Table 1. Estimated Value of Ecosystem-Services Provided Ranked by Ecosystem Type.

Ecosystem Type	Annual Value of Ecosystem Services ($ per hectare)	Global Area (hectares x 10^6)	Total Annual Value of Ecosystem Services ($ billion)
Estuaries	22,832	180	4,110
Swamps/floodplains	19,580	165	3,231
Seagrass/algal beds	19,004	200	3,801
Tidal marsh/mangroves	9,990	165	1,648
Lakes/rivers	8,498	200	1,700
Coral reefs	6,075	62	375
Tropical forest	2,007	1,900	3,813

Source: Costanza et al. 1997.

from ecosystem services as well as from marketable goods and services (along with other sources). Moreover, ecosystems that generate the greatest value of ecosystem services per hectare are environments that are defined by water (Table 1). From this we know that the global value of water's role in producing ecosystem services is large, but in any given specific situation, we need to know the current local *marginal ecological economic costs and benefits* associated with various management or policy options. Accurately measuring these is the methodological challenge for ecological economics as a guide to decision-making rather than more accurately calculating the $33 trillion figure (Toman 1998).

The contingent valuation method (CVM), for all its flaws, has proven useful in evaluating how individuals make trade-offs between marketable goods and services and non-market ecosystem services (Braden 1997; Mitchell and Carson 1989). CVM and other environmental economics methods such as the property value method therefore have important roles to play in doing ecological economics, but ecological economics may provide a different interpretation of willingness to pay (WTP) and willingness to accept compensation (WTA) bids. For example, the high WTA bids often received by CVM researchers for diminishment in water-derived ecosystem services has sometimes been explained as risk- or loss-aversion, but may also be strong evidence of the high value people place on ecosystem services as a source of utility beyond that derived from marketable commodities. Secondly, while CVM treats ecosystem services as a source of individual utility similar to purchased goods and services, they of course are rarely individually owned but instead generally accrue to geographically defined communities over long periods of time. All of the time-honored debates about discount rates and the distinction between "consumers" and "citizens" therefore apply, with ecological economics generally favoring citizens with low discount rates. High WTA bids may also indicate ethical problems with receiving individual payment for diminishment of a community benefit. These vigorous debates over CVM illustrate the theoretical distinctions between neo-classical and ecological economics and provide a guide to better utilizing this valuable methodology in ecological economic analysis.

Perhaps more powerful than CVM and other valuation techniques in the long run for evaluating management and policy options in a complex ecological-economic system are advancements in evolutionary algorithms, such as genetic algorithms (GAs). GAs have proven successful for decision support in a variety of water resources applications, including water supply system design (Murphy et al. 1993), groundwater management (Hilton and Culver 2000), pavement drainage design (Hellman and Nicklow, 2000), and reservoir management (Esat and Hall 1994; Nicklow and Bringer 2001). GAs thus show promise for tackling problems of finding

From: Lant, C., Water resources sustainability: An ecological economics perspective, Water Resources Update 127, 2004.
Table is after: Costanza, R, et al., The value of the world's ecosystem services and natural capital, Bioscience 43(8), 545-554, 1993.