Supporting Information

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SI Text

Supplementary information includes (*i*) assumptions and source data for estimation of global seagrass ecosystem services, (*ii*) description of data sources for the analyses, (*iii*) calculation method for decadal seagrass change, (*iv*) assessment of potential bias from the increase in seagrass observational effort over time, and (*v*) contribution numbers for authorship team.

Ecosystem Services. The global value of ecosystem services for seagrasses is presented as estimated by Costanza et al. (1). These authors give a total estimated value of US $\$3.8 \times 10^{12}$ to global nutrient cycling in coastal shelf ecosystems, defined as seagrass and algae beds. We have used 50% of this value as the relative contribution of seagrass beds vs. algae beds. Using US $\$1.9 \times 10^{12}$ for nutrient cycling provided globally by seagrass ecosystems and our reported 35% loss of seagrass area since 1980, US $665 billion has been lost in this ecosystem service alone. Other estimates of ecosystem service values are based on specific case studies as indicated and are not intended as global estimates of seagrass values.

Data Sources. There were 4 publication categories among the 70 sources incorporated into the final seagrass trajectories database: journal articles ($n = 55$), published reports ($n = 10$), verified databases ($n = 2$), and theses ($n = 3$). When different sources covered the same site and time period (e.g., reviews, reinterpretation of primary data, extensions of data sets), only a single data source was included in the final database. On average, a delay of 5 years (range: 0–16 years) was observed from the date of the last data point collected to the year of publication. Therefore, the data available at the time of this analysis (data compiled in 2006) may represent only 30% of the data for the decade (2000–2010). A complete list of data included in the final analysis is included in Table S1. In some cases, numerical estimates of seagrass area were not included in a data source and area estimates were inferred from graphical presentation using DataThief III (B. Tummers, DataThief III, 2006).

Decadal Analysis. Decadal trajectories (% rate of change, μ) were assessed for sites with data traversing more than 1 decade as depicted in Fig. S3. The data analysis incorporated up to 2 data points for each site within each decade; if there were more than 2 records within a decade, only the earliest and latest records were included in analyses. For example, in site A of Fig. S3, the record in the middle of the 1970s would be omitted from analyses. The net areas for site A of Fig. S3 would be +131 (*i* of Fig. S3) for the 1960s and −109 (*ii* of Fig. S3) for the 1970s.

In more complex trajectories in which data were collected over several intervening decades, as shown for site B of Fig. S3, areas at the boundaries of each decade were interpolated based on μ (% rate of change), as shown by circles above. The "boundary" areas were then used to estimate the net change for that decade. When a record was not at the boundary of that decade, the net area was calculated as the sum of the 2 areas on each side of the record; thus, net area was calculated only once for each site in each decade. When there were trajectories leading into a decade, within a decade, and out of a decade, all 3 were included in the calculation of μ as a best estimate of the trend across included data, as in site C of Fig. S3.

Observational Effort. Efforts to assess the general status and trends of seagrass meadows have expanded in recent decades; for example, local communities are increasingly involved in the monitoring of their seagrass meadows (2). This increase is largely attributable to the onset of regional and global monitoring programs (2) promoted by increasing evidence of the value of seagrass meadows as sensitive indicators of overall coastal ecosystem health (3). Most of the early (before 1980) observations of seagrass trajectories were made as part of problem-driven research, whereas the majority of the recent data since then derive from large-scale monitoring efforts. Synthetic studies (4–6) have pointed to seagrass losses occurring soon after human settlement, well before the advent of any quantitative seagrass assessment or even full recognition of its intrinsic value. In addition, monitoring initiated after a large-scale decline often leads to observations of small-scale seagrass changes (increases and decreases). In such cases, the overall trajectory for a location where monitoring starts after a loss will not be reflected by monitoring data. In the context of our analysis, the synthesis of data from all time periods, irrespective of study motivation, location, or scale, will provide the best, albeit conservative, overall interpretation of global trends.

Contribution Numbers for Author Institutions. Institutional contribution numbers are as follows: School of Marine Science at the Virginia Institute of Marine Science, College of William and Mary, 3020; University of Maryland Center for Environmental Science, 4302; Bodega Marine Laboratory, University of California at Davis, 2461; Southeast Environmental Research Center at Florida International University, 434; Jackson Estuarine Laboratory, University of New Hampshire, 477; Dauphin Island Sea Laboratory, 398; Marine and Tropical Sciences Research Facility, James Cook University projects 1.1.1 and 1.1.3.

1. Costanza R, et al. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.
2. Orth RJ, et al. (2006) A global crisis for seagrass ecosystems. *Bioscience* 56:987–996.
3. Dennison WC, et al. (1993) Assessing water quality with submerged aquatic vegetation. *Bioscience* 43:86–94.
4. Lotze HK, et al. (2006) Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312:1806–1809.
5. Pandolfi JM, et al. (2003) Global trajectories of the long-term decline of coral ecosystems. *Science* 301:955–958.
6. Jackson JBC, et al. (2001) Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293:629–638.

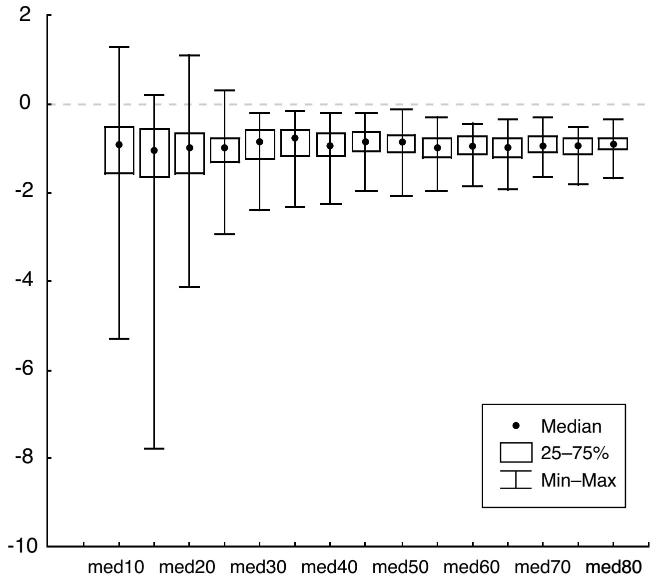

Fig. S1. Box and whisker plot of the overall estimate of the median of μ, including an increasing number of randomly selected samples. Error bars indicate the 25% and 75% quartiles for median estimates across 100 replicate resampling runs.

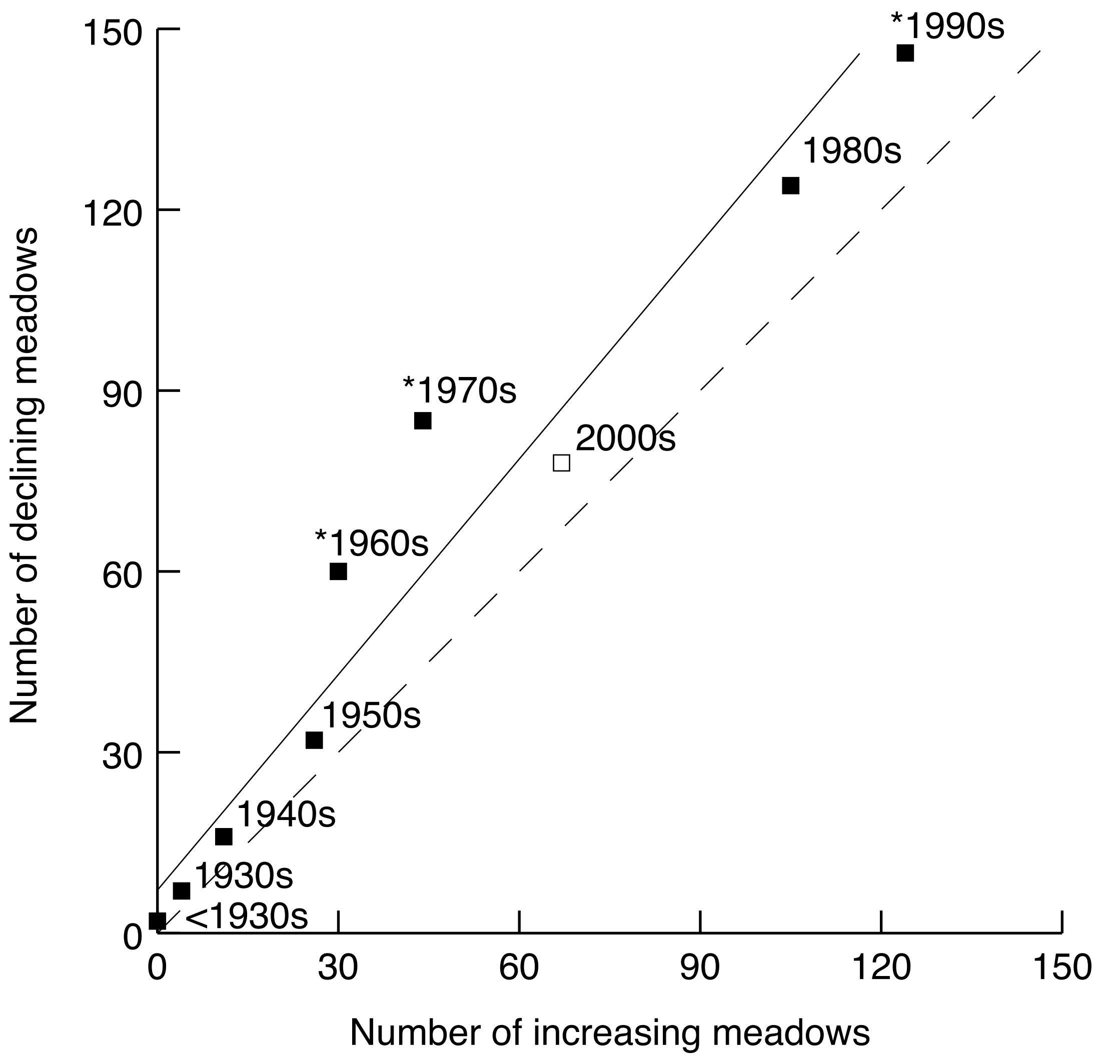

Fig. S2. Plot of relationship between number of sites experiencing decreases in area and increases in area by decade. Dashed line represents the 1:1 relationship expected if the distribution is random, and decades marked with an asterisk (*) exhibited a significant χ^2 value ($P < 0.05$, df = 2). The overall trend was significant (Wilcoxon signed pair ranked test, $P = 0.002$).

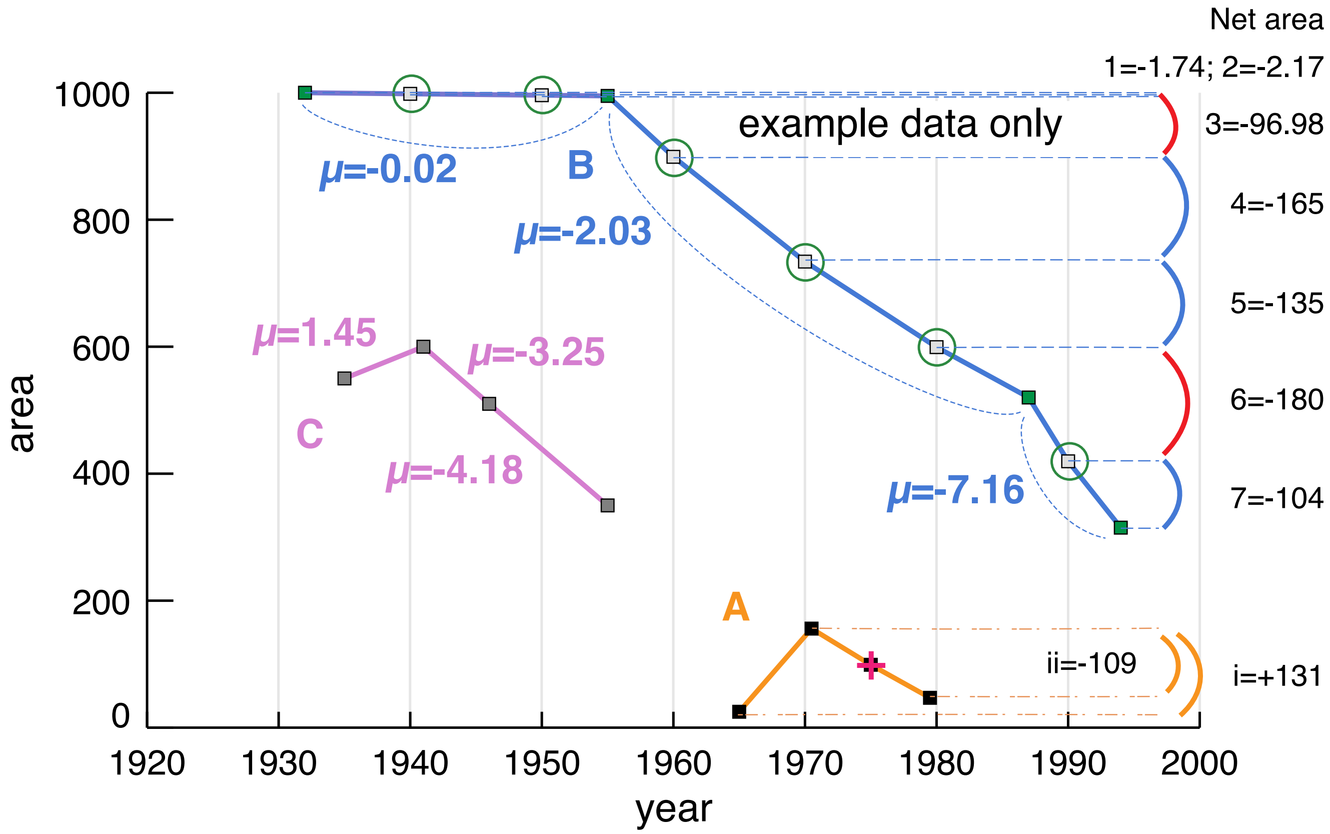

Fig. S3. Calculation of decadal trajectories. Values are for illustrative purposes only. Time is divided into decades starting with January 1 at the beginning of a decade (e.g., January 1, 2000). Area is presented as hectares. The rate of change, μ, is calculated as outlined in *Materials and Methods*. Shaded boxes are data points included in decadal analysis, and circled open boxes are inferred area estimates based on the within-decade values calculated from μ. A, B, and C represent different sites.

Other Supporting Information Files

Table S1
Table S2