Bio-monitoring: lessons from the past, challenges for the future

Plant strategies as biological indicators of ecosystem services

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<table>
<thead>
<tr>
<th>Types of ecosystem services</th>
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<tbody>
<tr>
<td><strong>Provisioning</strong></td>
<td>the supply of ecosystem products (affecting food, fuel and water)</td>
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<tr>
<td><strong>Supporting</strong></td>
<td>such as nutrient cycles, photosynthesis and ecosystem processes that allow other services to proceed</td>
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<tr>
<td><strong>Regulating</strong></td>
<td>controlling the extent of environmental processes, including climate change</td>
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<tr>
<td><strong>Cultural</strong></td>
<td>spiritual, recreational and scientific benefits</td>
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</tbody>
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## Methods: trait-based ecosystem service indices for 60 herbaceous communities

### Provisioning

Index of ‘biomass’ based on:

- Community above-ground dry weight (AGDW)
- Community-weighted mean (CWM): Canopy height (CH)_{CWM}
- Leaf dry weight (LDW)_{CWM}

\[ = \sqrt{\left( \frac{AGDW}{10} \right) \cdot CH \cdot LDW} / 1000 \]

### Supporting

Index of ‘flowering nitrogen use period’ (potential extent and period of support for flowering from leaf nitrogen):

- Leaf nitrogen content (LNC)_{CWM}
- Flowering start (FS)_{CWM}
- Flowering period (FP)_{CWM}

\[ = \sqrt{LNC \cdot (6 - FS) \cdot FP} \cdot 2 \]

### Regulating

Index of ‘carbon sequestration’ based on:

- Community below-ground dry weight (BGDW)
- Leaf carbon content (LCC)_{CWM}

\[ = \frac{BGDW \cdot LCC}{20000} \]

### Cultural

Index of ‘botanical quality’ based on relative abundance, within the plant community, of:

- Protected species (PS)
- Black list species (BL)
- Species with evident/aesthetic flowers (SF)

\[ = \frac{PS + (100 - BL) + SF}{20} \]
Grime’s CSR strategies are calculated from the trade-off between leaf area (LA), leaf dry matter content (LDMC) and specific leaf area (SLA).

Pierce et al. (2013) 
*Functional Ecology* 27(4): 1002-1010

These traits are NOT used in the calculation of the four ecosystem service indices.
CSR as a framework for ecosystem service assessment

a). Provisioning
(amount of aboveground and photosynthetic biomass)

b). Supporting
(nitrogen use efficiency)

c). Regulating
(carbon sequestration)

d). Cultural
(flowering of rare or alien species)
Relationship between community types, plant strategies and ecosystem services
Relationship between community types, plant strategies and ecosystem services

Pearson’s correlation coefficient between R and Supporting ES index = 0.761 ($p<0.01$)

Pearson’s correlation coefficient between C and Provisioning ES index = 0.713 ($p<0.01$)

Pearson’s correlation coefficient between S and Regulating ES index = 0.384 ($p<0.01$)

∴ C, S and R are strong indicators of physical/chemical ecosystem services.
Greater ‘flowering nitrogen use period’ is associated with R-selection, disturbed ecosystems and actually indicates ecosystem instability and the degree of inconsistency of supporting services.
A high degree of S-selection is an indicator of **sequestration** of organic matter in ecosystems with slow dynamics.
C-selection is associated with greater ‘biomass’ provisioning in less disturbed ecosystems.
Our ‘provisioning’ index and C-selection actually represent the potential biomass provision. Our ‘botanical quality’ cultural index represents where ecosystems actually do provide biomass regularly, following mowing (meadows) or grazing (pastures). This is indicated by a low degree of C-selection at one end of a ‘provisioning gradient’.
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Cultural value depends on the intensity of biomass use!

Yes! And Grime’s C-S-R strategies appear to be good general indicators summarizing the relationships between plant trait spectra and ecosystem services!

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