attenuation not only have a magnitude and a quality dimension, as emphasized by Koedam and Dahdouh-Guebas, but also are likely to be highly dynamic, i.e., changing over space and time. For example, plant growth in interface habitats varies seasonally, especially at higher latitudes; plant community composition will differ with latitude and climate; and ecosystem functions can change with the tidal phase, sedimentation processes and coastline conditions. Such issues of how spatial, taxonomic and temporal scale may influence various ecosystem functions and the benefits they generate have been raised for mangroves (*9, 10*). The next step in "detangling the effect" of the physical and vegetative properties underlying the benefits of mangroves and other interface habitats is to analyze how spatial and temporal non-linearities influence storm protection and other ecosystem services.

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Ecological Quality Changes Precede Changes in Quantity in Mangrove Forests 2 October 2008

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The paper by E. B. Barbier *et al*.

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Respond to this E-Letter:
Re: Ecological Quality Changes Precede Changes in Quantity in Mangrove Forests

(Reports, "Coastal ecosystem–based management with nonlinear ecological functions and values,", 18 January 2008, p. 321) indicates the non-linearity of ecosystem services (coast protection) offered by coastal vegetation such as mangroves relative to the area covered. It is also important to consider ecological and biological aspects, which may strongly increase the risk of non-linear loss of ecosystem services inclusive of coast protection with area.

Areal change is usually preceded and/or accompanied by ecological change. First of all physiognomic changes (*1*), then change in age structure of vegetation (*2*), followed by clear floristic shifts or more cryptic ecological degradation (*3*), which may all affect the ecological functioning of the system. Areal change therefore may have an effect by itself and Barbier and colleagues correctly pointed this out. In reality, however, change effects are much strengthened by the ecological corollary by ecosystem management leading to areal decrease. This may be a general observation, but it is particularly acute in mangroves, which often grow in narrow strips, lining lagoons, estuaries, or patches. The 1000m width applied by Barbier and colleagues is realistic in many cases; often, however, this width is not reached naturally in important mangrove areas and long coastal stretches, and the mangrove width is almost never composed entirely of the species used to calculate the ability to attenuate storm waves, i.e. Rhizophoraceae representatives (*4–7*). The margin-to-area ratio in mangroves is high, and once human intervention has started it progresses rapidly. Even the larger areas are rarely or never pristine and have undergone changes before areal decrease may be detectable, on the ground or by remote sensing. We had circumstantial evidence that lower coastal protection occurred when true mangrove species were replaced (*8*), however, further data are required. This is important because mangrove forests, poorly defined in terms of physiognomy, forest cover, density and floristic composition

(*9*), are often quantified by areal extent only. Data for areal extent are usually obtained by remote sensing or rough estimation but do not account at all for ecological value, and therefore almost invariably overestimate an effective area.

We welcome the timeliness of the message expressed in Barbier *et al*.'s paper, also addressing policy makers and managers, but wish to draw attention to the risk incurred by the side effects or correlated or concomitant processes of areal decrease. There is a pressing need for in-depth investigation of the protection function of various mangrove formations and coast-geomorphological settings, various root types, and various species compositions. Detangling the effect of such complexity under various water-related impacts—not only from storms and tsunamis, but also sea-level rise, daily tidal action, and heavy El-Niño rains—will enable scientists to fully explore and understand the power of mangroves and other coastal vegetation as protective buffers. These priorities in fundamental research should be considered in parallel with research and policy measures on the conservation and restoration of mangrove functionality (*10*). Restoration, as well as the creation of an early warning system for detecting ecological quality changes and to detect ecological mangrove degradation is particularly urgent as we face the prospect of a world without mangroves (*11*).

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