Worldwide cross-ecosystem carbon subsidies and their contribution to ecosystem functioning

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Abstract

Ecosystems are widely inter-connected by spatial flows of resources^{1,2}, yet primarily studied in a local context. Meta-ecosystem models suggest that cross-ecosystem subsidies can play an essential role in ecosystem functioning, notably by controlling local availability of resources for biological communities³⁻⁶. The general contribution of these resource connections to ecosystem functioning, however, remains unclear in natural systems, due to the heterogeneity and dispersion of data across the ecological literature. Here we provide the first quantitative synthesis on spatial flows of carbon connecting ecosystems worldwide. These cross-ecosystem subsidies range over eight orders of magnitude, between 10^{-3} and 10^5 gC m⁻² yr⁻¹, and are highly diverse in their provenance. We found that spatial carbon flows and local carbon fluxes are of the same order of magnitudes in freshwater and benthic ecosystems, suggesting an underlying dependency of these systems on resources provided by connected terrestrial and pelagic ecosystems respectively. By contrast, in terrestrial systems, cross-ecosystem subsidies were two to three orders of magnitude lower than local production (grasslands and forests), indicating a weaker quantitative influence on functioning. Those subsidies may still be qualitatively important, however, as some have high nutrient content^{7,8}. We also find important gaps in carbon flow quantification, notably of cross-ecosystem subsidies driven by animal movements, which likely leads to general underestimations of the magnitude and direction of cross-ecosystem linkages⁹. Overall, we demonstrate strong ecosystem couplings, suggesting that ecosystems can be vulnerable to alterations of these flows and pointing to an urgent need to re-think ecosystem functioning in a spatial perspective.

Main text

Ecosystems and the services that they provide are essential for material and cultural human welfare^{10,11}, but paradoxically, human activities threaten ecosystem integrity^{12,13}. Maintaining functional ecosystems, or restoring degraded ones, requires the identification of dominant mechanisms driving their dynamics. At the local scale, ecologists have accumulated extensive data on individual ecosystems' functioning¹⁴. Accurate depictions of within-ecosystem fluxes, such as biomass and detritus production, respiration, or decomposition, exist for all broad ecosystems types, including terrestrial, freshwater and marine ones.

But ecosystems are not isolated. For flows of dispersing organisms the role on large-scale species coexistence and community dynamics is well studied^{15,16}. However, it remains unclear to which extent ecosystem functioning also depends on cross-ecosystem flows of resources, such as in the form of detritus or nutrients^{1,17}. According to the recently developed meta-ecosystem theory^{16,18}, such cross-ecosystem resource flows can induce strong interdependencies between ecosystems and drive ecosystem functioning³⁻⁶. While the literature on subsidies provides emblematic cases of resources moving between ecosystems, including passive transport of leaves windblown from forests to streams², or active transport such as aquatic insects emerging onto land¹⁹, we still lack a general quantification of these flows. The dispersion of data over many research areas and inconsistencies in the units of measurements used has hitherto precluded a general and synthetic overview of resource spatial flows.

Here, we conduct the first quantitative synthetic assessment of cross-ecosystem subsidies connecting the major ecosystem types across the globe (Figure 1). Specifically, we compare the magnitudes of cross-ecosystem subsidies to within-ecosystem fluxes in order to infer their relative contribution to ecosystem functioning. This also gives a basis to identify ecosystems' vulnerability to increasing alterations of resource flows under the context of ongoing global changes²⁰. We based our analysis on generally convertible estimates in units of carbon ($\text{gC m}^2 \text{y}^{-1}$; see Methods) and systematically searched for

quantifications of spatial subsidies connecting terrestrial (forest, grassland, agro-ecosystem, desert), freshwater (stream, lake), and marine (pelagic and benthic) ecosystems. To compare these spatial flows, we also assembled comprehensive quantifications of local biological fluxes of carbon (i.e., gross primary production, ecosystem respiration, and decomposition; see Methods) within the different ecosystem types. We assembled 518 measurements of spatial flows and 2516 of local fluxes, reaching a total of 3034 data points extracted from 557 studies. Analysing this data set with its internally-consistent measurements in carbon units reveals for the first time the widespread importance of spatial resource flows to local ecosystem functioning.

Spatial flows of cross-ecosystem carbon subsidies range over eight orders of magnitude of mass of carbon annually transported to ecosystems ($\text{gC m}^{-2} \text{y}^{-1}$), from a few milligrams (aquatic insects deposited in forest) to more than ten tons per meter squared and year (wrack on shores) (Figure 2). The materials transported among ecosystems are as various as living animals, dead plants and animals, and dissolved carbon. Ecosystems occupying the lowest elevations in land- and seascapes receive downward flows of dead material or small organisms falling from above ecosystems, while terrestrial ecosystems receive more lateral flows, for instance of material transported by wind, ocean tides, or animal movements. Not surprisingly, ecosystems dominated by primary producer biomass (e.g., forests, grasslands, submarine meadows, and kelp forests), export the largest flows of primary production-derived material (median / interquartile range [IQR] of $148.7 / [47.1\text{--}246.6]$ and $164 / [93.2\text{--}1659.3]$ $\text{gC m}^{-2} \text{yr}^{-1}$ for terrestrial vegetation and macro-algae, respectively). By comparison, invertebrate subsidies are substantially lower (median: $1.51 \text{ gC m}^{-2} \text{y}^{-1}$ / IQR: $[0.44\text{--}5.41]$), but might reach similar values in specific ecosystems (e.g., $124 \text{ gC m}^{-2} \text{y}^{-1}$ of aquatic insects flowing from lakes to tundras in Iceland). Lastly, few studies document spatial flows of vertebrate origin (3.1%), and those which do report highly contrasting values: faeces of foraging deer or fishery discards represent small flows of around $0.1\text{--}1 \text{ gC m}^{-2} \text{y}^{-1}$, while the net inputs to freshwater ecosystems of hippopotamus defecating into rivers, or of drowned migrating wildebeests, range between 100 and 1000 gC y^{-1} per meter squared of river. These disparities stress that the quantitative effect of carbon brought to ecosystems via large

animals might greatly depend on how resource deposition is spatially constricted to small or large areas. Overall, our global picture highlights the ubiquity of cross-ecosystem subsidies, and the variety in their magnitude.

To assess the importance of these subsidies to ecosystem functioning, we compared their magnitude to those of local biological fluxes within each receiving ecosystem. Magnitudes of subsidies versus local fluxes are similar in freshwater and in some benthic systems, whereas subsidies are generally far smaller than local fluxes in terrestrial ecosystems (Figure 3). This results both from more abundant cross-ecosystem subsidies in the direction of freshwater and benthic ecosystems than terrestrial and pelagic systems, and from substantially lower primary production in the former. Ecosystem respiration in freshwater and benthic systems often exceeds local primary production, despite a noticeable variability, for example due to differences in light availability in shallow tropical sea grass meadows *versus* deep waters promoting or constraining photosynthesis respectively. Ecosystem heterotrophy (see negative net ecosystem production in Extended data Figure 1) is associated with cross-ecosystem inflows of comparable or greater magnitude than local production, indicating that functioning in these ecosystems depends substantially on allochthonous resources. This dependency makes freshwater and deep unproductive benthic systems sensitive to alterations of these resources and, thus, to donor ecosystem dynamics^{21,22}.

By contrast, terrestrial and pelagic ecosystems tend to have a net autotrophic functioning and receive negligible subsidies compared to their local production, except in deserts (Figure 3). In the latter case, where local production is limited (e.g., by water availability), the potential impact of subsidies provided by other, less limited ecosystems (e.g., oceans) increases. Otherwise, autotrophic ecosystems seem relatively free from influence of spatial resources (or at least, from the influence of aquatic subsidies: we found only two studies reporting subsidies between terrestrial ecosystems). However, carbon subsidies are intimately linked to nutrients within biological molecules. Though quantitatively small in terms of carbon, subsidies to terrestrial systems are of higher quality with respect to nitrogen content than the vegetation-based subsidies they export

(e.g. insects versus leaves in terrestrial-freshwater couplings^{8,23}). Some cross-ecosystem subsidies, not considered here, are even predominantly of nitrogen or phosphorus, enriching terrestrial (e.g., guano from foraging sea birds²⁴) or pelagic systems (e.g., excretion of marine mammals²⁵). Carbon and nutrients in cross-ecosystem subsidies may relax different limitations in recipient ecosystems, thus enhancing regional production^{6,26}.

Overall, our synthesis of carbon-based cross-ecosystem subsidies identifies strong spatial couplings between autotrophic and heterotrophic ecosystems (Figure 4). Cataloguing the types of subsidies documented so far, and their drivers (Figure 1), also reveals important gaps in the assessment of ecosystem couplings. A large portion of the quantified subsidies concerns flows occurring at terrestrial-freshwater (66.9%) or pelagic-benthic (18.0%) interfaces, and are driven by passive rather than active processes (Figure 2c; 70.5%). This may be because passive flows of detritus or of small organisms can be easily measured by various traps. By contrast, it is more challenging to quantify active spatial flows resulting from animal movement. This requires indirect estimations, for instance combining animal tracking and measurements of ingestion and excretion rates²⁷. Quantifications are rare (Figure 2), but the few existing studies suggest that widespread animal movements, such as foraging or migration, could act as important ecosystem connectors²⁸. In particular, mobile species using multiple ecosystems²⁹, or those whose behaviour leads to massive aggregations of individuals, likely move important amounts of resources among ecosystems. At the moment, the lack of data hinders an assessment of the global importance of these actively-driven cross-ecosystem subsidies⁹. However, such linkages could render common ecosystem couplings more bi-directional than previously thought, as proposed for the aquatic-terrestrial interface^{8,30}. Detailed evaluation of flow bi-directionality is essential to better understand spatial feedbacks between connected ecosystems. Resource exchanges between ecosystems underlie both optimization in resource use at the landscape scale, and potentials for spatial amplification of local perturbations.

In summary, the magnitude and importance of cross-ecosystem carbon subsidies for ecosystem functioning is globally variable, but predictable based on general

knowledge of internal ecosystem fluxes and metabolism (net heterotroph vs. autotroph). Freshwater and benthic ecosystems might be especially vulnerable to subsidy alteration, and to perturbations in autotrophic ecosystems spatially cascading via these subsidies. However, gaps in subsidy quantification leave some uncertainty as to whether different ecosystems might act as buffers or amplifiers of spatial dynamics within landscapes. Documenting these ecological blind spots is necessary to improve our ability to predict ecosystem responses to global changes across landscapes.

Methods

We conducted an extensive literature review of empirical values of cross-ecosystem subsidies over the globe (distribution in Figure 1), and compared their magnitude to local fluxes within ecosystems receiving these subsidies. We chose carbon as the focal material unit to profit from widely available carbon data for local fluxes. To enable the spatial flows to local flux comparison, we only considered measurements of spatial flows that were either provided in or could be converted into $\text{gC m}^{-2} \text{yr}^{-1}$.

Data collection

Our systematic search covered four broad categories of terrestrial ecosystems (forest, grassland, agro-ecosystem, and desert) and four of aquatic ecosystems (stream, lake, pelagic ocean and benthic ocean). We considered all ecosystems (if available) in five major global climatic zones (arctic/alpine, boreal, temperate, tropical and arid). Extended Data Table 1 provides the definitions of ecosystem categories and climatic zones. For marine ecosystems, we grouped arctic, boreal, temperate *versus* arid and tropical climates into “Cold” and “Warm” waters respectively, to account for a lesser influence of climate on oceanic systems due to the buffering effect of large water volumes. For each relevant ecosystem x climatic zone combination (see Extended Data Figure 2), we collected local carbon flux and spatial carbon flow data. We used all possible combinations of these categories and terms with similar meanings (see Extended Data Table 1) in our systematic search (see details in the next paragraphs).

We collected available values of subsidies linking the above-mentioned different ecosystems, and which could be converted into $\text{gC m}^{-2} \text{yr}^{-1}$ in order to homogenize data and make comparisons possible. The latter constraint excluded cross-ecosystem flows of nutrients for which no carbon equivalent was possible, and flows expressed without information of the area of influence in the ecosystem receiving the subsidy. For instance, measurements of amount of dissolved organic carbon flowing from streams into estuaries³¹ were excluded because the impacted area was undefined. Terms primarily used for the search of spatial flows were “(subsid* OR spatial flow*) AND ecosystem”, with “ecosystem” also being replaced by specific ecosystems or pairwise combinations of the ecosystem types of interest.

In addition, for each ecosystem x climatic zone combination, we systematically searched published literature for values of the following within-ecosystem carbon fluxes: gross primary production (GPP), secondary production in aquatic ecosystems, ecosystem respiration (R_e), net ecosystem production (NEP), and decomposition fluxes. Since decomposition fluxes were rarely directly provided, we derived them from detritus stocks and decomposition rates (see next section for calculations). A first systematic search was conducted by using all possible combinations of the names of each ecosystem type, climatic zone and flux of interest, with small variation when relevant (e.g. “decomposition OR decay” for decomposition flux and rates). The different terminologies used across various research fields to describe the same processes, and the fact that the data of interest were often located in different sections of the studies (Methods *versus* Results) limited the efficiency of standardized keyword search across the data types. We therefore complemented the dataset with multiple customized searches until we compiled a minimum number of ten independent values of each variable of interest (i.e. fluxes, detritus stock, and decomposition rate) for each ecosystem x climatic zone combination. At the end, data were pooled by ecosystem type.

In total, we collected 3,034 values from 557 published studies, including 518 values of cross-ecosystem subsidies. A summary of all values and the respective references are provided in Extended data Table 2 (cross-ecosystem subsidies) and Extended data Table 3 (local fluxes).

Calculations used for data extraction

When only two of three major fluxes (production and respiration, and net ecosystem production (GPP , R_e , and NEP , respectively) were reported, we estimated the unreported flux:

$$NEP = GPP - R_e \quad [1]$$

$$NEP = NPP - R_h \quad [2]$$

$$NPP = GPP - R_a \quad [3]$$

NPP is the net primary production, R_h the heterotrophic respiration and R_a the autotrophic respiration.

We derived decomposition fluxes D_F from detritus stocks D_M and decomposition rates k , with the classical exponential decay model:

$$D_F = D_M(1 - e^{-kt}) \quad [4]$$

To calculate individual decomposition flux values, we parameterized detritus stock D_M with the median values of all detritus stocks in a given ecosystem x climatic zone combination and used the decomposition rate values collected from the literature to produce flux values. The rates were values of k , the first order constant in the classical exponential decay model. When not directly provided, we derived k with one of the equations proposed by Cebrian and Lartigue¹⁴ depending on the data available in the study:

$$D_t = D_{t_0} e^{-k(t-t_0)} \quad [5]$$

$$D_F = (D_P - E)(1 - e^{-kt}) \quad [6]$$

In Equation [5], D_t is the detrital mass at time t and D_{t_0} the initial detrital mass. This equation was used when decomposition was estimated as the proportion of detrital mass loss ($1 - D_t/D_{t_0}$) via a litter-bag experiment, a classical method in freshwater and terrestrial ecology. In equation [6], D_F is the (absolute) decomposition flux during the study period t , that is the flux from detritus stock to bacteria and other detritivores, D_P is the detritus production, and E the detritus export (e.g. sedimentation). In few cases of ocean pelagic data, we used the microbial loop of primary production *versus* bacterial production to parameterize D_P and D_F , respectively. If not available, the export rate was set to 0, leading to k underestimation, which is conservative in our cross-ecosystem comparison given that k is already at the higher end of the range in these pelagic systems.

Unit conversions

Once collected, we standardized values by converting them all into areal carbon units, that is, gC m^{-2} for detritus stocks and $\text{gC m}^{-2} \text{yr}^{-1}$ for local fluxes and cross-ecosystem subsidies. Decomposition rates were expressed in yr^{-1} .

Carbon conversion: We used data in carbon units (gC) when it was directly provided in the study, or we calculate the values using carbon content when reported in the study. Alternatively, we applied the most direct conversion of the data into carbon

units depending on the level of detail available (see Extended data Table 4 for conversion factors). For decomposition rates, we did not transform units into carbon, assuming carbon loss rate to be identical to loss rate in the unit provided.

Time extrapolation: for local fluxes or rates provided in daily units, we extrapolated to the year by multiplying by 365 days in tropical systems where low or no seasonality is assumed. For the others, we multiplied by the number of days in the growing season as reported in the study, or the ice-free period in cold climates. When growing season length (GSL) was not specified in the study we used averaged estimates detailed by Garonna et al.³² for the different climatic zones in Europe³³: 181 days for temperate climate (mean of atlantic and continental), 155 days for boreal, 116 days for arctic, and 163 days for arid systems (mean of Mediterranean and steppic). We did not apply any conversion if the value was measured on a study period longer than the above GSL for the corresponding climate.

Volume to area conversions and depth integration: Some data were given per unit of volume. For freshwater systems, we converted the data into area units by integrating them over the water column, using the mean depth of the river or lake. When not directly available in the study we calculated depth by dividing the volume per the area in lakes, or by estimating depth from discharge in rivers with the formula $\text{depth} = c \cdot Q^f$, with $c = 0.2$, $f = 0.4$ and Q the discharge in $\text{m}^3 \text{s}^{-1}$ ³⁴. For small catchment areas, that is $<1 \text{ km}^2$, we estimated the depth to be 5 cm based on known river scaling-properties³⁴. For marine data, notably production in the pelagic zone, studies generally provide a meaningful depth, which defines the euphotic zone such as the Secchi depth or the 1% light inflow depth. We integrated values in volume units over this depth, and to 100 m depth when only sampling depths were provided.

Areal units for cross-ecosystem subsidies: Since we were interested in comparing the magnitude of spatial subsidies to that of the recipient ecosystem's own local fluxes, we needed cross-ecosystem subsidies measured in areal units of the recipient ecosystem. Depending on the method of quantification, cross-ecosystem flow can be directly expressed in this way (e.g. litter traps in the recipient ecosystem). In other cases, for example with vertical fluxes between pelagic and benthic ecosystems, the equivalence of donor and recipient ecosystem areas affected by the flow is obvious. However, in the case

of lateral flows occurring from aquatic to terrestrial ecosystems (e.g. emergent insects, carcasses of salmon caught by bears), flows were often provided per m² of donor area. We could not use such measurements directly because the magnitude of the flow in the recipient ecosystem depends on both the total surface of production and the boundary length. For instance, lakes with the same area but having circular *versus* complex-shorelines will lead, for the same total emergent insect flux, to higher *versus* lower magnitudes of flows, respectively, distributed per areal unit of the recipient ecosystem. Moreover, the maximum influence of such cross-ecosystem flow is found near at the shoreline and decreases with distance from the shore (for example, in aquatic insects¹⁹). To adjust for this in a conservative approach, we homogenized our aquatic-to-terrestrial flows assuming a uniform distribution of the flow on the first ten meters from the shore, a distance within which most of the aquatic insect flows fall³⁵ (but could fall substantially farther in some specific systems³⁶), or most of the salmon carcasses brought by bears on land are deposited³⁷. Therefore, when the values of spatial flows were provided in areal unit of the donor ecosystem (aquatic), we first calculated the flow per meter shoreline (in some cases, values were already provided per meter shoreline; e.g., wrack deposited on beaches), and then divided this value by 10 meters of influenced land. To calculate the spatial flow per shoreline length in freshwater systems, we followed the method described by Gratton et al.¹⁹ for insect emergence data: In lakes we multiplied the data per the total lake area and divided per the perimeter. When not directly available, the perimeter was approximated by $2 \cdot D_L \cdot (\text{area} \cdot \pi)^{1/2}$, with D_L the development factor defined by Kalff³⁸, which is 1 for circular shapes, 2 for the same area with a twofold larger perimeter. In streams we multiplied the original donor area flow value by stream width, and then divided it per two (riversides) to obtain the flow per shoreline length. The Extended Data Figure S3 show that our conclusions are not sensitive to the choice of the distance from shoreline used to calculate the recipient terrestrial area of aquatic subsidies: using a more conservative threshold of 100m only decreases the importance of spatial subsidies for terrestrial ecosystems, that we already assess as low.

Flow drivers

We defined categories of flow drivers to examine the underlying processes of documented cross-ecosystem subsidies. Drivers could be either passive, via physical processes such as gravity, wind, water currents, tides, diffusion, or active, via animal movements such as those triggered by foraging behaviours, seasonal migration or cross-ecosystem movement of animals needed to complete a life-cycle. We kept these last three categories for active drivers and we clumped the passive drivers into categories reflecting broad classes of spatial flows: “Fall/wind” for aerial transport from terrestrial systems, “leaching” for diffusion processes, “current, tides” for lateral flows from aquatic systems and “sinking” for vertical passive flows in the water column (see Extended data Table 5). We analysed the data and plotted the figures with the software R³⁹ and the R-packages ggmap⁴⁰, maps⁴¹, and pgirmess⁴².

Data availability

Data that support the findings of this study are summarized in Extended Data Table 2 and Extended Data Table 3, with all associated references in Supplementary Table 1.

References

1. Polis, G. A., Power, M. E. & Huxel editors, G. R. *Food Webs at the landscape level*. (University of Chicago Press, Chicago and London, 2004).
2. Richardson, J. S. & Sato, T. Resource subsidy flows across freshwater-terrestrial boundaries and influence on processes linking adjacent ecosystems. *Ecohydrology* **8**, 406–415 (2015).
3. Leroux, S. J. & Loreau, M. Dynamics of Reciprocal Pulsed Subsidies in Local and Meta-Ecosystems. *Ecosystems* **15**, 48–59 (2012).
4. Gravel, D., Guichard, F., Loreau, M. & Mouquet, N. Source and sink dynamics in meta-ecosystems. *Ecology* **91**, 2172–2184 (2010).
5. Gounand, I. *et al.* The Paradox of Enrichment in Metaecosystems. *Am. Nat.* **184**, 752–763 (2014).
6. Gounand, I., Harvey, E., Ganesanandamoorthy, P. & Altermatt, F. Subsidies mediate interactions between communities across space. *Oikos* **126**, 972–979 (2017).
7. Bultman, H., Hoekman, D., Dreyer, J. & Gratton, C. Terrestrial deposition of aquatic insects increases plant quality for insect herbivores and herbivore density. *Ecol. Entomol.* **39**, 419–426 (2014).
8. Schindler, D. E. & Smits, A. P. Subsidies of Aquatic Resources in Terrestrial Ecosystems. *Ecosystems* **20**, 78–93 (2017).
9. Gounand, I., Harvey, E., Little, C. J. & Altermatt, F. Meta-Ecosystems 2.0 : Rooting the Theory into the Field. *Trends Ecol. Evol.* **33**, 36–46 (2018).
10. Millenium Ecosystem Assessment Panel. *Ecosystems and Human Well-Being: Synthesis*. (Island Press Washington DC, 2005).
11. Russell, R. *et al.* Humans and Nature : How Knowing and Experiencing Nature Affect Well-Being. *Annu. Rev. Environ. Resour.* **38**, 473–502 (2013).
12. Vörösmarty, C. J. *et al.* Global threats to human water security and river biodiversity. *Nature* **467**, 555–561 (2010).
13. Halpern, B. S., Walbridge, S., Al, E. & Wtsaon, R. A global map of human impact on marine ecosystems. *Science*. **319**, 948–952 (2008).
14. Cebrian, J. & Lartigue, J. Patterns of herbivory and decomposition in aquatic and

- terrestrial ecosystems. *Ecol. Monogr.* **74**, 237–259 (2004).
15. Leibold, M. A. *et al.* The metacommunity concept: a framework for multi-scale community ecology. *Ecol. Lett.* **7**, 601–613 (2004).
 16. Massol, F. *et al.* How life-history traits affect ecosystem properties: effects of dispersal in meta-ecosystems. *Oikos* **126**, 532–546 (2017).
 17. Reiners, W. A. & Driese, K. Transport of energy, information and material through the biosphere. *Annu. Rev. Environ. Resour.* **28**, 107–135 (2003).
 18. Loreau, M., Mouquet, N. & Holt, R. D. Meta-ecosystems: a theoretical framework for a spatial ecosystem ecology. *Ecol. Lett.* **6**, 673–679 (2003).
 19. Gratton, C. & Vander Zanden, M. J. Flux of aquatic insect productivity to land: Comparison of lentic and lotic ecosystems. *Ecology* **90**, 2689–2699 (2009).
 20. Greig, H. S. *et al.* Warming , eutrophication , and predator loss amplify subsidies between aquatic and terrestrial ecosystems. *Glob. Chang. Biol.* **18**, 504–514 (2012).
 21. Ball, B. a. *et al.* Direct and Terrestrial Vegetation-mediated Effects of Environmental Change on Aquatic Ecosystem Processes. *Bioscience* **60**, 590–601 (2010).
 22. Griffiths, J. R. *et al.* The importance of benthic-pelagic coupling for marine ecosystem functioning in a changing world. *Glob. Chang. Biol.* **23**, 2179–2196 (2017).
 23. Elser, J. J. *et al.* Nutritional constraints in terrestrial and freshwater food webs. *Nature* **408**, 578–80 (2000).
 24. Adame, M., Fry, B., Gamboa, J. & Herrera-Silveira, J. Nutrient subsidies delivered by seabirds to mangrove islands. *Mar. Ecol. Prog. Ser.* **525**, 15–24 (2015).
 25. Doughty, C. E. *et al.* Global nutrient transport in a world of giants. *Proc. Natl. Acad. Sci.* **113**, 1–6 (2015).
 26. Soininen, J., Bartels, P., Heino, J., Luoto, M. & Hillebrand, H. Toward More Integrated Ecosystem Research in Aquatic and Terrestrial Environments. *Bioscience* **65**, 174–182 (2015).
 27. Abbas, F. *et al.* Roe deer may markedly alter forest nitrogen and phosphorus budgets across Europe. *Oikos* **121**, 1271–1278 (2012).

28. Bauer, S. & Hoyer, B. J. Migratory animals couple biodiversity and ecosystem functioning worldwide. *Science*. **344**, 1242552 (2014).
29. Lundberg, J. & Moberg, F. Mobile link organisms and ecosystem functioning: Implications for ecosystem resilience and management. *Ecosystems* **6**, 87–98 (2003).
30. Baxter, C. V., Fausch, K. D. & Saunders, W. C. Tangled webs: Reciprocal flows of invertebrate prey link streams and riparian zones. *Freshw. Biol.* **50**, 201–220 (2005).
31. Regnier, P. *et al.* Anthropogenic perturbation of the carbon fluxes from land to ocean. *Nat. Geosci.* **6**, 597 (2013).
32. Garonna, I. *et al.* Strong contribution of autumn phenology to changes in satellite-derived growing season length estimates across Europe (1982–2011). *Glob. Chang. Biol.* **20**, 3457–3470 (2014).
33. Mùcher, C. A., Klijn, J. A., Wascher, D. M. & Schaminée, J. H. J. A new European Landscape Classification (LANMAP): A transparent, flexible and user-oriented methodology to distinguish landscapes. *Ecol. Indic.* **10**, 87–103 (2010).
34. Rodríguez-Iturbe, I. & Rinaldo, A. *Fractal river networks: chance and self-organization*. (Cambridge University Press, 1997).
35. Iwata, T., Nakano, S. & Murakami, M. Stream meanders increase insectivorous bird abundance in riparian deciduous forests. *Ecography*. **26**, 325–337 (2003).
36. Gratton, C., Donaldson, J. & Zanden, M. J. Vander. Ecosystem Linkages Between Lakes and the Surrounding Terrestrial Landscape in Northeast Iceland. *Ecosystems* **11**, 764–774 (2008).
37. Gende, S. M., Quinn, T. P., Willson, M. F., Heintz, R. & Scott, T. M. Magnitude and fate of salmon-derived nutrients and energy in a coastal stream ecosystem. *J. Freshw. Ecol.* **19**, 149–160 (2004).
38. Kalff, J. *Limnology—Inland water ecosystems*. (Upper Saddle River, N.J. : Prentice Hall, 2002). doi:10.2307/1468422
39. R Core Team. *R: A Language and Environment for Statistical Computing*. (R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>, 2017).

40. Kahle, D. & Wickham, H. ggmap: Spatial Visualization with ggplot2. *The R Journal*. **5**, 144–161 (2013).
41. Original S code by Becker, R. A., and Wilks, A. R., R version by Brownrigg, R., Enhancements by Minka, T. P. & and Deckmyn, A. maps: Draw Geographical Maps. *R Packag. version 3.2.0*. URL <https://cran.r-project.org/package=maps> (2017).
42. Giraudoux, P. pgirmess: Data Analysis in Ecology. *R Packag. version 1.6.6*. URL <https://CRAN.R-project.org/package=pgirmess> (2017).

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Author contribution

I.G., C.J.L., E.H. and F.A. conceived the study and collected the data. I.G. analysed the data, produced the figures and wrote the first draft of the manuscript. All authors edited and contributed to the final version of the manuscript.

Figure 1 | Global distribution of available cross-ecosystem subsidy data. Colours and shapes indicate the type of ecosystems coupled by cross-ecosystem subsidies: terrestrial (i.e., forest, grassland, agro-ecosystem, desert), marine (i.e., ocean pelagic, ocean benthic) and freshwater (i.e., stream, lake, wetland).

Figure 2 | Architecture of cross-ecosystem carbon subsidies. Values are provided (a) by types of ecosystems connected by the subsidies, with vertical labels specifying ecosystems (“Agro” stands for “Agro-ecosystem”) or flow direction, and (b) by underlying flow driver, either via passive or active processes. Shapes and colours denote material transported. a, b – Bottom numbers, n, indicate the number of data points. Values are in $\text{gC m}^{-2} \text{y}^{-1}$ on a log scale. The areal unit, m^2 , refers to the recipient ecosystem. Boxplots give median (white line), 25% and 75% percentiles (box), and range (whiskers). c – Number of studies by driver type.

Figure 3 | Comparison of local fluxes *versus* cross-ecosystem subsidies. Local fluxes within (green), and cross-ecosystem subsidies to (pink), specific ecosystem types (different panels). Represented local fluxes are gross primary production, ecosystem respiration, decomposition flux, and secondary production in aquatic systems. Cross-ecosystem subsidies are clumped into imported material of four origins: primary producers invertebrates, vertebrates, and organic carbon (particulate and dissolved). No subsidy to pelagic systems was documented. Circles give values in $\text{gC m}^{-2} \text{yr}^{-1}$ on a log scale. Boxplots give median (white line), 25% and 75% percentiles (box), and range (whiskers). Whisker and three null values of GPP in streams are omitted due to log scale.

Figure 4 | Well-documented natural meta-ecosystems. Cross-ecosystem subsidies suggest significant spatial couplings between (a) terrestrial and freshwater ecosystems and (b) pelagic and benthic areas in marine ecosystems. Round and horizontal arrows represent gross primary production (GPP) and cross-ecosystem subsidies, respectively. Numbers in *italic* are median values for GPP and sum of median values of cross-ecosystem subsidies of each different origin (primary producer, invertebrate, vertebrate, and particulate and dissolved organic carbon), both expressed in $\text{gC m}^{-2} \text{y}^{-1}$. Width of arrows is proportional to these values (based on double squared root transformation).

Extended Data Display

Worldwide cross-ecosystem carbon subsidies and their contribution to ecosystem functioning

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Extended Data Figure 1 | Net Ecosystem Production for different ecosystem types.

Net ecosystem production corresponds to the balance between gross primary production and ecosystem respiration. Negative values denote net heterotrophic functioning. Circles give individual values in $\text{gC m}^{-2} \text{y}^{-1}$. Note that these are production fluxes and not productivity rates (biomass turnover), for which we would have higher values in aquatic compared to terrestrial systems. Boxplots give median (white line), 25% and 75% percentiles (box), and range (whiskers). Bottom numbers (n) indicate the number of data points.

		Climatic zones				
		Arctic	Boreal	Temperate	Tropical	Arid
Ecosystems	Forest					
	Grassland					
	Agro-ecosystem					
	Desert					
	Stream					
	Lake / Pond					
	Ocean pelagic		Cold		Warm	
	Ocean benthic		Cold		Warm	

Extended Data Figure 2 | Data collection. Combinations of ecosystem types and climatic zones considered in this study. We collected values of local carbon fluxes for all combinations marked by a grey rectangle, as well as cross-ecosystem subsidies linking these ecosystems. The other combinations either do not exist, or do not have enough data available.

Extended Data Figure 3 | Sensitivity of local fluxes *versus* cross-ecosystem subsidies to shoreline threshold. Local fluxes within- (green) and cross-ecosystem subsidies to- (pink), specific ecosystem types (different panels). A threshold of 100 meters from shoreline (rather than 10m in Figure 3) was used to calculate the recipient terrestrial area influenced by aquatic cross-ecosystem subsidies. Circles give values in $\text{gC m}^{-2} \text{y}^{-1}$ on a log scale. Black dots show the data points influenced by this choice. Boxplots give median (white line), 25% and 75% percentiles (box), and range (whiskers). Whisker and three null values of GPP in streams are omitted due to log scale. Bottom numbers (n) indicate the number of data points.

Extended Data Table 1 | Definition of ecosystem and climate categories.

	Definition	Example ecosystems
Climatic zones		
Arctic	Extreme temperature limitation of growing season length, with abiotic conditions not supporting tree growth in arctic, subarctic, and alpine zones; OR high latitude oceans, generally above 66.5°	Tundra (grassland) Alpine grassland
Boreal	Strong temperature limitation of terrestrial growth, but environment supports tree growth. Covers northern parts of North America, Europe and Russia from latitudes 50° to 55°; OR oceans between 50° and 66.5°	Taiga (forest) Sub-alpine forest
Temperate	Seasonal terrestrial growth with some temperature limitation. Covers latitudes between 23.5° and 50° to 55°, including oceans in this latitudinal range	Beech forest
Tropical	Warm terrestrial tropical, sub-tropical, equatorial systems not limited by drought between 0° to 23.5° latitude (including subtropical system), including oceans in this latitude range	Savanna (grassland), rainforest
Arid	Severely water-limited terrestrial systems at all latitudes, including arid, semi-arid, xeric, xerophytic, xeromorphic, Mediterranean systems, continental, warm or cold, and polar deserts	Garrigue (grassland), shrubland (grassland or forest, depending on the canopy), chaparral (grassland), steppe (grassland), caatinga (forest), cerrado
Ecosystems		
Forest	Complete vegetation cover with trees as dominant vegetation; tree canopy covers most of the surface	Rainforest, caatinga, woodland, some shrubland, cerrado
Grassland	Complete vegetation cover, but with only very few or no trees; vegetation dynamics dominated by water limitation, fires and grazing.	Steppe, savannah, meadow, prairie, tundra, old field, some shrublands, herbaceous rich-fen vegetation.
Desert	Extreme growth limitation by water availability, with little vegetation distributed in remote patches	Sandy land.
Agro-ecosystem	Ecosystems devoted to crop production or cattle grazing, often fertilized or irrigated to remove nutrient or water limitations for growth	Cropland, pasture.
Stream	Running freshwater and lotic systems of all sizes, including rivers	Creek, brook, river, stream
Lake	Standing (lentic) freshwater systems	Reservoir, lake, pond
Ocean	All salt water ecosystems with no emerged vegetation, including internal seas	Sea, ocean shelf, estuary, lagoon
Ocean pelagic	Ecosystems in the open water columns of oceans and seas	Upwelling system, open ocean
Ocean benthic	Ecosystems at the bottom of oceans and seas	Coral reef, sea grass bed, eelgrass meadow, kelp forest, deep-sea floor.

Extended Data Table 2 | Summary of cross-ecosystem subsidy data.

Donor	Recipient	Material	n	Min	q25	Median	q75	Max	Data References
Forest	Agroeco.	Vegetation	2	13.545	36.360	59.175	81.990	104.81	50
Forest	Stream	Vegetation	96	0.2500	55.247	178.65	280.62	2,085.8	8, 12, 13, 14, 15, 16, 17, 21, 26, 27, 28, 29, 30, 31, 33, 65, 78, 90, 96, 117, 118, 123, 124, 138, 203, 205, 212, 235, 375, 389, 392
Forest	Stream	Terr.inverteb.	49	0.1414	1.0683	3.0368	7.3321	20.386	2, 3, 4, 5, 6, 7, 23, 25, 32, 65, 98, 147, 365, 369, 370, 375, 525, 526
Forest	Lake	Vegetation	9	1.2000	1.5439	6.4000	47.000	465.00	20, 109, 295, 316, 375, 520, 521
Forest	Lake	Terr.inverteb.	1	0.0184	0.0184	0.0184	0.0184	0.0184	375
Forest	Lake	Small amphib.	11	0.0331	0.4706	1.3528	3.7450	7.4100	60, 61
Forest	Lake	POC	2	1.8100	3.3259	4.8418	6.3576	7.8735	522
Forest	Ocean	Vegetation	18	0.1000	27.249	153.80	312.00	492.80	430, 523
Forest	Ocean	Terr.inverteb.	5	0.1300	0.1700	0.8600	1.5100	1.6400	527
Forest	Ocean	POC	9	0.0003	9.1000	15.100	56.900	285.00	430
Forest	Ocean	DOC	7	0.1000	40.500	48.000	82.050	138.10	430
Grassland	Stream	Vegetation	9	0.5500	16.000	64.593	250.00	265.77	16, 18, 65, 89, 117, 118, 138, 205
Grassland	Stream	Terr.inverteb.	6	0.1005	0.3413	0.8304	2.0334	2.5296	9, 32, 365
Grassland	Stream	Mammal faeces	2	502.00	746.75	991.50	1,236.2	1,481.0	364
Grassland	Stream	Carcass	1	136.80	136.80	136.80	136.80	136.80	556
Agroeco.	Forest	Mammal faeces	2	0.4829	0.6448	0.8067	0.9686	1.1305	367
Agroeco.	Stream	Vegetation	23	1.4000	61.814	104.70	165.15	264.80	12, 78
Agroeco.	Stream	Terr.inverteb.	5	1.4544	4.4640	5.2699	6.1504	6.1504	3, 98, 365
Desert	Stream	Vegetation	1	8.4000	8.4000	8.4000	8.4000	8.4000	94
Wetland	Forest	Small amphib.	1	64.634	64.634	64.634	64.634	64.634	59
Wetland	Grassland	Aqu. insects	6	0.0136	0.0339	0.1410	0.3297	2.4408	57, 66
Stream	Forest	Aqu. insects	30	0.0022	0.1377	0.4857	0.9384	8.3480	10, 11, 19, 65, 67, 74, 77, 78, 147, 266, 365, 366, 477
Stream	Forest	Carcass	14	0.0693	1.7076	2.9078	5.8411	15.980	386, 390
Stream	Grassland	Aqu. insects	5	0.0027	0.0628	0.1329	0.2828	0.9516	65, 77, 365
Stream	Agroeco.	Aqu. insects	9	0.0067	0.2648	1.4607	4.3822	9.6100	69, 77, 78, 365
Stream	Desert	Aqu. insects	4	0.1742	1.3000	1.8098	2.7536	5.1815	22, 34, 387
Lake	Forest	Aqu. insects	14	0.0976	0.7246	1.8110	9.1252	467.87	62, 368, 374, 518, 524, 528
Lake	Forest	Small amphib.	11	0.0030	0.0273	0.0914	41.002	127.33	58, 60, 528
Lake	Grassland	Aqu. insects	20	0.3057	1.2527	4.7484	24.641	467.87	1, 24, 62, 368, 374, 383, 517, 519
Lake	Desert	POC	1	0.1530	0.1530	0.1530	0.1530	0.1530	56
L. Pelagic	L. Benthic	Phytoplankton	3	1.0971	8.1016	15.106	19.965	24.824	99, 134, 379
L. Pelagic	L. Benthic	Zooplankton	1	24.983	24.983	24.983	24.983	24.983	379
L. Pelagic	L. Benthic	POC	13	2.1448	13.950	20.925	32.860	141.82	294, 296, 485
Ocean	Forest	POC	1	0.1000	0.1000	0.1000	0.1000	0.1000	430
Ocean	Forest	DOC	6	0.4000	8.7500	15.900	20.350	67.300	430
Ocean	Desert	Macroalgae	6	44.520	93.921	835.79	1,638.3	2,646.9	103, 104, 371
Ocean	Desert	Carcass	3	4.9500	10.125	15.300	19.575	23.850	104
Ocean	Stream	Carcass	3	59.667	61.075	62.483	66.847	71.211	389
Oc. Pelagic	Oc. Benthic	Macroalgae	1	0.1786	0.1786	0.1786	0.1786	0.1786	503
Oc. Pelagic	Oc. Benthic	Phytoplankton	16	0.0362	0.1222	0.4978	2.7648	142.00	310, 311, 499, 539
Oc. Pelagic	Oc. Benthic	Zooplankton	38	0.3167	0.7563	1.5629	6.4680	156.90	308, 311, 384, 385, 495, 539, 557
Oc. Pelagic	Oc. Benthic	Carcass	4	0.0157	0.1134	0.1556	0.5290	1.6200	499, 500, 503, 504
Oc. Pelagic	Oc. Benthic	POC	40	0.1330	5.7875	19.444	70.250	562.91	80, 102, 116, 131, 133, 304, 306, 311, 319, 330, 334, 335, 338, 393, 494, 514
Oc. Benthic	Desert	Macroalgae	7	0.4795	176.46	1,522.1	4,730.8	17,365	372, 373, 382
Oc. Benthic	Oc. Benthic	Macroalgae	3	115.80	124.65	133.50	148.75	164.00	418, 420

Agroeco. = Agro-ecosystem; Oc. = Ocean; Terr. = Terrestrial; Aqu. = Aquatic; inverteb. = invertebrates;

amphib. = amphibians; POC = Particulate Organic Carbon; DOC = Dissolved Organic Carbon.

We provide the number of data points (n), the minimum, 25% quartile (q25), median, 75% quartile (q75) and maximum values of estimates distribution for each pair of ecosystems coupled and per type of the material exchanged, as well as the associated references from which we extracted the data, listed in Supplementary Table 1. Values are expressed in $\text{gC m}^{-2} \text{yr}^{-1}$. Donor and Recipient refer respectively to the ecosystem from which comes and to which go the spatial flow.

Extended Data Table 3 | Summary of local ecosystem data.

Ecosystem	Variable	n	Min	q25	Median	q75	Max	Data References
Forest	GPP	74	387.00	1,064.0	1,379.5	1,786.0	4,188.0	38, 39, 41, 42, 49, 52, 145, 146, 155, 156, 157, 158, 160, 161, 162, 163, 167, 169, 170, 171, 174, 250, 257, 283, 288, 289, 545
Forest	R	75	131.00	825.00	1,098.0	1,333.2	3,860.0	38, 39, 41, 42, 49, 52, 108, 145, 146, 155, 156, 157, 158, 160, 161, 162, 163, 170, 171, 174, 249, 250, 257, 283, 288, 289, 545
Forest	NEP	87	-146.00	101.50	200.00	336.00	976.00	38, 39, 41, 42, 49, 145, 146, 151, 155, 156, 157, 158, 160, 161, 162, 163, 165, 166, 168, 170, 171, 174, 249, 250, 257, 263, 271, 280, 283, 287, 288, 289, 398, 421, 545
Forest	Detritus	90	70.871	447.88	1,040.0	2,491.9	24,98	36, 37, 38, 40, 41, 42, 63, 64, 73, 148, 149, 150, 151, 153, 154, 164, 173, 183, 224, 226, 248, 258, 259, 352, 398, 422, 529, 530
Forest	D. rate	78	0.0120	0.2371	0.4334	0.9717	66.000	91, 95, 122, 135, 152, 176, 184, 201, 224, 225, 226, 228, 229, 248, 249, 251, 252, 253, 255, 256, 354, 356, 358
Grassland	GPP	77	36.500	232.00	611.53	1,047.4	3,723.0	47, 54, 81, 86, 87, 88, 92, 100, 167, 177, 178, 188, 189, 190, 257, 278, 279, 283, 285, 286, 394, 400, 403, 404, 405, 408, 410, 411, 412, 427, 439, 452
Grassland	R	62	52.900	235.50	556.38	1,023.0	5,725.6	35, 47, 54, 70, 71, 72, 76, 81, 86, 87, 88, 92, 100, 177, 178, 189, 257, 260, 278, 279, 283, 285, 286, 394, 400, 405, 408, 409, 410, 411, 412, 427, 439, 452, 531
Grassland	NEP	70	-212.00	-34.750	52.884	119.92	2,810.5	47, 54, 81, 86, 87, 88, 92, 100, 168, 172, 177, 178, 189, 257, 260, 263, 278, 279, 280, 282, 283, 285, 286, 377, 394, 397, 400, 405, 408, 410, 411, 412, 427, 439, 452
Grassland	Detritus	64	3.7568	88.198	176.81	279.35	2,250.0	44, 46, 51, 54, 75, 85, 150, 151, 175, 180, 187, 282, 377, 378, 399, 406, 410, 413, 414, 415, 424, 426, 429, 432, 435, 436, 437, 530, 531
Grassland	D. flux	5	10.585	12.447	13.104	13.322	20.988	376
Grassland	D. rate	64	0.0120	0.1863	0.6230	1.0227	3.3731	91, 119, 120, 121, 125, 175, 179, 181, 182, 185, 186, 187, 194, 195, 227, 236, 284, 376, 407, 413, 415, 423, 425, 426, 531
Agroeco.	GPP	24	599.00	1,286.8	1,772.4	1,992.6	2,520.7	167, 232, 257, 277, 279, 281, 402, 428
Agroeco.	R	22	714.00	1,066.9	1,309.5	1,563.1	1,996.0	76, 257, 277, 279, 281, 402, 428
Agroeco.	NEP	21	-115.00	155.00	303.00	361.05	1,204.5	168, 257, 277, 279, 281, 402, 428
Agroeco.	Detritus	14	19.520	134.53	153.75	213.30	379.22	381, 429, 431, 438, 453
Agroeco.	D. flux	3	68.750	69.875	71.000	99.000	127.00	106
Agroeco.	D. rate	12	0.5209	0.8503	1.1250	1.6598	2.6593	273, 380, 381, 416, 453, 454
Desert	GPP	12	20.000	76.598	106.44	138.49	220.00	396, 402, 440, 441, 442, 443, 445, 446
Desert	R	12	33.797	52.865	92.442	133.57	180.00	396, 402, 441, 442, 445, 446, 449, 450
Desert	NEP	15	-30.000	7.7626	32.596	62.483	130.41	151, 280, 391, 395, 396, 402, 441, 442, 444, 445, 446
Desert	Detritus	11	0.0000	0.9022	13.050	125.83	217.35	151, 406, 434, 447, 448, 450
Desert	D. rate	12	0.0250	0.2672	0.5275	0.7105	1.4268	91, 237, 254, 433, 451
Stream	GPP	128	0.0000	13.470	55.240	155.36	1,770.0	12, 15, 18, 28, 89, 90, 93, 94, 96, 97, 110, 111, 138, 159, 203, 207, 209, 210, 214, 218, 234, 235, 239, 261, 264, 266, 267, 268, 270, 275, 388, 389, 401, 455, 456, 465, 467, 547, 548
Stream	2nd Prod.	107	0.1132	2.1238	5.5056	14.175	287.75	13, 22, 93, 117, 215, 238, 239, 240, 241, 242, 243, 244, 245, 246, 265, 266, 368, 387, 388, 458, 459, 460, 472, 476, 477
Stream	R	136	2.0323	76.093	290.41	617.58	2,148.9	12, 15, 28, 89, 93, 96, 110, 111, 138, 159, 203, 207, 208, 210, 214, 218, 234, 235, 245, 261, 264, 266, 267, 268, 270, 275, 401, 455, 456, 464, 465, 467, 546, 547, 548, 549
Stream	NEP	129	-1,795.3	-400.46	-114.10	-20.900	568.95	12, 15, 28, 33, 89, 93, 96, 110, 111, 138, 159, 203, 207, 209, 210, 214, 218, 234, 235, 261, 262, 264, 267, 268, 270, 271, 274, 275, 276, 401, 455, 456, 465, 467, 547, 548
Stream	Detritus	139	0.0941	11.376	56.500	281.67	6,475.9	10, 13, 14, 28, 33, 67, 89, 90, 93, 94, 96, 124, 202, 204, 206, 210, 211, 212, 213, 217, 235, 238, 239, 240, 242, 244, 266, 321, 388, 392, 417, 457, 466, 470, 471, 474, 475, 540, 541, 542, 543, 544, 549
Stream	D. rate	100	0.1508	1.9109	4.0954	9.5022	203.90	8, 136, 137, 143, 144, 191, 192, 193, 196, 197, 198, 199, 200, 201, 216, 219, 230, 269, 353, 354, 355, 357, 359, 360, 361, 362, 363, 366, 389, 392, 468, 469
Lake	GPP	42	0.5270	16.796	53.050	161.67	1,922.0	20, 53, 79, 101, 112, 114, 115, 290, 292, 293, 295, 297, 316, 317, 318, 323, 336, 379, 487, 488, 489, 490, 532, 535, 536
Lake	2nd Prod.	66	0.0200	1.6521	6.1314	19.443	442.00	246, 247, 290, 291, 295, 332, 336, 368, 473, 482
Lake	R	44	10.092	17.653	37.999	85.757	1,100.5	53, 101, 113, 115, 290, 292, 293, 295, 297, 298, 336, 487, 488, 489, 490, 532, 533, 534, 535, 536
Lake	NEP	89	-230.02	-27.512	-12.865	-4.9348	65.922	53, 101, 109, 115, 271, 272, 274, 276, 290, 292, 293, 295, 297, 336, 462, 487, 488, 489, 490, 532, 535, 536
Lake	Detritus	43	0.7500	2.7875	4.7693	33.667	3,840.0	53, 68, 298, 307, 320, 322, 323, 336, 379, 461, 463, 485, 486, 491, 537, 538
Lake	D. flux	1	49.268	49.268	49.268	49.268	49.268	485
Lake	D. rate	54	0.0167	0.2331	0.9424	1.9288	92.646	68, 105, 107, 139, 140, 141, 142, 231, 272, 316, 323, 376, 379, 478, 479, 480, 481, 483, 484, 486, 492, 493
Oc. Pelagic	GPP	66	0.7100	66.025	114.50	242.49	748.13	55, 80, 102, 116, 126, 128, 129, 130, 131, 132, 133, 304, 305, 309, 310, 311, 312, 313, 314, 315, 319, 329, 335, 337, 339, 341, 349, 351, 494, 516
Oc. Pelagic	2nd Prod.	22	2.4360	7.1014	13.277	23.067	122.63	319, 341, 351, 460, 494, 502, 503, 508, 550, 551, 552, 553, 554, 555
Oc. Pelagic	R	24	4.7433	55.635	112.36	217.95	521.28	304, 305, 313, 314, 315, 319, 329, 335, 337, 339, 341, 344, 349, 351, 494, 516
Oc. Pelagic	NEP	71	-69.927	17.507	40.000	86.868	447.00	43, 45, 48, 116, 304, 305, 313, 314, 315, 319, 329, 330, 337, 339, 341, 348, 349, 351, 494, 507, 516
Oc. Pelagic	Detritus	36	0.0180	2.0595	4.5426	12.660	334.49	129, 130, 311, 315, 319, 328, 334, 337, 338, 339, 344, 348, 349, 351, 457, 494, 513, 514, 516
Oc. Pelagic	D. rate	31	0.6492	2.1721	9.8550	44.632	788.40	126, 127, 132, 133, 319, 327, 328, 376, 495, 515
Oc. Benthic	GPP	54	10.000	83.365	240.71	745.20	4,369.1	82, 83, 84, 221, 222, 223, 299, 300, 301, 311, 313, 315, 324, 333, 339, 340, 343, 344, 349, 350, 506
Oc. Benthic	2nd Prod.	42	0.3519	6.7409	11.400	25.715	745.90	311, 331, 350, 494, 501, 502, 503, 504, 506, 507, 508, 510, 511, 512
Oc. Benthic	R	47	2.4717	84.390	253.43	570.15	2,737.5	83, 221, 222, 223, 233, 299, 300, 301, 304, 305, 311, 313, 315, 319, 324, 331, 333, 339, 340, 344, 349, 350
Oc. Benthic	NEP	50	-401.50	-103.70	-4.1724	39.542	2,120.7	83, 116, 220, 221, 222, 223, 299, 300, 301, 311, 313, 315, 324, 331, 333, 339, 340, 344, 348, 349, 350,

420, 507

Oc. Benthic	Detritus	51	0.0250	8.5950	324.01	976.10	3,520.0	300, 302, 303, 311, 319, 325, 326, 339, 347, 348, 350, 498, 501, 502, 503, 504, 505, 507, 508, 509
Oc. Benthic	D. flux	2	15.600	47.700	79.800	111.90	144.00	342, 393
Oc. Benthic	D. rate	38	0.3855	1.2632	3.4537	6.9958	32.589	303, 326, 345, 346, 347, 376, 418, 419, 420, 496, 497, 499

Oc. = Ocean; GPP = Gross Primary Production; R = ecosystem respiration; NEP = Net Ecosystem

Production; D. = Decomposition.

We provide the number of data points (n), the minimum, first quartile (q25), median, third quartile (q75) and maximum values of estimate distributions for each ecosystem x variable combination, as well as the associated references from which we extracted the data, listed in Supplementary Table 1. Values of stocks (Detritus), fluxes (GPP, R, NEP, 2nd Prod, and D. flux) and rates (D. rates) are expressed in gC m⁻², gC m⁻² yr⁻¹ and yr⁻¹, respectively.

Extended Data Table 4 | Factors used for conversions into grams of carbon.

Type of material	KJ	Kcal	molC	gCO ₂	gO ₂	molO ₂	g WW	g DW	g AFDW
Organic Tissue ^a	0.02	0.09	12	0.2727			0.09	0.45	0.5
Productivity, photosynthetic quotient = 1.2 ^b					0.3125	10			
Respiration, respiration quotient = 1 ^{ab}					0.375	12			
Non woody primary producer terrestrial ^c								1/3.33*	
Algae, sea grasses ^c							1/16.7	1/2.92	
Salamanders ^d								0.473	
Arthropods ^e								0.496	

KJ = kilojoule; Kcal = kilocalorie; molC = mole of carbon; gCO₂ = gram of carbon dioxide; gO₂ = gram of di-oxygen; molO₂ = mole of di-oxygen; gWW = gram of wet weight; dDW = gram of dry weight; gAFDW = gram of ash-free dry weight.

^a from Table 1 of Section II: Ecological Energetics, p26; in: Weathers, K. C., Strayer, D. L. & Likens G. E. *Fundamentals of ecosystem Science*, (Academic Press, 2013); and references therein.

^b Irons III, J. G. and Oswood, M. W. Organic matter dynamics in 3 subarctic streams of interior Alaska, USA. *J N Am Benthol Soc* **16**(1), 23–27 (1997); Duarte, C. M., et al. Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. *Global Biogeochem. Cycles* **24**(4), 1–8 (2010); Huchette, S. M. H., Beveridge, M. C. M., Baird, D. J. & Ireland, M. The impacts of grazing by tilapias *Oreochromis niloticus* L. on periphyton communities growing on artificial substrate in cages. *Aquaculture* **186**, 45–60 (2000).

^c from Table 2.5 p26 In: Opitz S. *Trophic Interactions in Caribbean Coral Reefs. Technical Reports* **43**, (International Center for Living Aquatic Resources Management, 1996).

^d Semlitsch, R. D., O'Donnell K. M. & Thompson III, F.R. Abundance, biomass production, nutrient content, and the possible role of terrestrial salamanders in Missouri Ozark forest ecosystems. *Can. J. Zool.* **92**, 997–1004 (2014).

^e Small, G. E., Torres, P. J., Schweizer, L. M., Duff, J. H. & Pringle, C. M. et al. Importance of terrestrial arthropods as subsidies in lowland Neotropical rain forest stream ecosystems. *Biotropica* **45**(1), 80–87 (2013).

* used general conversion factor 0.45 in desert and arid grassland where the vegetation comprise woody species

Extended Data Table 5 | Definition of flow drivers.

Definition		Example cross-ecosystem subsidy
Passive drivers		<i>With reference to studies included in this study</i>
Fall / Wind	Movement of terrestrial particles, detritus, or organisms simply falling or windblown	Tree leaves windblown in lakes ⁵³ ; terrestrial arthropods falling in streams ³ ; mangrove arboricole crabs falling in water and eaten by fish ⁵²⁷
Leaching	Movement of small particles or dissolved molecules through diffusion in aquatic medium	Dissolved or particle organic carbon diffusing ⁴³⁰
Current / Tide	Lateral movement of particles, detritus or organisms triggered by water currents or tides	Wrack grounding on beech ³⁷² ; macroalgal drift ⁴²⁰ ; carcass deposited on beach ¹⁰⁴
Sinking	Vertical movements particles, detritus or organisms triggered by gravity along the water column	“Marine snow” ⁸⁰ , which can comprise phytoplankton sinking ⁹⁹ , zooplankton faecal pellets ³⁰⁸ , salp carcasses ⁴⁹⁵ ; fishery discard ⁵⁰³
Active drivers		
Foraging	Daily movements of organisms to find food which trigger cross-ecosystem movement of resources (only those are considered here)	Deer grazing in agro-ecosystems and defecating in forests ³⁶⁷ ; hippopotamus grazing in savannah and defecating in river ³⁶⁴ ; zooplankton eating in pelagic area and finding refuge in deep sea ³⁸⁴ ; bears bringing salmon carcasses on land ³⁸⁶ .
Migration	Seasonal long-distance movement of populations triggering cross-ecosystem movement of resources	Downing of wildebeest during seasonal migration ⁵⁵⁶ .
Life-cycle	Cross-ecosystem organismal movements required to complete a life-cycle	Emergence of aquatic insects to land ¹ ; salamander egg deposition in or emergence from aquatic systems ⁶⁰ ; anadromous salmon dying after breeding in freshwater systems ³⁸⁹ .

Supplementary Information associated with the article "Worldwide cross-ecosystem carbon subsidies and their contribution to ecosystem functioning" by Isabelle Gounand, Chelsea J. Little, Eric Harvey & Florian Altermatt

Supplementary Table 1: List of references from which the data are extracted; see summary of the data in Extended Data Tables 2 and 3.

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ID	Title	Authors	Year	Journal	Volume	Issue	Page	DOI / URL
1	Ecosystem Linkages Between Lakes and the Surrounding Terrestrial Landscape in Northeast Iceland	Gratton C. et al.	2008	Ecosystems	11	5	764-774	10.1007/s10021-008-9158-8
2	Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs	Allan J. D. et al.	2003	Can. J. of Fish. and Aq. Sci.	60		309-320	10.1139/f03-019
3	Terrestrial prey inputs to streams bordered by deciduous broadleaved forests, conifer plantations and clear-cut sites in southwestern Japan: Effects on the abundance of red-spotted masu salmon	Inoue M. et al.	2013	Ecology of Freshwater Fish	22	3	335-347	10.1111/eff.12029
4	Arthropod 'rain' into tropical streams: The importance of intact riparian forest and influences on fish diets	Chan E. K. W. et al.	2008	Marine and Freshwater Research	59		653-660	10.1071/MF07191
5	Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies	Baxter C. V. et al.	2004	Ecology	85	10	2656-2663	10.1890/04-138
6	Invading rainbow trout usurp a terrestrial prey subsidy from native charr and reduce their growth and abundance	Baxter C. V. et al.	2007	Oecologia	153	2	461-470	10.1007/s00442-007-0743-x
7	The energetic importance of terrestrial arthropod inputs to three warm-water streams	Cloe III, W. W. and Garman G. C.	1996	Freshwater Biology	36	1	105-114	10.1046/j.1365-2427.1996.00080.x
8	Effects of different types of conditioning on rates of leaf-litter shredding by <i>Xiphocaris longata</i> , a Neotropical freshwater shrimp	Crowl T. A. et al.	2006	J. of the North Am. Benth. Soc.	25	1	198-208	10.1899/0887-3593(2006)25[198:EODTOC]2.0.CO;2
9	Annual contribution of terrestrial invertebrates to a New Zealand trout stream	Edwards E. D. and Huryn A. D.	1995	New Zealand Journal of Marine and Freshwater Research	29	4	467-477	10.1080/00288330.1995.9516680
10	Linking stream habitats and spider distribution: spatial variations in trophic transfer across a forest–stream boundary	Iwata T.	2007	Ecological Research	22	4	619-628	10.1007/s11284-006-0060-6
11	Stream meanders increase insectivorous bird abundance in riparian deciduous forests	Iwata T. et al.	2003	Ecography	26		325–337	10.1034/j.1600-0587.2003.03355.x
12	Shifts in allochthonous input and autochthonous production in streams along an agricultural land-use gradient	Hagen E. M. et al.	2010	Hydrobiologia	655	1	61-77	0.1007/s10750-010-0404-7
13	Effects of resource limitation on a detrital-based ecosystem	Wallace J. B. et al.	1999	Ecological Monographs	69	4	409-442	10.1890/0012-9615(1999)069[0409:EORLOA]2.0.CO;2
14	Input and storage of benthic detritus in an Alaskan subarctic stream	Cowan C. A. and Oswood M. W.	1983	Polar Biology	2		35-40	10.1007/BF00258283
15	Organic Matter Dynamics in 5 Subarctic Streams, Quebec, Canada	Naiman R. J. and Link L. G.	1997	J. of the North Am. Benth. Soc.	16	1	33-39	10.2307/1468228
16	Hydrologic and Riparian Influences on the Import and Storage of Coarse Particulate Organic Matter in a Prairie Stream	Gurtz M. E. et al.	1988	Can. J. of Fish. and Aq. Sci.	45	4	655-665	10.1139/f88-079
17	Production de litiere de la ripisylve de la Garonne et apport au fleuve	Chauvet E. and Jean-Louis A.-M.	1988	Acta Oecologica	9	3	265-279	10.1016/j.materresbull.2012.08.034
18	Carbon flow in a tundra stream ecosystem	Peterson B. J. et al.	1986	Can. J. of Fish. and Aq. Sci.	43		1259-1270	10.1139/f86-156
19	Prey use by web-building spiders: stable isotope analyses of trophic flow at a forest-stream ecotone	Kato C. et al.	2004	Ecological Research	19	6	633-643	10.1111/j.1440-1703.2004.00678.x
20	Airborne litterfall as a source of organic matter in lakes	Gasith A. and Hasler A. D.	1976	Limnology and Oceanography	21	2	253-258	10.4319/lo.1976.21.2.0253
21	Effects of Hemlock Mortality on Streams in the Southern Appalachian Mountains	Webster J. R. et al.	2012	The American Midland Naturalist	168	1	112-131	10.1674/0003-0031-168.1.112
22	Secondary Production, Emergence, and Export of Aquatic Insects of a Sonoran Desert Stream	Jackson J. K. and Fisher S. G.	1986	Ecology	67	3	629-638	10.2307/1937686
23	Terrestrial invertebrate inputs determine the local abundance of stream fishes in a forested stream	Kawaguchi Y. et al.	2003	Ecology	84	3	701-708	10.1890/0012-9658(2003)084[0701:TIIDTL]2.0.CO;2
24	Quantifying aquatic insect deposition from lake to land	Dreyer J. et al.	2015	Ecology	96	2	499-509	10.1890/14-0704.1
25	Importance of Terrestrial Arthropods as Subsidies in Lowland Neotropical Rain Forest Stream Ecosystems	Small G. E. et al.	2013	Biotropica	45	1	80-87	10.1111/j.1744-7429.2012.00896.x
26	Organic Matter Dynamics in small streams of the Pacific Northwest	Richardson J. S. et al.	2005	Journal of the American Water Resources Association	41	4	921-934	10.1111/j.1752-1688.2005.tb03777.x
27	Riparian litter inputs to streams in the central Oregon Coast Range	Hart S. K. et al.	2013	Freshwater Science	32	1	343-358	10.1899/12-074.1
28	An invasive riparian tree reduces stream ecosystem efficiency via a recalcitrant organic matter subsidy	Mineau M. M. et al.	2012	Ecology	93	7	1501-1508	10.1890/11-1700.1
29	Regulation leads to increases in riparian vegetation, but not direct allochthonous inputs, along the Colorado River in Grand Canyon, Arizona	Kennedy T. A. and Ralston B. E.	2012	River Research and Applications	28			10.1002/rra.1431
30	Particulate Allochthonous Inputs: Relationships with Stream Size in an Undisturbed Watershed	Connors M. E. & Naiman R. J.	1984	Can. J. of Fish. and Aq. Sci.	41		1473-1484	10.1139/f84-181
31	Litterfall, litter decomposition, and flux of particulate organic material in a coastal plain stream	Post H. A. and De La Cruz A. A.	1977	Hydrobiologia	55		201-207	10.1007/BF00017551
32	Contribution of terrestrial invertebrates to the annual resource budget for salmonids in forest and grassland reaches of a headwater stream	Kawagushi Y. and Nakano S.	2001	Freshwater Biology	46		303-316	10.1046/j.1365-2427.2001.00667.x

33	Energy Flow in Bear Brook, New Hampshire: An Integrative Approach to Stream Ecosystem Metabolism	Fisher S. G. & Likens G. E.	1973	Ecological Monographs	43	4	421-439	10.2307/1942301
34	Temporal variability in insectivorous bat activity along two desert streams with contrasting patterns of prey availability	Hagen M. H. and Sabo J. L.	2014	Journal of Arid Environments	102		104-112	10.1016/j.jaridenv.2013.11.016
35	The importance of winter in annual ecosystem respiration in the High Arctic	Morgner E. et al.	2010	Polar Research	29	1	58-74	10.1111/j.1751-8369.2010.00151.x
36	Boreal forest and Tundra.	Apps M. J. et al	1993	In: Terrestrial Biospheric Carbon Fluxes: Quantification of Sinks and Sources of CO ₂ .			39-54	10.1007/978-94-011-1982-5
37	Studies on the Biomass and Productivity in a Series of Montane Rain Forests in Jamaica	Tanner E. V. J.	1980	Journal of Ecology	68	2	573-588	10.2307/2259423
38	Integrating aquatic and terrestrial components to construct a complete carbon budget for a north temperate lake district	Buffam I. et al.	2011	Global Change Biology	17	2	1193-1211	10.1111/j.1365-2486.2010.02313.x
39	Climatic controls on the carbon and water balances of a boreal aspen forest, 1994–2003	Barr A. G. et al.	2007	Global Change Biology	13	3	561-576	10.1111/j.1365-2486.2006.01220.x
40	Implications of increased deciduous cover on stand structure and aboveground carbon pools of Alaskan boreal forests	Alexander H. et al.	2012	Ecosphere	3	5	Art.45	10.1890/ES11-00364.1
41	Production, Respiration, and Overall Carbon Balance in an Old-growth Pseudotsuga-Tsuga Forest Ecosystem	Harmon M. E. et al.	2004	Ecosystems	7		498-512	10.1007/s10021-004-0140-9
42	Carbon balance of different aged Scots pine forests in Southern Finland	Kolari P. et al.	2004	Global Change Biology	10	7	1106-1119	10.1111/j.1365-2486.2004.00797.x
43	Synthesis of primary production in the Arctic Ocean: III. Nitrate and phosphate based estimates of net community production	Codispoti L. A. et al.	2013	Progress in Oceanography	110		126-150	10.1016/j.pocean.2012.11.006
44	Temporal variability in plant and soil nitrogen pools in a high-Arctic ecosystem	Bardgett R. D. et al.	2007	Soil Biology and Biochemistry	39	8	2129-2137	10.1016/j.soilbio.2007.03.016
45	Annual net community production and the biological carbon flux in the ocean	Emerson S.	2014	Global Biogeochemical Cycles	28		14-28	10.1002/2013GB004680
46	Primary Production in Arctic Cottongrass Tussock Tundra Communities	Wein R. W. and Bliss L. C.	1974	Arctic and Alpine Research	6	3	261-274	10.2307/1550062
47	CO ₂ exchange in three Canadian High Arctic ecosystems: Response to long-term experimental warming	Welker J. M. et al.	2004	Global Change Biology	10	12	1981-1995	10.1111/j.1365-2486.2004.00857.x
48	Global net community production estimated from the annual cycle of surface water total dissolved inorganic carbon	Lee K.	2001	Limnology and Oceanography	46	6	1287-1297	10.4319/lo.2001.46.6.1287
49	Influence of temperature and drought on seasonal and interannual variations of soil, bole and ecosystem respiration in a boreal aspen stand	Gaumont-Guay D. et al.	2006	Agricultural and Forest Meteorology	140		203-219	10.1016/j.agrformet.2006.08.002
50	Blowing litter across a landscape: effects on ecosystem nutrient flux and implications for landscape management	Shen W. et al.	2011	Landscape Ecology	26	5	629-644	10.1007/s10980-011-9599-x
51	Impacts of Grazing and Climate Warming on C Pools and Decomposition Rates in Arctic Environments	Sjögersten S. et al.	2012	Ecosystems	15	3	349-362	10.1007/s10021-011-9514-y
52	Primary production and carbon allocation in relation to nutrient supply in a tropical experimental forest	Giardina C. P. et al.	2003	Global Change Biology	9		1438-1450	10.1046/j.1365-2486.2003.00558.x
53	A Carbon Budget of a Small Humic Lake: An Example of the Importance of Lakes for Organic Matter Cycling in Boreal Catchments	Sobek S. et al.	2006	AMBIO: A Journal of the Human Environment	35	8	469-475	10.1579/0044-7447(2006)35[469:ACBOAS]2.0.CO;2
54	Carbon balance of a tropical savanna of northern Australia	Chen X. et al.	2003	Oecologia	137	3	405-416	10.1007/s00442-003-1358-5
55	Phytoplankton phenology and production around Iceland and Faroes	Zhai L. et al.	2012	Continental Shelf Research	37		15-25	10.1016/j.csr.2012.01.013
56	Redistributed lacustrine detritus as a spatial subsidy of biological resources for soils in an Antarctic dry valley	Hopkins D. W. et al.	2008	Geoderma	144	1-2	86-92	10.1016/j.geoderma.2007.10.016
57	Hydrologic Influences on Insect Emergence Production from Central Platte River Wetlands	Whiles M. R. and Goldowitz B. S.	2001	Ecological Applications	11	6	1829-1842	10.1890/1051-0761(2001)011[1829:HIOIEP]2.0.CO;2
58	Variation in the trophic basis of production and energy flow associated with emergence of larval salamander assemblages from forest ponds	Regehr K. J. et al.	2008	Freshwater Biology	53	9	1754-1767	10.1111/j.1365-2427.2008.02073.x
59	Remarkable Amphibian Biomass and Abundance in an Isolated Wetland: Implications for Wetland Conservation	Gibbons J. W. et al.	2006	Conservation Biology	20	5	1457-1465	10.1111/j.1523-1739.2006.00443.x
60	Linking the evolution of habitat choice to ecosystem functioning: direct and indirect effects of pond-reproducing fire salamanders on aquatic-terrestrial subsidies.	Reinhardt T. et al.	2013	Oecologia	173	1	281-291	10.1007/s00442-013-2592-0
61	Decomposition Rates of Salamander (Ambystoma Maculatum) Life Stages and Associated Energy and Nutrient Fluxes in Ponds and Adjacent Forest in Southern Illinois	Regehr K. J. and Whiles M. R.	2006	Copeia	2006	4	640-649	10.1643/0045-8511(2006)6[640:DROSAM]2.0.CO;
62	Emergence of Aquatic Insects from 2 Habitats in a Small Wetland of the Southeastern USA: Temporal Patterns of Numbers and Biomass	Stagliano D. M. et al.	1998	J. of the North Am. Benth. Soc.	17	1	37-53	10.2307/1468050
63	Rates of Forest Floor and Nutrient Turnover in Aspen , Pine , and Spruce Stands on Two Different Soils	Perala D. A. and Alban D. H.	1982	Res. Pap. NC-227. St Paul, MN: U.S. Dep. of Agriculture, Forest Service, North Central Forest Experiment Station. 5 p.				
64	A Comparative Analysis of Potential Nitrification and Nitrate Mobility in Forest Ecosystems	Vitousek P. M. et al.	1982	Ecological Monographs	52	2	155-157	10.2307/1942609
65	Emergence production and export of aquatic insects from a tallgrass prairie stream	Gray L. J.	1989	The Southwestern Naturalist	34	3	313-318	10.2307/3672158
66	Life history and production of a semi-terrestrial limnephilid caddisfly in an intermittent Platte River wetland	Whiles M. R. et al.	1999	J. of the North Am. Benth. Soc.	18	4	533-544	10.2307/1468385
67	Longitudinal patterns of ecosystem processes and community structure in a subarctic river continuum	Naiman R. J. et al.	1987	Ecology	68	5	1139-1156	10.2307/1939199

68	Major findings (book section)	Hobbie J. E. et al.	1980	In: Limnology of tundra ponds, Barrow, Alaska				1-19
69	Benthic secondary production and biomass of insects emerging from a northern German temperate stream	Poepperl R.	2000	Freshwater Biology	44	2	199-211	10.1046/j.1365-2427.2000.00558.x
70	Soil carbon dioxide fluxes in northern semiarid grasslands	Frank A. B. et al.	2002	Soil Biology and Biochemistry	34	9	1235-1241	10.1016/S0038-0717(02)00062-7
71	Responses of Soil Respiration to Clipping and Grazing in a Tallgrass Prairie	Bremer D. J. et al.	1998	Journal of Environmental Quality	27	6	1539-1548	10.2134/jeq1998.00472425002700060034x
72	Soil CO ₂ flux in a tallgrass prairie	Mielnick P. C. and Dugas W. A.	2000	Soil Biology and Biochemistry	32	2	221-228	10.1016/S0038-0717(99)00150-9
73	A 70-year retrospective analysis of carbon fluxes in the Canadian Forest Sector	Kurz W. A. and Apps M. J.	1999	Ecological Applications	9	2	526-547	10.1890/1051-0761(1999)009[0526:AYRAOC]2.0.CO;2
74	Dynamics of aquatic insect flux affects distribution of riparian web-building spiders	Kato C. et al.	2003	Oikos	103	Marc h	113-120	10.1034/j.1600-0706.2003.12477.x
75	Productivity and carbon fluxes of tropical savannas	Grace J. et al.	2006	Journal of Biogeography	33		387-400	10.1111/j.1365-2699.2005.01448.x
76	Tillage-induced soil carbon dioxide loss from different cropping systems	Reicosky D. C. et al.	1997	Soil and Tillage Research	41	1-2	105-118	10.1016/S0167-1987(96)01080-X
77	Aquatic prey subsidies to riparian spiders in a stream with different land use types	Krell B. et al.	2015	Limnologia	51		1-7	10.1016/j.limno.2014.10.001
78	Land-use effects on terrestrial consumers through changed size structure of aquatic insects	Stenroth K. et al.	2015	Freshwater Biology	60	1	136-149	10.1111/fwb.12476
79	Whole-lake estimates of carbon flux through algae and bacteria in benthic and pelagic habitats of clear-water lakes	Ask J. et al.	2009	Ecology	90	7	1923-1932	10.1890/07-1855.1
80	Revisiting Carbon Flux Through the Ocean ' s Twilight Zone	Buesseler K. O. et al.	2007	Science	316	April	567-570	10.1126/science.1137959
81	Permafrost degradation stimulates carbon loss from experimentally warmed tundra	Natali S. M. et al.	2014	Ecology	95	3	602-608	10.1890/13-0602.1
82	Patterns of primary production and nutrient availability in a Bahamas lagoon with fringing mangroves	Koch M. S. and Madden C. J.	2001	Marine Ecology Progress Series	219		109-119	10.3354/meps219109
83	Mass balance constraints on nutrient cycling in tropical seagrass beds	Erftemeijer P. L. A. and Middelburg J. J.	1995	Aquatic Botany	50		21-36	10.1016/0304-3770(94)00440-W
84	Production and consumption of tropical seagrass fields in Eastern Indonesia measured with bell jars and microelectrodes	Lindeboom H. J. and Sandee A. J. J.	1989	Netherlands Journal of Sea Research	23	2	181-190	10.1016/0077-7579(89)90012-4
85	Biogeochemical pools and fluxes of carbon and nitrogen in a maritime tundra near penguin colonies along the Antarctic Peninsula	Park J.-H. et al.	2007	Polar Biology	30	2	199-207	DOI 10.1007/s00300-006-0173-y
86	Seasonal patterns of carbon dioxide and water fluxes in three representative tundra ecosystems in northern Alaska	Euskirchen E. S. et al.	2012	Ecosphere	3	1	Art.4	10.1890/ES11-00202.1
87	Longer growing seasons do not increase net carbon uptake in the northeastern Siberian tundra	Parmentier F. J. W. et al.	2011	Journal of Geophysical Research: Biogeosciences	116	4	G04013	10.1029/2011JG001653
88	Trends in CO ₂ exchange in a high Arctic tundra heath, 2000–2010	Lund M. et al.	2012	Journal of Geophysical Research: Biogeosciences	117		G02001	10.1029/2011JG001901
89	Organic matter dynamics in the Kuparuk River, a tundra river in Alaska, USA	Harvey C. J. et al.	1997	J. of the North Am. Benth. Soc.	16	1	18-23	10.2307/1468225
90	Organic matter dynamics in 3 subarctic streams of interior Alaska, USA	Irons III J. G. and Oswood M. W.	1997	J. of the North Am. Benth. Soc.	16	1	23-27	10.2307/1468226
91	Net primary and ecosystem production and carbon stocks of terrestrial ecosystems and their responses to climate change	Cao M. and Woodward I. F.	1998	Global Change Biology	4	2	185–198	10.1046/j.1365-2486.1998.00125.x
92	The growing season greenhouse gas balance of a continental tundra site in the Indigirka lowlands, NE Siberia	Van der Molen M. K. et al.	2007	Biogeosciences	4	6	985-1003	10.5194/bg-4-985-2007
93	Organic Matter Processing by a Stream-Segment Ecosystem: Fort River, Massachusetts, U.S.A.	Fisher S. G.	1977	Internationale Revue der gesamten Hydrobiologie und Hydrographie	62	6	701-727	10.1002/iroh.1977.3510620601
94	Organic Matter Dynamics in Sycamore Creek, a Desert Stream in Arizona, USA	Jones J. B. et al.	1997	J. of the North Am. Benth. Soc.	16	1	78-82	10.2307/1468238
95	Belowground biomass, production, and carbon cycling in mature Norway spruce, Maine, U.S.A.	Cronan C. S.	2003	Canadian Journal of Forest Research	33	2	339-350	10.1139/X02-189
96	Organic Matter Dynamics in the West Fork of Walker Branch, Tennessee, USA	Mulholland P. J.	1997	J. of the North Am. Benth. Soc.	16	1	61-67	10.2307/1468235
97	Canada Stream: a glacial meltwater stream in Taylor Valley, South Victoria Land, Antarctica	McKnight D. M. and Tate C. M.	1997	J. of the North Am. Benth. Soc.	16	1	14-17	10.2307/1468224
98	The input of terrestrial invertebrates from tree canopies to a stream	Mason C. F. and MacDonald S. M.	1982	Freshwater Biology	12	4	305-311	10.1111/j.1365-2427.1982.tb00624.x
99	An algal carbon budget for pelagic-benthic coupling in Lake Michigan	Fitzgerald S. A. and Gardner W. S.	1993	Limnology and Oceanography	38	3	547-560	10.4319/lo.1993.38.3.0547
100	Carbon balance in East European tundra	Heikkinen J. E. P. et al.	2004	Global Biogeochemical Cycles	18	1	GB1023	10.1029/2003GB002054
101	Benthic Photosynthesis and Respiration in Char Lake	Welch H. E. and Kalff J.	1974	Journal of the Fisheries Research Board of Canada	31	5	609-620	10.1139/f74-093
102	Annual primary production and export flux in the Southern Ocean from sediment trap data	Wefer G. and Fischer G.	1991	Marine Chemistry	35	1-4	597-613	10.1016/S0304-4203(09)90045-7
103	Extraordinarily high spider densities on islands: flow of energy from the marine to terrestrial food webs and the absence of predation	Polis G. A. and Hurd S. D.	1995	Proceedings of the National Academy of Sciences	92	10	4382-4386	10.1073/pnas.92.10.4382

104	Linking Marine and Terrestrial Food Webs: Allochthonous Input from the Ocean Supports High Secondary Productivity on Small Islands and Coastal Land Communities	Polis G. A. and Hurd S. D.	1996	The American Naturalist	147	3	396-423	http://www.jstor.org/stable/2463215
105	Regeneration of Nutrient and Detritus Formation from Aerobic Decomposition of Natural Phytoplankton	Aizaki M. and Takamura N.	1991	Japanese Journal of Limnology	52	2	83-94	10.3739/rikusui.52.83
106	Organic carbon and nitrogen flows	Andr��n O. et al.	1990	Ecological bulletins	40	May	85-126	http://www.jstor.org/stable/20113040
107	Differentiating the degradation dynamics of algal and terrestrial carbon within complex natural dissolved organic carbon in temperate lakes	Guillemette F. et al.	2013	Journal of Geophysical Research: Biogeosciences	118		963-973	10.1002/jgrg.20077
108	Ecosystem respiration in two Mediterranean evergreen Holm Oak forests: drought effects and decomposition dynamics	Reichstein M. et al.	2002	Functional ecology	16		27-39	10.1046/j.0269-8463.2001.00597.x
109	Drivers of metabolism and net heterotrophy in contrasting lakes	Staeher P. A. et al.	2010	Limnology and Oceanography	55	2	817-830	10.4319/lo.2010.55.2.0817
110	Multiple Scales of Temporal Variability in Ecosystem Metabolism Rates: Results from 2 Years of Continuous Monitoring in a Forested Headwater Stream	Roberts B. J. et al.	2007	Ecosystems	10	4	588-606	10.1007/s10021-007-9059-2
111	Annual cycle and inter-annual variability of gross primary production and ecosystem respiration in a floodprone river during a 15-year period	Uehlinger U.	2006	Freshwater Biology	51	5	938-950	10.1111/j.1365-2427.2006.01551.x
112	Nutrient Supply and Primary Production in Clear Lake, Eastern Ontario	Schindler D. W. and Nighswander J. E.	1970	Journal of the Fisheries Research Board of Canada	27	11	2009-2036	10.1139/f70-226
113	Metabolic rates of Arctic lakes	Welch H. E.	1974	Limnology and Oceanography	19	1	65-73	10.4319/lo.1974.19.1.0065
114	Epipellic and pelagic primary production in Alaskan Arctic lakes of varying depth	Whalen S. C. et al.	2008	Hydrobiologia	614	1	243-257	0.1007/s10750-008-9510-1
115	The Ecosystem of Thingvallavatn: A Synthesis	Jonasson P. M.	1992	Oikos	64	1-2	405-434	10.2307/3545062
116	Intra-regional comparison of productivity, carbon flux and ecosystem composition within the northern Barents Sea	Reigstad M. et al.	2011	Progress in Oceanography	90	1-4	33-46	10.1016/j.pocean.2011.02.005
117	Relative importance of carbon sources for macroinvertebrates in a Rocky Mountain stream	McCutchan J. H. Jr. and Lewis W. M. Jr.	2002	Limnology and Oceanography	47	3	742-752	10.4319/lo.2002.47.3.0742
118	Particulate organic matter inputs to a glacial stream ecosystem in the Swiss Alps	Zah R. and Uehlinger U.	2001	Freshwater Biology	46	12	1597-1608	10.1046/j.1365-2427.2001.00847.x
119	Structure and Function of Tundra Ecosystems: Devon Island, Canada	Bliss L.C.	1975	Ecological Bulletin	20		17-60	
120	Structure and Function of Tundra Ecosystems:Barrow, Alaska, USA	Bunnell FL et al.	1975	Ecological Bulletin	20		73-124	
121	Structure and Function of Tundra Ecosystems:Agapa, USSR	Vassiljevskaya V. D. et al.	1975	Ecological Bulletin	20		141-158	
122	Structure and Function of Tundra Ecosystems: Kevo, Finland	Kallio P.	1975	Ecological Bulletin	20		193-224	
123	Litter inputs to a tropical Australian rainforest stream	Benson L. J. and Pearson R. G.	1993	Australian Journal of Ecology	18	4	377-383	10.1111/j.1442-9993.1993.tb00465.x
124	Allochthonous litter inputs, organic matter standing stocks, and organic seston dynamics in upland Panamanian streams: potential effects of larval amphibians on organic matter dynamics	Colon-Gaud C. et al.	2008	Hydrobiologia	603	1	301-312	10.1007/s10750-008-9294-3
125	Plant litter decomposition in a semi-arid ecosystem controlled by photodegradation.	Austin A. T. and Vivanco L.	2006	Nature	442	7102	555-558	10.1038/nature05038
126	Biomass and production of heterotrophic bacterioplankton in the oceanic subarctic Pacific	Kirchman D. L. et al.	1993	Deep Sea Research Part I: Oceanographic Research Papers	40	5	967-988	10.1016/0967-0637(93)90084-G
127	Major role of bacteria in biogeochemical fluxes in the ocean's interior	Cho B.C. and Azam F.	1988	Nature	332	6163	441-443	10.1038/332441a2
128	Primary production in the North Pacific Central Gyre: some new measurements based on 14C	Marra J. and Heinemann K. R.	1987	Deep Sea Research Part A. Oceanographic Research Papers	34	11	1821-1829	10.1016/0198-0149(87)90056-2
129	Role of plankton in the carbon and nitrogen budgets of Santa Monica Basin, California	Small L. F. et al.	1989	Marine ecology Progress series	56		57-74	10.3354/meps056057
130	Organic carbon partitioning during spring phytoplankton blooms in the Ross Sea polynya and the Sargasso Sea	Carlson C. A. et al.	1998	Limnology and Oceanography	43	3	375-386	10.4319/lo.1998.43.3.0375
131	Overview of the US JGOFS Bermuda Atlantic Time-series Study (BATS): A decade-scale look at ocean biology and biogeochemistry	Steinberg D. K. et al.	2001	Deep-Sea Research Part II: Topical Studies in Oceanography	48	8-9	1405-1447	10.1016/S0967-0645(00)00148-X
132	Minireview: The bacterial content of the oceanic euphotic zone	Ducklow H. W.	1999	FEMS Microbiology-Ecology	30	1	1-10	10.1111/j.1574-6941.1999.tb00630.x
133	Benthic-pelagic coupling in the Greenland-Norwegian Sea and its effect on the geological record	Graf G. et al.	1995	Geologische Rundschau	84	1	49-58	10.1007/BF00192241
134	Pelagic-benthic coupling: Profundal benthic community response to spring diatom deposition in mesotrophic Lake Erken	Goedkoop W. and Johnson R. K.	1996	Limnology and Oceanography	41	4	636-647	10.4319/lo.1996.41.4.0636
135	Decomposition of ponderosa pine needles in a Mediterranean-type climate	Hart S. C. et al.	1992	Canadian Journal of Forest Research	22	3	306-314	10.1139/x92-040
136	Stable successional patterns of aquatic hyphomycetes on leaves decaying in a summer cool stream	Gessner M. O. et al	1993	Mycological Research	97	2	163-172	10.1016/S0953-7562(09)80238-4
137	The role of leaf litter macroinvertebrates in stream-floodplain dynamics	Merrit R. W. and Lawson D. L.	1992	Hydrobiologia	248	1	65-77	10.1007/BF00008886
138	Organic carbon flow in a swamp-stream ecosystem	Mulholland P. J.	1981	Ecological Monographs	51	3	307-322	10.2307/2937276
139	Sources, degradation and recycling of organic matter associated with sinking particles in Lake Michigan	Meyers P. A. and Eadie B. J.	1993	Organic Geochemistry	20	1	47-56	10.1016/0146-6380(93)90080-U
140	Decomposition of Blue-Green Algal (Cyanobacterial) Blooms in Lake Mendota, Wisconsin	Fallon & Brock	1979	Applied and Environmental Microbiology	37	5	820-830	
141	The breakdown and decomposition of allochthonous and autochthonous plant litter in an oligotrophic lake (Llyn Frongoch)	Hanlon R. D. G.	1982	Hydrobiologia	88		281-288	10.1007/BF00008508
142	Decomposition of dominant submerged macrophytes: implications for nutrient release in Myall Lake, NSW, Australia	Shilla D. et al.	2006	Wetlands Ecology and Management	14	5	427-433	10.1007/s11273-006-6294-9

143	The influence of elevated nitrate concentration on rate of leaf decomposition in a stream	Meyer J. L. and Johnson C.	1983	Freshwater Biology	13	2	177-183	10.1111/j.1365-2427.1983.tb00669.x
144	Decomposition rate of plant material in the Parana Medio River (Argentina)	Hammerly J. et al.	1989	Hydrobiologia	183		179-184	10.1007/BF00007238
145	Contribution of semi-arid forests to the climate system	Rotenberg E. and Yatir D.	2010	Science	327	5964	451-454	10.1126/science.1179998
146	CO2 balance of boreal, temperate, and tropical forests derived from a global database	Luyssaert S. et al.	2007	Global Change Biology	13		2509–2537	10.1111/j.1365-2486.2007.01439.x
147	Reciprocal fluxes of stream and riparian invertebrates in a coastal California basin with Mediterranean climate	Rundio D. E. and Lindley S. T.	2012	Ecological research	27	3	539-550	10.1007/s11284-011-0920-6
148	Carbon stocks in a tropical dry forest in Brazil	Pereira Junior L. R. et al.	2016	Revista Ciência Agronômica	47	1	32-40	10.5935/1806-6690.20160004
149	Carbon Sequestration and Nutrient Reserves Under Different Land Use Systems	Aguiar M. I. et al.	2014	Revista Árvore	38	1	81-93	10.1590/S0100-67622014000100008
150	Effects of non-native Asian earthworm invasion on temperate forest and prairie soils in the Midwestern US	Qiu J. and Turner M. G.	2016	Biological Invasions	19	1	73-88	10.1007/s10530-016-1264-5
151	Differential responses of production and respiration to temperature and moisture drive the carbon balance across a climatic gradient in New Mexico	Anderson-Teixeira K. et al.	2011	Global Change Biology	17	1	410-424	10.1111/j.1365-2486.2010.02269.x
152	Sequestration of C in Spanish deciduous oak forests	Gallardo Lancho J. F. and Gonzalez Hernandez M. I.	2004	Catena / Advances in Geoecology	37		341-351	
153	Carbon storage and emissions offset potential in an African dry forest, the Arabuko-Sokoke Forest, Kenya	Glenday J.	2008	Environmental Monitoring and Assessment	142		85-95	10.1007/s10661-007-9910-0
154	Drying and wetting of Mediterranean soils stimulates decomposition and carbon dioxide emission: the "Birch effect".	Jarvis P. et al.	2007	Tree Physiology	27	7	929-940	10.1093/treephys/27.7.929
155	Components, drivers and temporal dynamics of ecosystem respiration in a Mediterranean pine forest	Matteucci M. et al.	2015	Soil Biology and Biochemistry	88		224-235	10.1016/j.soilbio.2015.05.017
156	Carbon budget of tropical forests in Southeast Asia and the effects of deforestation : an approach using a process-based model and field measurements	Adachi M. et al.	2011	Biogeosciences	8		2635-2647	10.5194/bg-8-2635-2011
157	Plant Ecology & Diversity The productivity , allocation and cycling of carbon in forests at the dry margin of the Amazon forest in Bolivia	Araujo-Murakami A. et al.	2014	Plant Ecology and Diversity	7	1-2	55-69	10.1080/17550874.2013.798364
158	Seasonal and annual variation of carbon exchange in an evergreen Mediterranean forest in southern France	Allard V. et al.	2008	Global Change Biology	14	4	714-725	10.1111/j.1365-2486.2008.01539.x
159	Inter-regional comparison of land-use effects on stream metabolism	Bernot M. J. et al.	2010	Freshwater Biology	55	9	1874-1890	10.1111/j.1365-2427.2010.02422.x
160	The seasonal cycle of productivity, metabolism and carbon dynamics in a wet aseasonal forest in north-west Amazonia (Iquitos, Peru)	Aguila-Pasquel del J. et al.	2014	Plant Ecology and Diversity	7	1-2	71-83	10.1080/17550874.2013.798365
161	Carbon allocation in a Bornean tropical rainforest without dry seasons	Katayama A. et al.	2013	Journal of plant research	126	4	505-515	10.1007/s10265-012-0544-0
162	Response of net ecosystem productivity of three boreal forest stands to drought	Kljun N. et al.	2007	Ecosystems	10	6	1039-1055	10.1007/s10021-007-9088-x
163	The productivity, metabolism and carbon cycle of two lowland tropical forest plots in south-western Amazonia, Peru	Malhi Y. et al.	2014	Plant Ecology and Diversity	7	1-2	85-105	10.1080/17550874.2013.820805
164	Carbon stocks and dynamics at different successional stages in an Afromontane tropical forest	Nyirambangutse B. et al.	2016	Biogeosciences Discussions	14		1285–1303	10.5194/bg-14-1285-2017
165	Biometric and Micrometeorological Measurements of Tropical Forest Carbon Balance	Miller S. D. et al.	2014	Ecological Applications	14	4	S114-S126	10.1890/02-6005
166	Land-atmosphere carbon and water flux relationships to vapor pressure deficit, soil moisture, and stream flow	Mitchell S. R. et al.	2015	Agricultural and Forest Meteorology	208		108-117	10.1016/j.agrformet.2015.04.003
167	Spatial – temporal variability of terrestrial vegetation productivity in the Yangtze River Basin during	Zhang Y. et al.	2014	Journal of plant ecology	7	1	10-23	10.1093/jpe/rtt025
168	Scaling net ecosystem production and net biome production over a heterogeneous region in the western United States	Turner D. P. et al.	2007	Biogeosciences	4	2	1093-1135	10.5194/bgd-4-1093-2007
169	Modelling the climatic drivers determining photosynthesis and carbon allocation in evergreen Mediterranean forests using multiproxy long time series	Gea-Izquierdo G. et al.	2015	Biogeosciences	12		3695-3712	10.5194/bg-12-3695-2015
170	Landscape and Urban Planning Environmental control over seasonal variation in carbon fluxes of an urban temperate forest ecosystem	Xie J. et al.	2015	Landscape and Urban Planning	142		63-70	10.1016/j.landurbplan.2015.04.011
171	Seasonal and inter-annual variations in net ecosystem exchange of two old-growth forests in southern China	Yan J. et al.	2013	Agricultural and Forest Meteorology	182-183		257-265	10.1016/j.agrformet.2013.03.002
172	Upscaling carbon fluxes over the Great Plains grasslands : Sinks and sources	Zhang L. et al.	2011	Journal of Geophysical Research: Biogeosciences	116	1	G00J03	10.1029/2010JG001504
173	Airborne scanning LiDAR in a double sampling forest carbon inventory	Stephens P. R. et al.	2012	Remote Sensing of Environment	117		348-357	10.1016/j.rse.2011.10.009
174	Seasonal changes in photosynthesis, respiration and NEE of a mixed temperate forest	Carrara A. et al.	2004	Agricultural and Forest Meteorology	126	1-2	15-31	10.1016/j.agrformet.2004.05.002
175	Primary productivity of natural grass ecosystems of the tropics: A reappraisal	Long S. P. et al.	1989	Plant and Soil	115	2	155-166	10.1007/BF02202584
176	A Meta-analysis of Climatic and Chemical Controls on Leaf Litter Decay Rates in Tropical Forests	Waring B. G.	2012	Ecosystems	15	6	999-1009	10.1007/s10021-012-9561-z
177	Carbon dioxide exchange in a tropical wet grassland	Meirelles M. L. et al.	2015	Wetlands Ecology and Management	23	5	817-826	10.1007/s11273-015-9421-7
178	The utility of the eddy covariance techniques as a tool in carbon accounting: tropical savanna as a case study	Hutley L. B. et al.	2005	Australian Journal of Botany	53	7	663-675	10.1071/bt04147
179	Decomposition and nutrient release patterns of mistletoe litters in a semi-arid savanna, southwest Zimbabwe	Ndagurwa H. G. T. et al.	2015	Austral Ecology	40	2	178-185	10.1111/aec.12191

180	Litterfall and nutrient return in a semi-arid southern African savanna woodland dominated by <i>Colophospermum mopane</i>	Mlambo D. and Nyathi P.	2008	Plant Ecology	196	1	101-110	10.1007/s11258-007-9337-2
181	Inhibition of nitrification alters carbon turnover in the Patagonian steppe	Austin A. T. et al.	2006	Ecosystems	9	8	1257-1265	10.1007/s10021-005-0039-0
182	Soil carbon pools and fluxes after land conversion in a semiarid shrub-steppe ecosystem	Cochran R. L. et al.	2007	Biology and Fertility of Soils	43	4	479-489	10.1007/s00374-006-0126-1
183	Plant functional diversity and carbon storage - an empirical test in semi-arid forest ecosystems	Conti G. and Diaz S.	2013	Journal of Ecology	101	1	18-28	10.1111/1365-2745.12012
184	Decomposition and nutrient dynamics of <i>Quercus pubescens</i> leaf litter in a naturally enriched CO2 Mediterranean ecosystem	Cotrufo M. F. et al.	1999	Functional Ecology	13	3	343-351	10.1046/j.1365-2435.1999.00328.x
185	The Role of Termites in the Decomposition of Wood and Leaf Litter in the Southern Guinea Savanna of Nigeria	Collins N. M.	1981	Oecologia	51	3	389-399	10.1007/BF00540911
186	Decomposition of grasses and forbs in coastal savanna of southern Somalia	Thurrow L. T.	1989	African Journal of Ecology	27	3	201-206	10.1111/j.1365-2028.1989.tb01013.x
187	Litter production and decomposition patterns in seral grasslands at Cherrapunji in north-eastern India	Ram S. C. and Ramakrishnan P. S.	1988	Pedobiologia	32	1-2	65-76	
188	Environmental controls on the spatial variability of savanna productivity in the Northern Territory, Australia	Kanniah K. D. et al.	2011	Agriculture and Forest Meteorology	151	11	1429-1439	10.1016/j.agrformet.2011.06.009
189	Dynamics in carbon exchange fluxes for a grazed semi-arid savanna ecosystem in West Africa	Tagesson T. et al.	2015	Agriculture, Ecosystems and Environment	205		15-24	10.1016/j.agee.2015.02.017
190	Phenology and gross primary production of two dominant savanna woodland ecosystems in Southern Africa	Jin C. et al.	2013	Remote Sensing of Environment	135	Marc h	189-201	10.1016/j.rse.2013.03.033
191	Nutrient addition does not enhance leaf decomposition in a Southeastern Brazilian stream (Espinhaço mountain range)	Abelho M. et al.	2010	Brazilian Journal of Biology	70	3	747-754	10.1590/S1519-69842010000400007
192	Does leaf quality mediate the stimulation of leaf breakdown by phosphorus in Neotropical streams?	Ardon M. et al.	2010	Freshwater Biology	51	4	618-633	10.1111/j.1365-2427.2006.01515.x
193	The Effect of Macroinvertebrate Exclusion on Leaf Breakdown Rates in a Tropical Headwater Stream	Wright and Covich	2005	Biotropica	37	3	403-408	10.1111/j.1744-7429.2005.00053.x
194	Soil-Litter Mixing Accelerates Decomposition in a Chihuahuan Desert Grassland	Hewins D. B. et al.	2013	Ecosystems	16	2	183-195	10.1007/s10021-012-9604-5
195	Decomposition of dominant plant species litter in a semi-arid grassland	Koukoura Z. et al.	2003	Applied Soil Ecology	23	1	13-23	10.1016/S0929-1393(03)00006-4
196	Leaf breakdown in a natural open tropical stream	Alvim A. et al.	2015	Journal of Limnology	74	2	248-260	10.4081/jlimnol.2014.982
197	Litter decomposition in a temperate and a tropical stream: the effects of species mixing, litter quality and shredders	Bruder A. et al.	2014	Freshwater Biology	59	3	438-449	10.1111/fwb.12276
198	Breakdown of leaf litter in a neotropical stream	Mathuriau C. and Chauvet E.	2002	J. of the North Am. Benth. Soc.	21	3	384-396	10.2307/1468477
199	Macroinvertebrates and the Processing of Leaf Litter in a Tropical Stream	Benstead J. P.	1996	Biotropica	28	3	367-375	10.2307/2389200
200	Leaf-litter breakdown in 3 streams in temperate, Mediterranean, and tropical Cerrado climates	Goncalves J. F. et al.	2006	J. of the North Am. Benth. Soc.	25	2	344-355	http://dx.doi.org/10.1899/0887-3593(2006)25[344:LBISIT]2.0.CO_2
201	Evaluation of macrofaunal effects on leaf litter breakdown rates in aquatic and terrestrial habitats	Ribas A. D. de A. et al.	2006	Austral Ecology	31	6	783-790	10.1111/j.1442-9993.2006.01640.x
202	Relationships of Stream Invertebrate Communities To Deforestation in Eastern Madagascar	Benstead J. P. et al.	2003	Ecological Applications	13	5	1473-1490	10.1890/02-5125
203	Modeling C and N flows through a stream food web: an inverse approach	Larned S. T. et al.	2008	J. of the North Am. Benth. Soc.	27	3	674-689	10.1899/07-134.1
204	Seasonal dynamics of benthic detritus and associated macroinvertebrate communities in a neotropical stream	Mathuriau C. et al.	2008	Fundamental and Applied Limnology Archiv für Hydrobiologie	171	4	323-333	10.1127/1863-9135/2008/0171-0323
205	Organic Matter Processing in Tropical Streams	Wantzen K. M. et al.	2008	In: Tropical Stream Ecology (book)			43-64	doi:10.1016/B978-012088449-0.50005-4
206	Impacts of Benthic Coarse Particulate Organic Matter variations on Macroinvertebrate Density and Diversity in the Njoro River, A Kenyan Highland Stream	Mbaka J. G. et al.	2014	Journal of East African Natural History	103	1	39-48	10.2982/028.103.0101
207	Ecosystem measures of river health and their response to riparian and catchment degradation	Bunn S. E. et al.	1999	Freshwater Biology	41	2	333-345	10.1046/j.1365-2427.1999.00434.x
208	Metabolism of a tropical rainforest stream	Ortiz-Zayas J. R. et al.	2005	J. of the North Am. Benth. Soc.	24	4	769-783	10.1899/03-094.1
209	Seasonally variable riverine production in the Venezuelan llanos	Cotner J. B. et al.	2006	J. of the North Am. Benth. Soc.	25	1	171-184	10.1899/0887-3593(2006)25[171:SVRPIT]2.0.CO_2
210	Seasonal changes in light availability modify the temperature dependence of ecosystem metabolism in an arctic stream	Hurn A. D. et al.	2014	Ecology	95	10	2826-2839	10.1890/13-1963.1
211	Inter-biome comparison of factors controlling stream metabolism	Mulholland P. J. et al.	2001	Freshwater Biology	46		1503-1517	10.1046/j.1365-2427.2001.00773.x
212	Composition and dynamics of allochthonous organic matter inputs and benthic stock in a Brazilian stream	França J. S. et al.	2009	Marine and Freshwater Research	60	10	990-998	10.1071/MF08247
213	Detritivores in Kenyan highland streams: more evidence for the paucity of shredders in the tropics?	Dobson M. et al.	2002	Freshwater Biology	47	5	909-919	10.1046/j.1365-2427.2002.00818.x
214	Influence of watershed-climate interactions on stream temperature, sediment yield, and metabolism along a land use intensity gradient in Indonesian Borneo	Carlson K. M. et al.	2014	Journal of Geophysical Research: Biogeosciences	119	6	1110-1128	10.1002/2013JG002516
215	Structure and Production of a Benthic Insect Assemblage in a Neotropical Stream	Ramírez A. and Pringle C. M.	1998	J. of the North Am. Benth. Soc.	17	4	443-463	10.2307/1468365
216	Biodiversity and ecosystem function in species-poor communities: community structure and leaf litter breakdown in a Pacific island stream	Benstead J. P. et al.	2009	J. of the North Am. Benth. Soc.	28	2	454-465	http://dx.doi.org/10.1899/07-081.1
217	Detritivorous fish indirectly reduce insect secondary production in a tropical river	Hall R. O. et al.	2011	Ecosphere	2	12	Art.135	10.1890/ES11-00042.1

218	Impacts of agricultural land use on ecosystem structure and whole-stream metabolism of tropical Cerrado streams	Gücker B. et al.	2009	Freshwater Biology	54		2069-2085	10.1111/j.1365-2427.2008.02069.x
219	Differential Decomposition of Leaves in Grassland and Gallery Forest Reaches of Kings Creek	Hooker K. L. et al.	1987	Transactions of the Kansas Academy of Science	90	1-2	17-24	10.2307/3628107
220	Dissolved organic matter release in a Posidonia oceanica meadow	Barrón C. and Duarte C. M.	2009	Marine Ecology Progress Series	374		75-84	10.3354/meps07715
221	Community metabolism and carbon budget along a gradient of seagrass (Cymodocea nodosa) colonization	Barrón C. et al.	2009	Limnology and Oceanography	49	5	1642-1651	10.4319/lo.2004.49.5.1642
222	Factors controlling net ecosystem metabolism in U.S. estuaries	Caffrey J. M.	2004	Estuaries	27	1	90-101	10.1007/BF02803563
223	Primary production of seagrass beds in South Sulawesi (Indonesia): a comparison of habitats, methods and species	Ertfemeijer P. L. A. et al.	1993	Aquatic Botany	46		67-90	10.1016/0304-3770(93)90065-5
224	Opposing effects of substrate quality and site factors on forest floor turnover rates: an example from the tropics	Rahman M. M. and Tsukamoto J.	2014	Forestry	88	2	190-199	10.1093/forestry/cpu043
225	Effects of manipulated herbivore inputs on nutrient flux and decomposition in a tropical rainforest in Puerto Rico	Schowalter T. D. et al.	2011	Oecologia	167	4	1141-1149	10.1007/s00442-011-2056-3
226	Litter decomposition rates in relation to litter stocks in boreal coniferous forests along climatic and soil fertility gradients	Hilli S. et al.	2010	Applied Soil Ecology	46	2	200-208	10.1016/j.apsoil.2010.08.012
227	An experimental comparison of chemical traits and litter decomposition rates in a diverse range of subarctic bryophyte, lichen and vascular plant species	Lang S. L. et al.	2009	Journal of Ecology	97	5	886-900	10.1111/j.1365-2745.2009.01538.x
228	Decomposition of pure and mixed foliage litter in a young lodgepole pine - Sitka alder stand in the central interior of British Columbia	Sanborn P. T. and Brockley R. P.	2009	Canadian Journal of Forest Research	39	11	2257-2262	10.1139/X09-122
229	Decomposition of Scots pine fine woody debris in boreal conditions: Implications for estimating carbon pools and fluxes	Vávřová P. et al.	2009	Forest Ecology and Management	257	2	401-412	10.1016/j.foreco.2008.09.017
230	Breakdown and macroinvertebrate and fungal colonization of alder, birch, and willow leaves in a boreal forest stream	Haapala A. et al.	2001	J. of the North Am. Benth. Soc.	20	3	395-407	10.2307/1468037
231	The timing of winter-growing shredder species and leaf litter turnover rate in an oligotrophic lake, SE Sweden	Bohman I. M. and Herrmann J.	2006	Hydrobiologia	556	1	99-108	10.1007/s10750-005-1052-1
232	Remote estimation of gross primary production in maize and support for a new paradigm based on total crop chlorophyll content	Peng Y. et al.	2011	Remote Sensing of Environment	115	4	978-989	10.1016/j.rse.2010.12.001
233	Benthic respiration and nitrogen release in Buzzards Bay, Massachusetts	Banta G. T. et al.	1995	Journal of Marine Research	53	1	107-135	10.1357/0022240953213287
234	Metabolism of a Desert Stream	Busch D. E. and Fisher S. G.	1981	Freshwater Biology	11	May	301-307	10.1111/j.1365-2427.1981.tb01263.x
235	Flow extremes and benthic organic matter shape the metabolism of a headwater Mediterranean stream	Acuña V. et al.	2004	Freshwater Biology	49	7	960-971	10.1111/j.1365-2427.2004.01239.x
236	Interrelationships Among Shrub Encroachment , Land Management , and Litter Decomposition in a Semidesert Grassland	Throop H. L. and Archer S. R.	2007	Ecological Applications	17	6	1809-1823	10.1890/06-0889.1
237	In situ litter decomposition and litter quality in a Mojave Desert ecosystem: effects of elevated atmospheric CO2 and interannual climate variability	Weatherly H. E. et al.	2003	Global Change Biology	9	8	1223-1233	10.1046/j.1365-2486.2003.00653.x
238	Organic Matter Flow in Stream Food Webs With Reduced Detrital Resource Base	Hall R. O. et al.	2000	Ecology	81	12	3445-3463	10.2307/177506
239	Trophic model of the subtropical headwater stream habitat of formosan landlocked salmon oncorhynchus formosanus	Lin H.-J. et al.	2012	Aquatic Biology	17	3	269-283	10.3354/ab00481
240	Macroinvertebrate production and trophic structure in a tallgrass prairie headwater stream	Stagliano D. M. and Whiles M. R.	2002	J. of the North Am. Benth. Soc.	21	1	97-113	10.2307/1468303
241	Secondary Production Estimates Of Benthic Insects In 3 Cold Desert Streams	Gaines W. L. et al.	1992	Great Basin Naturalist	52	1	11-24	10.2307/41712690
242	Effects of Disturbance on Benthic Functional Structure and Production in Mountain Streams	Lugthart J. G. and Wallace B. J.	1992	J. of the North Am. Benth. Soc.	11	2	138-164	10.2307/1467381
243	Trophic basis of invertebrate production in 2 streams at the Hubbard Brook Experimental Forest	Hall R. O. et al.	2001	J. of the North Am. Benth. Soc.	20	3	432-447	10.2307/1468040
244	Secondary Production and Trophic Relationships in a Spring Invertebrate Community	Iversen T. M.	1988	Limnology and Oceanography	33	4	582-592	10.4319/lo.1988.33.4.0582
245	Secondary Production and Organic Matter Processing by Collector Macroinvertebrates in a Desert Stream	Fisher S. G. and Gray L. J.	1983	Ecology	64	5	1217-1224	10.2307/1937830
246	Secondary Production in Inland Waters	Waters T. F.	1977	Advances in Ecological Research	10	C	91-164	10.1016/S0065-2504(08)60235-4
247	Benthic and Pelagic Secondary Production in Lake Erie after the Invasion of Dreissena spp. with Implications for Fish Production	Johannsson O. E. et al.	2000	Journal of Great Lakes Research	26	1	31-54	10.1016/S0380-1330(00)70671-X
248	Litter carbon dynamics analysis in forests in an arid ecosystem with a model incorporating the physical removal of litter	Kumada S. et al.	2008	Ecological Modelling	215	1-3	190-199	10.1016/j.ecolmodel.2008.02.022
249	Quantifying carbon budgets of conifer Mediterranean forest ecosystems, Turkey	Evrendilek F. et al.	2006	Environmental Monitoring and Assessment	119		527-543	10.1007/s10661-005-9041-4
250	Spatial heterogeneity of ecosystem carbon fluxes in a broadleaved forest in Northern Germany	Kutsch W. L. et al.	2005	Global Change Biology	11	1	70-88	10.1111/j.1365-2486.2004.00884.x
251	Production and Litter Decomposition Rate in Acahuales of Deciduous Tropical Forest in Chiapas	Rivera Vasquez R. et al.	2013	Revista Mexicana de Ciencias Forestales	4	20	20-30	http://www.redalyc.org/articulo.oa?id=63433994003

252	Rate of litter decomposition and microbial activity in an area of caatinga	Souto P. C. et al.	2013	Cerne	19	4	559-565	10.1590/S0104-77602013000400005
253	Tree Species Effect on Litter Decomposition and Nutrient Release in Mediterranean Oak Forests Changes Over Time	Aponte C. et al.	2012	Ecosystems	15	7	1204-1218	10.1007/s10021-012-9577-4
254	Role of desert annuals in nutrient flow in arid area of Northwestern China: A nutrient reservoir and provider	Chen B.-M. et al.	2009	Plant Ecology	201		401-409	10.1007/s11258-008-9526-7
255	Litter quality and decomposition in a CO ₂ -enriched Mediterranean forest ecosystem	De Angelis P. et al.	2000	Plant and Soil	224	1	31-41	10.1023/A:1004790328560
256	Regional patterns and controls of leaf decomposition in Australian tropical rainforests	Parsons S. A. et al.	2012	Austral Ecology	37	7	845-854	10.1111/j.1442-9993.2011.02347.x
257	Seasonality of ecosystem respiration and gross primary production as derived from FLUXNET measurements	Falge E. et al.	2002	Agricultural and Forest Meteorology	113		53-74	10.1016/S0168-1923(02)00102-8
258	Estimation of carbon stock under different management regimes of tropical forest in the Terai Arc Landscape, Nepal	Gurung M. B. et al.	2015	Forest Ecology and Management	365		144-152	10.1016/j.foreco.2015.07.024
259	Carbon stocks in different carbon pools of a tropical lowland forest and a montane forest with varying topography	Jeyanny V. et al.	2014	Journal of Tropical Forest Science	26	4	560-571	http://www.frim.gov.my/.../560-571.pdf
260	Simulated annual carbon fluxes of grassland ecosystems in extremely arid conditions	Zhang N. et al.	2009	Ecological Research	24	1	185-206	10.1007/s11284-008-0497-x
261	Ecosystem metabolism controls nitrogen uptake in streams in Grand Teton National Park, Wyoming	Hall R. O. and Tank J. L.	2003	Limnology and Oceanography	48	3	1120-1128	10.4319/lo.2003.48.3.1120
262	Hot spots for carbon emissions from Mediterranean fluvial networks during summer drought	Gómez-Gener L. et al.	2015	Biogeochemistry	125	3	409-426	10.1007/s10533-015-0139-7
263	Ecohydrological impacts of woody-plant encroachment: Seasonal patterns of water and carbon dioxide exchange within a semiarid riparian environment	Scott R. L. et al.	2006	Global Change Biology	12	2	311-324	10.1111/j.1365-2486.2005.01093.x
264	Influence of land use on stream ecosystem function in a Mediterranean catchment	Von Schiller D. et al.	2008	Freshwater Biology	53	12	2600-2612	10.1111/j.1365-2427.2008.02059.x
265	High secondary production in a Coastal Plain river is dominated by snag invertebrates and fuelled mainly by amorphous detritus	Benke A. C. and Wallace J. B.	2015	Freshwater Biology	60	2	236-255	10.1111/fwb.12460
266	Bacterial production in the carbon flow of a central European stream, the Breitenbach	Marxsen J.	2006	Freshwater Biology	51	10	1838-1861	10.1111/j.1365-2427.2006.01620.x
267	Stream Organic Matter Budgets : An Introduction	Webster J. R. and Meyer J. L.	1997	J. of the North Am. Benth. Soc.	16	1	3-13	10.2307/1468223
268	Autotrophy in Stream Ecosystems	Minshall W. G.	1978	BioScience	28	12	767-771	10.2307/1307250
269	Leaf litter as a possible food source for chironomids (Diptera) in Brazilian and Portuguese headwater streams	Callisto M. et al.	2007	Revista Brasileira de Zoologia	24	2	442-448	10.1590/S0101-81752007000200023
270	Benthic community metabolism in four temperate stream systems: an inter-biome comparison and evaluation of the river continuum concept	Bott T. L. et al.	1985	Hydrobiologia	123	1	3-45	10.1007/BF00006613
271	Integrating aquatic carbon fluxes in a boreal catchment carbon budget	Jonsson A. et al.	2007	Journal of Hydrology	334	1-2	141-150	10.1016/j.jhydrol.2006.10.003
272	A comparison of the carbon balances of a natural lake (L. Öträsket) and a hydroelectric reservoir (L. Skinnmuddselet) in northern Sweden	Åberg J. et al.	2004	Water Research	38	3	531-538	10.1016/j.watres.2003.10.035
273	Litter quality effects on soil carbon and nitrogen dynamics in temperate alley cropping systems	Mungai N. W. and Motavalli P. P.	2006	Applied Soil Ecology	31	1-2	32-42	10.1016/j.apsoil.2005.04.009
274	Arctic lakes and streams as gas conduits to the atmosphere: implications for tundra carbon budgets.	Kling G. W. et al.	1991	Science	251	4991	298-301	10.1126/science.251.4991.298
275	Relationships between ecosystem metabolism, benthic macroinvertebrate densities, and environmental variables in a sub-arctic Alaskan river	Benson E. R. et al.	2013	Hydrobiologia	701	1	189-207	10.1007/s10750-012-1272-0
276	Short-term and long-term carbon dynamics in a northern peatland-stream-lake continuum: A catchment approach	Juutinen S. et al.	2013	Journal of Geophysical Research: Biogeosciences	118	1	171-183	10.1002/jgrg.20028
277	The carbon budget of newly established temperate grassland depends on management intensity	Ammann C. et al.	2007	Agriculture, Ecosystems and Environment	121		05-20	10.1016/j.agee.2006.12.002
278	Seasonal and interannual variation in carbon dioxide exchange and carbon balance in a northern temperate grassland	Flanagan L. B. et al.	2002	Global Change Biology	8	7	599-615	10.1046/j.1365-2486.2002.00491.x
279	Partitioning European grassland net ecosystem CO ₂ exchange into gross primary productivity and ecosystem respiration using light response function analysis	Gilmanov T. G. et al.	2007	Agriculture, Ecosystems and Environment	121		93-120	10.1016/j.agee.2006.12.008
280	Carbon dynamics of temperate grassland ecosystems in China from 1951 to 2007: An analysis with a process-based biogeochemistry model	Sui X. and Zhou G.	2013	Environmental Earth Sciences	68	2	521-533	10.1007/s12665-012-1756-2
281	Seasonal carbon dynamics and the effects of manure application on carbon budget of a managed grassland in a temperate, humid region in Japan	Matsuura S. et al.	2014	Grassland Science	60	2	76-91	10.1111/grs.12042
282	Carbon dynamics and budget in a <i>Zoysia japonica</i> grassland, central Japan	Dhital D. et al.	2010	Journal of Plant Research	123	4	519-530	10.1007/s10265-009-0289-6
283	Inter-annual variability in carbon dioxide exchange of an oak/grass savanna and open grassland in California	Ma S. et al.	2007	Agricultural and Forest Meteorology	147	3-4	157-171	10.1016/j.agrformet.2007.07.008
284	Warming alters potential enzyme activity but precipitation regulates chemical transformations in grass litter exposed to simulated climatic changes	Suseela V. et al.	2014	Soil Biology and Biochemistry	75		102-112	10.1016/j.soilbio.2014.03.022
285	Environmental influences on carbon dioxide fluxes over three grassland ecosystems in China	Fu Y. et al.	2009	Biogeosciences	6	12	2879-2893	10.5194/bg-6-2879-2009
286	Temperature and biomass influences on interannual changes in CO ₂ exchange in an alpine meadow on the Qinghai-Tibetan Plateau	Kato C. et al.	2006	Global Change Biology	12	7	1285-1298	10.1111/j.1365-2486.2006.01153.x
287	Characteristics of the gas exchange of a tropical rain forest in Peninsular Malaysia	Takanashi S. et al.	2005	Phyton; annales rei botanicae	45	4	61-66	

288	Three years of carbon and energy fluxes from Japanese evergreen broad-leaved forest	Kosugi Y. et al.	2005	Agricultural and Forest Meteorology	132	3-4	329-343	10.1016/j.agrformet.2005.08.010
289	Seasonal controls on the exchange of carbon and water in an Amazonian rain forest	Hutyrá L. R. et al.	2007	Journal of Geophysical Research: Biogeosciences	112	3	G03008	10.1029/2006JG000365
290	A regime shift from macrophyte to phytoplankton dominance enhances carbon burial in a shallow , eutrophic lake	Brothers S. M. et al.	2013	Ecosphere	4	11	Art. 137	10.1890/ES13-00247.3
291	Habitat, not resource availability, limits consumer production in lake ecosystems	Craig N. et al.	2015	Limnology and Oceanography	60	6	2079-2089	10.1002/lno.10153
292	From bacteria to piscivorous fish: Estimates of whole-lake and component-specific metabolism with an ecosystem approach	Cremona F. et al.	2014	PLoS ONE	9	7	e101845	10.1371/journal.pone.0101845
293	Benthic community metabolism in deep and shallow Arctic lakes during 13 years of whole-lake fertilization	Daniels W. C. et al.	2015	Limnology and Oceanography	60	5	1604-1618	10.1002/lno.10120
294	The importance of sedimenting organic matter, relative to oxygen and temperature, in structuring lake profundal macroinvertebrate assemblages	Jyväsjärvi J. et al.	2013	Hydrobiologia	709	1	55-72	10.1007/s10750-012-1434-0
295	Terrestrial organic matter support of lake food webs: Evidence from lake metabolism and stable hydrogen isotopes of consumers	Karlsson J. et al.	2012	Limnology and Oceanography	57	4	1042-1048	10.4319/lo.2012.57.4.1042
296	Biogeochemical characteristics of settling particulate organic matter in Lake Superior: a seasonal comparison	Li H. and Minor E. C.	2015	Organic Geochemistry	85		76-88	10.1016/j.orggeochem.2015.05.006
297	Spatial and Temporal Variability in the Ecosystem Metabolism of a High-elevation Lake: Integrating Benthic and Pelagic Habitats	Sadro S. et al.	2011	Ecosystems	14	7	1123-1140	10.1007/s10021-011-9471-5
298	Accounting for littoral primary production by periphyton shifts a highly humic boreal lake towards net autotrophy	Vesterinen J. et al.	2016	Freshwater Biology	61	3	265-27	10.1111/fwb.12700
299	Primary production of a seagrass bed on Kavaratti Atoll (Laccadives)	Qasim S. Z. and Bhattathiri P. M. A.	1971	Hydrobiologia	38	1	29-38	10.1007/BF00036790
300	Benthic metabolism across a gradient of anthropogenic impact in three shallow coastal lagoons in NW Florida	Stutes J. et al.	2007	Marine Ecology Progress Series	348		55-70	10.3354/meps07036
301	Organic Carbon Metabolism and Carbonate Dynamics in a Mediterranean Seagrass (Posidonia oceanica) Meadow	Barrón C. et al.	2006	Estuaries and coasts	29	3	417-426	10.1007/BF02784990
302	Accumulation and transport of seagrass-derived organic matter in reef flat sediment of Green Island, Great Barrier Reef	Miyajima T. et al.	1998	Marine Ecology Progress Series	175		251-259	10.3354/meps175251
303	The Detritic Compartment in a Posidonia oceanica Meadow : litter features, decomposition rates, and mineral stocks	Romero J. et al.	1992	Marine Ecology	13	1	69-83	10.1111/j.1439-0485.1992.tb00341.x
304	Effects of suspended mussel culture on benthic-pelagic coupling in a coastal upwelling system (Ría de Vigo, NW Iberian Peninsula)	Alonso-Pérez F. et al.	2010	Journal of Experimental Marine Biology and Ecology	382	2	96-107	10.1016/j.jembe.2009.11.008
305	Benthic fluxes, net ecosystem metabolism and seafood harvest: Completing the organic carbon balance in the Ría de Vigo (NW Spain)	Alonso-Pérez F. et al.	2015	Estuarine, Coastal and Shelf Science	163		54-63	10.1016/j.ecss.2015.05.038
306	A pelagic ecosystem model simulating production and sedimentation of biogenic particles: role of salps and copepods	Andersen V. and Nival P.	1988	Marine Ecology Progress Series	44	1	37-50	10.3354/meps044037
307	A carbon budget for an oligotrophic clearwater lake in mid-Sweden	Andersson E. and Kumbald L.	2006	Aquatic Sciences	68	1	52-64	10.1007/s00027-005-0807-0
308	Production and downward flux of zooplankton fecal pellets in the anticyclonic gyre off Shikoku, Japan	Ayukai T. and Hattori H.	1992	Oceanologica Acta	15	2	163-172	
309	Phytoplankton productivity on the Canadian Shelf of the Beaufort Sea	Carmack E. C. et al.	2004	Marine Ecology Progress Series	277	August	37-50	10.3354/meps277037
310	Spatial and temporal resolution of carbon fluxes in a shallow coastal ecosystem, the Kattegat	Carstensen J. et al.	2003	Marine Ecology Progress Series	252		35-50	10.3354/meps252035
311	Carbon flows in a subtidal fine sand community from the western English Channel: a simulation analysis	Chardy P. and Dauvin J.-C.	1992	Marine Ecology Progress Series	81	2	147-161	10.3354/meps081147
312	Primary production and nutrients in a tropical macrotidal estuary, Darwin Harbour, Australia	Burford M. A. et al.	2008	Estuarine, Coastal and Shelf Science	79	3	440-448	10.1016/j.ecss.2008.04.018
313	Metabolism of different benthic habitats and their contribution to the carbon budget of a shallow oligotrophic sub-tropical coastal system (southern Moreton Bay, Australia)	Eyre B. D. et al.	2011	Biogeochemistry	102	1	87-110	10.1007/s10533-010-9424-7
314	Nutrient cycling in the water column of a subtropical seagrass meadow	Ziegler S. and Benner R.	1999	Marine Ecology Progress Series	188		51-62	10.3354/meps188051
315	Carbon, nitrogen, and phosphorus budgets for a shallow subtropical coastal embayment (Moreton Bay, Australia)	Eyre B. D. and McKee L. J.	2002	Limnology and Oceanography	47	4	1043-1055	10.4319/lo.2002.47.4.1043
316	A partial budget of primary organic carbon flows in the littoral zone of a hardwater lake	Gessner M. O. et al	1996	Aquatic Botany	55	2	93-105	10.1016/S0304-3770(96)01064-9
317	Primary production of aquatic macrophytes and their epiphytes in two shallow lakes (Peipsi and Võrtsjärv) in Estonia	Nõges T. et al.	2010	Aquatic Ecology	44	1	83-92	10.1007/s10452-009-9249-4
318	Benthic and planktonic primary production along a nutrient gradient in Green Bay, Lake Michigan, USA	Althouse B. et al.	2014	Freshwater Science	33	2	487-498	10.1086/676314.
319	Carbon, nitrogen, oxygen and sulfide budgets in the Black Sea: A biogeochemical model of the whole water column coupling the oxic and anoxic parts	Grégoire M. and Soetaert K.	2010	Ecological Modelling	221		2287-2301	10.1016/j.ecolmodel.2010.06.007
320	The composition of particulate organic matter in the euphotic zone of Lake Superior	Halfon E.	1984	Journal of Great Lakes Research	10	3	299-306	10.1016/S0380-1330(84)71843-0

321	Carbon and nitrogen isotopic compositions of particulate organic matter in four large river systems across the United States	Kendall C. et al.	2001	Hydrological Processes	15	7	1301-1346	10.1002/hyp.216
322	Seasonal shifts between autochthonous and allochthonous carbon contributions to zooplankton diets in a subarctic lake	Rautio M. et al.	2011	Limnology and Oceanography	56	4	1513-1524	10.4319/lo.2011.56.4.1513
323	Nutrient uptake and release during growth and decomposition of eelgrass, <i>Zostera Marina</i> L., and its effects on the nutrient dynamics of Lake Grevelingen	Pellikan G. C. and Nienhuis P. H.	1988	Aquatic Botany	30	3	189-214	10.1016/0304-3770(88)90051-4
324	Metabolic imbalance in coastal vegetated (<i>Posidonia oceanica</i>) and unvegetated benthic ecosystems	Apostolaki E. et al.	2010	Ecosystems	13	3	459-471	10.1007/s10021-010-9330-9
325	Detrital stocks and dynamics of the seagrass <i>Posidonia oceanica</i> (L.) Delile in the Spanish Mediterranean	Cebrian J. and Duarte C. M.	2001	Aquatic Botany	70		295-309	10.1016/S0304-3770(01)00154-1
326	Biomass dynamics of seagrasses and the role of mangrove and seagrass vegetation as different nutrient sources for an intertidal ecosystem	De Boer W. F.	2000	Aquatic Botany	66		225-239	10.1016/S0304-3770(99)00072-8
327	Bioavailability of dissolved organic carbon linked with the regional carbon cycle in the East China Sea	Gan S. et al.	2016	Deep Sea Research Part II: Topical Studies in Oceanography	124		19-28	10.1016/j.dsr2.2015.06.024
328	Carbon fluxes within the pelagic food web in the coastal area off Antofagasta (23°S), Chile: The significance of the microbial versus classical food webs	Pavés H. J. and González H. E.	2008	Ecological Modelling	211	3-4	218-232	10.1016/j.ecolmodel.2007.10.004
329	Primary production and community respiration in the Humboldt Current System off Chile and associated oceanic areas	Danieri G. et al.	2000	Marine Ecology Progress Series	197		41-49	10.3354/meps197041
330	Integrated assessment of the carbon budget in the southeastern Bering Sea	Cross J. N. et al.	2014	Deep Sea Research Part II: Topical Studies in Oceanography	109		112-124	10.1016/j.dsr2.2014.03.003
331	Benthic trophic dynamics in California coastal\rbasin and continental slope communities inferred using inverse analysis	Eldridge P. M. and Jackson G. A.	1993	Marine Ecology Progress Series	99		115-135	10.3354/meps099115
332	Seasonal changes of the quantitative importance of protozoans in a large lake: An ecosystem approach using mass-balanced carbon flow diagrams.	Gaedke U. and Straile D.	1994	Marine Microbial Food Webs	8		163-188	http://nbn-resolving.de/urn:nbn:de:bsz:352-opus-39463
333	Benthic O ₂ exchange across hard-bottom substrates quantified by eddy correlation in a sub-Arctic fjord	Glud R. N. et al.	2010	Marine Ecology Progress Series	417		1-12	10.3354/meps08795
334	Seasonal plankton variability in Chilean Patagonia fjords: Carbon flow through the pelagic food web of Aysen Fjord and plankton dynamics in the Moraleda Channel basin	González H. E. et al.	2011	Continental Shelf Research	31		225-243	10.1016/j.csr.2010.08.010
335	Dynamics of the pelagic food web in St. Georges Bay, southern Gulf of St. Lawrence	Hargrave B. T. et al.	1985	Marine Ecology Progress Series	20		221-240	10.3354/meps020221
336	Carbon metabolism in a humic lake: Pool sizes and cycling through zooplankton	Hessen D. O. et al.	1990	Limnology and Oceanography	35	1	84-99	10.4319/lo.1990.35.1.0084
337	A carbon flow model and network analysis of the northern Benguela upwelling system, Namibia	Heymans J. J. and Baird D.	2000	Ecological Modelling	126	1	9-32	10.1016/S0304-3800(99)00192-1
338	Carbon budget of the planktonic food web in an atoll lagoon (Takapoto, French Polynesia)	Sakka A. et al.	2002	Journal of Plankton Research	24	4	301-320	10.1093/plankt/24.4.301
339	A comparison of selected ecosystem attributes of three South African estuaries with different freshwater inflow regimes, using network analysis	Scharler U. M. and Baird D.	2005	Journal of Marine Systems	56	3-4	283-308	10.1016/j.jmarsys.2004.12.003
340	Benthic exchange and biogeochemical cycling in permeable sediments.	Huettel M. et al.	2014	Annual Review of Marine Science	6		23-51	10.1146/annurev-marine-051413-012706
341	Seasonal variability of primary production in a fjord ecosystem of the Chilean Patagonia: Implications for the transfer of carbon within pelagic food webs	Montero P. et al.	2011	Continental Shelf Research	31	3-4	202-215	10.1016/j.csr.2010.09.003
342	Measurements of seasonal rates and annual budgets of organic carbon fluxes in an Antarctic coastal environment at Signy Island, South Orkney Islands, suggest a broad balance between production and decomposition	Nedwell D. B. et al.	1993	Applied and Environmental Microbiology	59	12	3989-3995	
343	Benthic primary production budget of a Caribbean reef lagoon (Puerto Morelos, Mexico)	Naumann M. S. et al.	2013	PLoS ONE	8	12	e82923	10.1371/journal.pone.0082923
344	Budget of coral-derived organic carbon in a fringing coral reef of the Gulf of Aqaba, Red Sea	Naumann M. S. et al.	2012	Journal of Marine Systems	105-108		20-29	10.1016/j.jmarsys.2012.05.007
345	Recycling of organic matter in antarctic sediments: a transect through the polar front in the southern ocean (Indian Sector)	Rabouille C. et al.	1998	Limnology and Oceanography	43	3	420-432	10.4319/lo.1998.43.3.0420
346	Dynamics of carbon and nitrogen during the decomposition of detritus derived from estuarine macrophytes	Rice D. L. and Tenore K. R.	1981	Estuarine, Coastal and Shelf Science	13	6	681-690	10.1016/S0302-3524(81)80049-7
347	Carbon cycling in mesohaline Chesapeake Bay sediments .2. Kinetics of particulate and dissolved organic carbon turnover	Roden E. E. and Tuttle J. H.	1996	Journal of Marine Research	54	2	343-383	10.1357/0022240963213349
348	Analysis of the trophic network of a macrotidal ecosystem: The Bay of Somme (Eastern Channel)	Rybarczyk H. et al.	2003	Estuarine, Coastal and Shelf Science	58	3	405-421	10.1016/S0272-7714(02)00294-9
349	Comparative ecosystem trophic structure of three US mid- Atlantic estuaries	Monaco M. E. and Ulanowicz R. E.	1997	Marine Ecology Progress Series	161		239-254	10.3354/meps161239
350	Carbon flows through a benthic food web: Integrating biomass, isotope and tracer data	Van Oevelen D.	2006	Journal of Marine Research	64	3	453-482	10.1357/002224006778189581
351	Export of biogenic carbon and structure and dynamics of the pelagic food web in the Gulf of St. Lawrence Part 2. Inverse analysis	Vézina A. F. et al.	2000	Deep-Sea Research Part II: Topical Studies in Oceanography	47	3-4	609-635	10.1016/S0967-0645(99)00120-4
352	Quantification of functional soil organic carbon pools for major soil units and land uses in southeast Germany (Bavaria)	Wiesmeier M. et al.	2014	Agriculture, Ecosystems and Environment	185		208-220	10.1016/j.agee.2013.12.028
353	Litter processing along a stream gradient: the role of invertebrates and decomposers	Graça M. A. S. et al.	2001	J. of the North Am. Benth. Soc.	20	3	408-420	10.2307/1468038

354	Ecosystem linkages between southern Appalachian headwater streams and their banks: Leaf litter breakdown and invertebrate assemblages	Hutchens J. J. Jr. and Wallace J. B.	2002	Ecosystems	5	1	80-91	10.1007/s10021-001-0057-5
355	Latitudinal patterns in leaf litter breakdown: Is temperature really important?	Irons III J. G. et al.	1994	Freshwater Biology	32	2	401-411	10.1111/j.1365-2427.1994.tb01135.x
356	Forest floor decomposition following hurricane litter inputs in several Puerto Rican forests	Ostertag R. et al.	2003	Ecosystems	6	3	261-273	10.1007/s10021-002-0203-8
357	Leaf litter breakdown rates in boreal streams: Does shredder species richness matter?	Jonsson M. et al.	2001	Freshwater Biology	46	2	161-171	10.1046/j.1365-2427.2001.00655.x
358	Leaf decomposition in two semi-evergreen tropical forests: Influence of litter quality	Loranger G. et al.	2002	Biology and Fertility of Soils	35	4	247-252	10.1007/s00374-002-0467-3
359	Macroconsumer effects on insect detritivores and detritus processing in a tropical stream	Rosemond A. D. et al.	1998	Freshwater Biology	39	3	515-523	10.1046/j.1365-2427.1998.00301.x
360	Leaf litter processing rates in a Kenyan highland stream, the Njoro River	Dobson M. et al.	2004	Hydrobiologia	519		207-210	10.1023/B:HYDR.0000026592.50734.ea
361	Effects of nutrient enrichment and leaf quality on the breakdown of leaves in a hardwater stream	Royer T. V. and Minshall W. G.	2001	Freshwater Biology	46	5	603-610	10.1046/j.1365-2427.2001.00694.x
362	Over-winter decomposition and associated macroinvertebrate communities of three deciduous leaf species in forest streams on the Canadian boreal shield	Muto E. A. et al.	2011	Hydrobiologia	658	1	111-126	10.1007/s10750-010-0455-9
363	Effects of nutrient enrichment on boreal streams: Invertebrates, fungi and leaf-litter breakdown	Bergfur J. et al.	2007	Freshwater Biology	52	8	1618-1633	10.1111/j.1365-2427.2007.01770.x
364	The hippopotamus conveyor belt : vectors of carbon and nutrients from terrestrial grasslands to aquatic systems in sub-Saharan Africa	Subaluski A. L. et al.	2015	Freshwater Biology	60	3	512-525	10.1111/fwb.12474
365	Shifts in reciprocal river-riparian arthropod fluxes along an urban-rural landscape gradient	Kautza A. and Sullivan S. M. P.	2015	Freshwater Biology	60	10	2156-2168	10.1111/fwb.12642
366	Leaf litter quality affects aquatic insect emergence: Contrasting patterns from two foundation trees	Compson Z. G. et al.	2013	Oecologia	173	2	507-519	10.1007/s00442-013-2643-6
367	Roe deer may markedly alter forest nitrogen and phosphorus budgets across Europe	Abbas F. et al.	2012	Oikos	121	8	1271-1278	10.1111/j.1600-0706.2011.20103.x
368	Flux of aquatic insect productivity to land: comparison of lentic and lotic ecosystems	Gratton C. and Vander Zanden J. M.	2009	Ecology	90	10	2689-2699	10.1890/08-1546.1
369	Forest-stream linkages: Effects of terrestrial invertebrate input and light on diet and growth of brown trout (salmo trutta) in a boreal forest stream	Eros T. et al.	2012	PLoS ONE	7	5	e36462	10.1371/journal.pone.0036462
370	Woody debris and terrestrial invertebrates – effects on prey resources for brown trout (Salmo trutta) in a boreal stream	Gustafsson P. et al.	2014	Environmental Biology of Fishes	97	5	529-542	10.1007/s10641-014-0250-y
371	Marine Macrophyte Wrack Inputs and Dissolved Nutrients in Beach Sands	Dugan J. E. et al.	2011	Estuaries and coasts	34	4	839-850	10.1007/s12237-011-9375-9
372	Ecosystem connectivity and trophic subsidies of sandy beaches	Liebowitz D. M. et al.	2016	Ecosphere	7	10	Art.e01503	10.1002/ecs2.1503
373	Changes in biomass and botancial compstion of beach-cast seaweeds in a dirturbed coastal area from Argentine Patagonia	Piriz M. L. et al.	2003	Journal of applied Phycology	15		67-74	10.1023/A:1022959005072
374	Cross-ecosystem fluxes: Export of polyunsaturated fatty acids from aquatic to terrestrial ecosystems via emerging insects	Martin-Creuzburg D. et al.	2017	Science of the Total Environment	577		174-182	10.1016/j.scitotenv.2016.10.156
375	Deposition and decomposition of periodical cicadas (Homoptera: Cicadidae: Magicicauda) in woodland aquatic ecosystems	Pray C. L. et al.	2009	J. of the North Am. Benth. Soc.	28	1	181-195	10.1899/08-038.1
376	Patterns of herbivory and decomposition in aquatic and terrestrial ecosystems	Cebrian J. and Lartigue J.	2004	Ecological Monographs	74	2	237-259	10.1890/03-4019
377	Above-Ground Crop Mass and Species Richness of the Principal Types of Herbaceous Rich- Fen Vegetation of Lowland England and Wales	Wheeler B. D. and Shaw S. C.	1991	Journal of Ecology	79	2	285-301	10.2307/2260713
378	Energy and Nutrient Dynamics of Spider and Orthopteran Populations in a Grassland Ecosystem	Van Hook R. I. Jr.	1971	Ecological Monographs	41	1	1-26	10.2307/1942433
379	Cycling of organic carbon in the photic zone of a eutrophic lake with special reference to the heterotrophic bacteria	Vadstein O. et al.	1989	Limnology and Oceanography	34	5	840-855	10.4319/lo.1989.34.5.0840
380	Medium-term effects of corn biochar addition on soil biota activities and functions in a temperate soil cropped to corn	Domene X. et al.	2014	Soil Biology and Biochemistry	72		152-162	10.1016/j.soilbio.2014.01.035
381	Management of small grain residues to retain legume-derived nitrogen in corn cropping systems	Starovoytov A. et al.	2010	Agronomy Journal	102	3	895-903	10.2134/agronj2009.0402
382	Coupling between macroalgal inputs and nutrients outcrop in exposed sandy beaches	Barreiro F. et al.	2013	Hydrobiologia	700	1	73-84	10.1007/s10750-012-1220-z
383	Fluxes of biomass and essential polyunsaturated fatty acids from water to land via chironomid emergence from a mountain lake	Borisova E. V. et al.	2016	Contemporary Problems of Ecology	9	4	446-457	10.1134/S199542551604003X
384	Upper Ocean Carbon Export and the Biological Pump	Ducklow H. W. et al.	2001	Oceanography	14	4	50-58	10.5670/oceanog.2001.06
385	Importance of copepod carcasses versus faecal pellets in the upper water column of an oligotrophic area	Frangoulis C. et al.	2011	Estuarine, Coastal and Shelf Science	92	3	456-463	10.1016/j.ecss.2011.02.005
386	Magnitude and fate of salmon-derived nutrients and energy in a coastal stream ecosystem	Gende S. M. et al.	2004	Journal of Freshwater Ecology	19	1	149-160	10.1080/02705060.2004.9664522
387	Carbon and nitrogen transfer from a desert stream to riparian predators	Sanzone D. M. et al.	2003	Oecologia	134	2	238-250	10.1007/s00442-002-1113-3
388	Sources of carbon fuelling production in an arid floodplain river	Burford M. A. et al.	2008	Marine and Freshwater research	59	3	224-234	10.1071/MF07159
389	Effects of the abundance of spawning sockeye salmon (Oncorhynchus nerka) on nutrients and algal biomass in forested streams	Johnston N. T. et al.	2004	Can. J. of Fish. and Aq. Sci.	61	August	384-403	10.1139/F03-172
390	Density-dependent predation by brown bears (Ursus arctos) on sockeye salmon (Oncorhynchus nerka)	Quinn T. P. et al.	2003	Can. J. of Fish. and Aq. Sci.	60		553-562	10.1139/F03-045

391	Large annual net ecosystem CO2 uptake of a Mojave Desert ecosystem	Wohlfahrt G. et al.	2008	Global Change Biology	14	7	1475-1487	10.1111/j.1365-2486.2008.01593.x
392	Coarse particulate detritus dynamics in small, montane streams of southwestern British Columbia	Richardson J. S.	1992	Can. J. of Fish. and Aq. Sci.	49		337-346	10.1139/f92-038
393	Carbon and nutrient deposition in a Mediterranean seagrass (Posidonia oceanica) meadow	Gacia E. et al.	2002	Limnology and Oceanography	47	1	23-32	10.4319/lo.2002.47.1.0023
394	Carbon and water fluxes in an exotic buffelgrass savanna	Hinojo-Hinojo C. et al.	2016	Rangeland Ecology and Management	69	5	334-341	10.1016/j.rama.2016.04.002
395	Seasonal and Annual Variations of Carbon Dioxide Fluxes in Desert Ecosystem	Liu R. et al.	2011	Journal of Desert Research	31		104-108	http://en.cnki.com.cn/Article_en/CJFDTOT-AL-ZGSS201101018.htm
396	Diurnal, seasonal and annual variation in the net ecosystem CO2 exchange of a desert shrub community (Sarcocaulis) in Baja California, Mexico	Hastings S. J. et al.	2005	Global Change Biology	11	6	927-939	10.1111/j.1365-2486.2005.00951.x
397	Carbon dioxide fluxes in a semiarid environment with high carbonate soils	Emmerich W. E.	2003	Agricultural and Forest Meteorology	116	1-2	91-102	10.1016/S0168-1923(02)00231-9
398	Carbon sequestration in arid-land forest	Grünzweig J. M. et al.	2003	Global Change Biology	9		791-799	10.1046/j.1365-2486.2003.00612.x
399	Response of vegetation and soil carbon and nitrogen storage to grazing intensity in semi-arid grasslands in the agro-pastoral zone of northern china	Xu M.-Y. et al.	2014	PLOS One	9	5	e96604	10.1371/journal.pone.0096604
400	Seasonal variation in carbon dioxide exchange over a Mediterranean annual grassland in California	Xu L. and Baldocchi D. D.	2004	Agricultural and Forest Meteorology	123	1-2	79-96	10.1016/j.agrformet.2003.10.004
401	Relationship between sediment organic matter, bacteria composition, and the ecosystem metabolism of alpine streams	Logue J. B. et al.	2004	Limnology and Oceanography	49	6	2001-2010	10.4319/lo.2004.49.6.2001
402	Diurnal and seasonal variations in carbon dioxide exchange in ecosystems in the Zhangye oasis Area, northwest China	Zhang L. et al.	2015	PLOS One	10	3	1-16	10.1371/journal.pone.0120660
403	Responses of gross primary productivity to different sizes of precipitation events in a temperate grassland ecosystem in Inner Mongolia, China	Guo Q. et al.	2016	Journal of Arid Land	8	1	36-46	10.1007/s40333-015-0136-7
404	Patterns of CO2 exchange and productivity of the herbaceous vegetation and trees in a humid savanna in western Kenya	Otieno D. et al.	2015	Plant Ecology	216	10	1441-1456	10.1007/s11258-015-0523-3
405	Elevated carbon dioxide alters impacts of precipitation pulses on ecosystem photosynthesis and respiration in a semi-arid grassland	Bachman S. et al.	2010	Oecologia	162	3	791-802	10.1007/s00442-009-1511-x
406	Grazing exclusion significantly improves grassland ecosystem C and N pools in a desert steppe of Northwest China	Wang K. et al.	2016	Catena	137		441-448	10.1016/j.catena.2015.10.018
407	Dynamics of soil carbon following destruction of tropical rainforest and the subsequent establishment of Imperata grassland in Indonesian Borneo using stable carbon isotopes	Yonekura Y. et al.	2012	Global Change Biology	18		2606-2616	10.1111/j.1365-2486.2012.02722.x
408	Eddy covariance and biometric measurements show that a savanna ecosystem in Southwest China is a carbon sink	Fei X. et al.	2017	Scientific Reports	7		41025	10.1038/srep41025
409	Soil carbon balance in a tropical grassland: Estimation of soil respiration and its partitioning using a semi-empirical model	Caquet B. et al.	2012	Agricultural and Forest Meteorology	158-159		71-79	10.1016/j.agrformet.2012.02.008
410	Seasonal dynamics in carbon dioxide fluxes of the herbaceous layer of a moist Kenyan savannah	K'Otuto G. O. et al.	2014	Applied Ecology and Environmental Research	12	1	63-82	ISSN 1785 0037 (Online)
411	Carbon fluxes from an urban tropical grassland	Ng B. J. L. et al.	2015	Environmental Pollution	203		227-234	10.1016/j.envpol.2014.06.009
412	Carbon dynamics in an Imperata grassland in Northeast India	Thokchom A. and Yadava P. S.	2016	Tropical Grasslands - Forrajes Tropicales	4	1	19-28	10.17138/TGFT(4)19-28
413	Regional patterns in carbon cycling across the Great Plains of North America	McCulley R. L. et al.	2005	Ecosystems	8	1	106-121	10.1007/s10021-004-0117-8
414	Impact of Land-Use Change on Carbon Stocks in Meadow Steppe of Northeast China	Lian P. et al.	2011	Applied Mechanics and Materials	108		262-268	10.4028/www.scientific.net/AMM.108.262
415	Formation of soil organic matter via biochemical and physical pathways of litter mass loss	Cotrufo M. F. et al.	2015	Nature Geosciences	8	10	776-779	10.1038/ngeo2520
416	Millipedes and earthworms increase the decomposition rate of 15N-labelled winter rape litter in an arable field	Martens H. et al.	2001	Isotopes in environmental and health studies	37	1	43-51	10.1080/10256010108033280
417	Dynamics in the trophic structure of the macroinvertebrate community in a Mediterranean, temporary stream	Álvarez M. and Pardo I.	2009	Aquatic Sciences	71	2	202-213	10.1007/s00027-009-9160-z
418	Carbon budget of leaves of the tropical intertidal seagrass Thalassia hemprichii	Chiu S.-H. et al.	2013	Estuarine, Coastal and Shelf Science	125		27-35	10.1016/j.ecss.2013.03.026
419	Response of early Ruppia cirrhosa litter breakdown to nutrient addition in a coastal lagoon affected by agricultural runoff	Menéndez M.	2009	Estuarine, Coastal and Shelf Science	82	4	608-614	10.1016/j.ecss.2009.02.029
420	Carbon budgets of multispecies seagrass beds at Dongsha Island in the South China Sea.	Huang Y.-H. et al.	2015	Marine Environmental Research	106		92-102	10.1016/j.marenvres.2015.03.004
421	A wildfire event influences ecosystem carbon fluxes but not soil respiration in a semi-arid woodland	Sun Q. et al.	2016	Agricultural and Forest Meteorology	226-227		57-66	10.1016/j.agrformet.2016.05.019
422	C stocks in forest floor and mineral soil of two mediterranean beech forests	De Marco A. et al.	2016	Forests	7		181	10.3390/f7080181
423	Enhanced summer warming reduces fungal decomposer diversity and litter mass loss more strongly in dry than in wet tundra	Christiansen C. T. et al.	2017	Global Change Biology	23		406-420	10.1111/gcb.13362
424	Plant production and nitrogen accumulation above- and belowground in low and tall birch tundra communities: the influence of snow and litter	Vankoughnett M. R. and Grogan P.	2016	Plant and Soil	408	1-2	195-210	10.1007/s11104-016-2921-2

425	The effects of snowpack properties and plant strategies on litter decomposition during winter in subalpine meadows	Saccone P. et al.	2013	Plant and Soil	363	1-2	215-229	10.1007/s11104-012-1307-3
426	An integrated assessment of ecosystem carbon pools and fluxes across an oceanic alpine toposequence	Britton A. B. et al.	2011	Plant and Soil	345	1	287-302	10.1007/s11104-011-0781-3
427	Carbon dioxide fluxes over a temperate meadow in eastern Inner Mongolia, China	Jing Y. et al.	2014	Environmental Earth Sciences	72	11	4401-4411	10.1007/s12665-014-3341-3
428	Effect of manure application on seasonal carbon fluxes in a temperate managed grassland in Southern Hokkaido, Japan	Shimizu M. et al.	2015	Catena	133		474-485	10.1016/j.catena.2015.05.011
429	Long-term grazing exclusion effects on vegetation characteristics, soil properties and bacterial communities in the semi-arid grasslands of China	Cheng J. et al.	2016	Ecological Engineering	97		170-178	10.1016/j.ecoleng.2016.09.003
430	Carbon and nutrient exchange of mangrove forests with the coastal ocean	Adame M. F. and Lovelock C. E.	2011	Hydrobiologia	663	1	23-50	10.1007/s10750-010-0554-7
431	Short-term contributions of cover crop surface residue return to soil carbon and nitrogen contents in temperate Australia	Zhou X. et al.	2016	Environmental Science and Pollution Research	23	22	23175-23183	10.1007/s11356-016-7549-5
432	Do sheep grazing patterns affect ecosystem functioning in steppe grassland ecosystems in Inner Mongolia?	Ren H. et al.	2015	Agriculture, Ecosystems and Environment	213		1-10	10.1016/j.agee.2015.07.015
433	Photodegradation of plant litter in the Sonoran Desert varies by litter type and age	Day T. A. et al.	2015	Soil Biology and Biochemistry	89		109-122	10.1016/j.soilbio.2015.06.029
434	Vegetation and soil property response of short-time fencing in temperate desert of the Hexi Corridor, northwestern China	Zhang Y. and Zhao W.	2015	Catena	133		43-51	10.1016/j.catena.2015.04.019
435	Agricultural Activities of a Meadow Eliminated Plant Litter from the Periphery of a Farmland in Inner Mongolia, China	Kawada K. et al.	2015	PLOS One	10	8	1-13	10.1371/journal.pone.0135077
436	Effects of grassland conversion from cropland on soil respiration on the semi-arid loess plateau, China	Wang D. et al.	2015	Clean - Soil, Air, Water	43	7	1052-1057	10.1002/clen.201300971
437	Are there any trade-offs between forage provision and the ecosystem service of C and N storage in arid rangelands?	Oñatibia G. R. et al.	2015	Ecological Engineering	77		26-32	10.1016/j.ecoleng.2015.01.009
438	The role of shoot residues vs. crop species for soil arthropod diversity and abundance of arable systems	Scheunemann N. et al.	2015	Soil Biology and Biochemistry	81		81-88	10.1016/j.soilbio.2014.11.006
439	Carbon dioxide exchange above a Mediterranean C3/C4 grassland during two climatologically contrasting years	Aires L. M. I. et al.	2008	Global Change Biology	14	3	539-555	10.1111/j.1365-2486.2007.01507.x
440	Grassland Carbon Sequestration Ability in China: A New Perspective from Terrestrial Aridity Zones	Chen Y. et al.	2016	Rangeland Ecology and Management	69	1	84-94	10.1016/j.rama.2015.09.003
441	Annual gross primary production and absorbtion of solar energy by artemisia sp. in arid and semiarid shrublands	Sanjerehei M. M.	2013	Applied Ecology and Environmental Research	11	3	355-370	10.15666/aeer/1103_355370
442	Sensitivity of Temperate Desert Steppe Carbon Exchange to Seasonal Droughts and Precipitation Variations in Inner Mongolia, China	Yang F. and Zhou G.	2013	PLOS One	8	2	e55418	10.1371/journal.pone.0055418
443	Primary production of Inner Mongolia, China, between 1982 and 1999 estimated by a satellite data-driven light use efficiency model	Brogaard S. et al.	2005	Global and Planetary Change	45	4	313-332	10.1016/j.gloplacha.2004.09.012
444	Net ecosystem CO2 exchange in Mojave Desert shrublands during the eighth year of exposure to elevated CO2	Jasoni R. L. et al.	2005	Global Change Biology	11	5	749-756	10.1111/j.1365-2486.2005.00948.x
445	Precipitation Pattern Determines the Inter-annual Variation of Herbaceous Layer and Carbon Fluxes in a Phreatophyte-Dominated Desert Ecosystem	Liu R. et al.	2016	Ecosystems	19	4	601-614	10.1007/s10021-015-9954-x
446	Irregular precipitation events in control of seasonal variations in CO2 exchange in a cold desert-shrub ecosystem in northwest China	Xie J. et al.	2015	Journal of Arid Environments	120		33-41	10.1016/j.jaridenv.2015.04.009
447	Phenological transition dictates the seasonal dynamics of ecosystem carbon exchange in a desert steppe	Huang G. and Li Y.	2015	Journal of Vegetation Science	26	2	337-347	10.1111/jvs.12236
448	Soil resource heterogeneity in the Mojave Desert	TitusJ. H. et al.	2002	Journal of Arid Environments	52	3	269-292	10.1006/jare.2002.1010
449	Contrasting diel hysteresis between soil autotrophic and heterotrophic respiration in a desert ecosystem under different rainfall scenarios	Song W. et al.	2015	Scientific Repots	5		16779	10.1038/srep16779
450	Winter soil CO2 efflux and its contribution to annual soil respiration in different ecosystems of a forest-steppe ecotone, north China	Qin L. et al.	2015	Eurasian Soil Science	48	8	871-880	10.1134/S1064229315080050
451	Leaf litter decomposition in a southern Sonoran Desert ecosystem, northwestern Mexico: Effects of habitat and litter quality	Martínez-Yrizar A. et al.	2007	Acta Oecologica	32	3	291-300	10.1016/j.actao.2007.05.010
452	The contribution of trees and grasses to productivity of an Australian tropical savanna	Moore C. E. et al.	2016	Biogeosciences	13	8	2387-2403	10.5194/bg-13-2387-2016
453	Legume proportion, poultry litter, and tillage effects on cover crop decomposition	Poffenbarger H. J. et al.	2015	Agronomy Journal	107	6	2083-2096	10.2134/agronj15.0065
454	Organic farming fosters agroecosystem functioning in Argentinian temperate soils: Evidence from litter decomposition and soil fauna	Domínguez A. et al.	2014	Applied Soil Ecology	83		170-176	10.1016/j.apsoil.2013.11.008
455	Functional measures and food webs of high elevation springs in the Swiss alps	Robinson C. T. et al.	2008	Aquatic Sciences	70	4	432-445	10.1007/s00027-008-8125-y
456	Discharge, legacy effects and nutrient availability as determinants of temporal patterns in biofilm metabolism and accrual in an arctic river	Kendrick M. R. and Huryn A. D.	2015	Freshwater Biology	60	11	2323-2336	10.1111/fwb.12659
457	Nutrient and organic matter patterns across the Mackenzie River, estuary and shelf during the seasonal recession of sea-ice	Emmertson C. A. et al.	2008	Journal of Marine Systems	74		741-755	10.1016/j.jmarsys.2007.10.001

458	Biological responses to fertilization of Oksrukuyik Creek, a tundra stream	Harvey C. J. et al.	1998	J. of the North Am. Benth. Soc.	17	2	190-209	10.2307/1467962
459	Bacterial production and microbial food web structure in a large arctic river and the coastal Arctic Ocean	Vallières C. et al.	2008	Journal of Marine Systems	74	3-4	756-773	10.1016/j.jmarsys.2007.12.002
460	Heterotrophic bacterial activity and fluxes of dissolved free amino acids and glucose in the Arctic rivers Ob, Yenisei and the adjacent Kara Sea	Meon B. and Amon R. M. W.	2004	Aquatic Microbial Ecology	37	2	121-135	10.3354/ame037121
461	Benthic and pelagic food resources for zooplankton in shallow high-latitude lakes and ponds	Rautio M. and Vincent W. F.	2006	Freshwater Biology	51	6	1038-1052	10.1111/j.1365-2427.2006.01550.x
462	Contribution of sediment respiration to summer CO2 emission from low productive boreal and subarctic lakes	Algesten G. et al.	2005	Microbial Ecology	50	4	529-535	10.1007/s00248-005-5007-x
463	Dynamics of dissolved organic carbon lability in a eutrophic lake	Søndergaard M. et al.	1995	Limnology and Oceanography	40	1	46-54	10.4319/lo.1995.40.1.0046
464	Longitudinal patterns of organic matter transport and turnover along a New Zealand grassland river	Young R. G. and Huryn A. D.	1997	Freshwater Biology	38		93-107	10.1046/j.1365-2427.1997.00196.x
465	Impact of Wildfire on Stream Nutrient Chemistry and Ecosystem Metabolism in Boreal Forest Catchments of Interior Alaska	Betts E. F. and Jones Jr J. B.	2009	Arctic, Antarctic, and Alpine Research	41	4	407-417	10.1657/1938-4246-41.4.407
466	Recovery of macroinvertebrate communities from stream habitat restoration	Laasonen P. et al.	1998	Aquatic Conservation: Marine and Freshwater Ecosystems	8	1	101-113	10.1002/(sici)1099-0755(199801/02)8:1<101::aid-aqc251>3.0.co;2-4
467	Epilithic chlorophyll a, photosynthesis, and respiration in control and fertilized reaches of a tundra stream	Bowden W. B. et al.	1992	Hydrobiologia	240		121-131	10.1007/BF00013457
468	The Effect of Invertebrate Predators on Leaf Litter Processing in an Alpine Stream	Obernborfer R. Y. et al.	1984	Ecology	65	4	1325-1331	10.2307/1938337
469	Litter quality, stream characteristics and litter diversity influence decomposition rates and macroinvertebrates	Leroy C. J. and Marks J. C.	2006	Freshwater Biology	51	4	605-617	10.1111/j.1365-2427.2006.01512.x
470	A cross-system comparison of bacterial and fungal biomass in detritus pools of headwater streams	Findlay S. et al.	2002	Microbial Ecology	43		55-66	10.1007/10.007/s00248-001-1020-x
471	Bryophytes and associated invertebrates in first-order alpine streams of Arthur 's Pass , New Zealand	Suren A.	1993	New Zealand Journal of Marine and Freshwater Research	27	4	479-494	10.1080/00288330.1993.9516589
472	Black fly (Diptera: Simuliidae) response to phosphorus enrichment of an arctic tundra stream	Hiltner A. L. and Hershey A. E.	1992	Hydrobiologia	240		259-265	10.1007/BF00013467
473	Production of fish stocks in Thingvallavatn, Iceland	Snorrason S. S. et al.	1992	Oikos	64	1-2	371-380	10.2307/3545059
474	Quantifying effective restoration: reassessing the productive capacity of a constructed stream 14 years after construction	Scrimgeour G. J. et al.	2014	Can. J. of Fish. and Aq. Sci.	71	4	589-601	10.1139/cjfas-2013-0354
475	Effect of tributary and braided con fl uences on aquatic macroinvertebrate communities and geomorphology in an alpine river watershed	Clay P. A. et al.	2015	Freshwater Science	34	3	845-856	10.1086/682329.
476	Secondary production of highly unsaturated fatty acids by zoobenthos across rivers contrasting in temperature	Gladyshev M. I. et al.	2015	River Research and Applications	22		1085-1095	10.1002/rra.2945
477	The macrobenthos of the pristine stream, Skiftessaa, Høylandet, Norway	Aagaard K. et al.	1997	Hydrobiologia	348		81-94	10.1023/A:1003037200703
478	Mosses in High-Arctic lakes: in situ measurements of annual primary production and decomposition	Riis T. et al.	2016	Polar Biology	39	3	543-552	10.1007/s00300-015-1806-9
479	Slow growth and decomposition of mosses in Arctic lakes	Sand-Jensen K. et al.	1999	Can. J. of Fish. and Aq. Sci.	56	3	388-393	10.1139/f98-184
480	The processes and control of the microbial colonization and decomposition of plant litter in an arctic lake	Federle T. W. and Vestal J. R.	1980	Applied and Environmental Microbiology	39	4	888-893	
481	Temperature sensitivity of organic carbon mineralization in contrasting lake sediments	Gudasz C. et al.	2015	Journal of Geophysical Research: Biogeosciences	120		1215-1225	10.1002/2015JG002928
482	Benthic secondary production in eight oligotrophic arctic Alaskan lakes	Northington R. M. et al.	2010	J. of the North Am. Benth. Soc.	29	2	465-479	10.1899/09-026.1
483	Ecological studies on the decomposition rate of fish carcasses by benthic organisms in the littoral zone of Lake Constance, Germany	Premke K. et al.	2010	J. of the North Am. Benth. Soc.	46	3	157-168	10.1051/limn/2010017
484	Fish decomposition in boreal lakes and biogeochemical implications	Chidami S. and Amyot M.	2008	Limnology and Oceanography	53	5	1988-1996	10.4319/lo.2008.53.5.1988
485	Whole-lake mineralization of allochthonous and autochthonous organic carbon in a large humic lake (Örträsket, N. Sweden)	Jonsson A. et al.	2001	Limnology and Oceanography	46	7	1691-1700	10.4319/lo.2001.46.7.1691
486	Organic matter characterization and decomposition dynamics in sub Antarctic streams impacted by invasive beavers	Ulloa E. et al.	2012	Latin American Journal of Aquatic Research	40	4	881-892	10.3856/vol40-issue4-fulltext-6
487	Can pelagic net heterotrophy account for carbon fluxes from eastern Canadian lakes?	Dubois K. et al.	2009	Applied Geochemistry	24	5	988-998	10.1016/j.apgeochem.2009.03.001
488	Ecosystem metabolism and greenhouse gas production in a mesotrophic northern temperate lake experiencing seasonal hypoxia	Salk K. R. et al.	2016	Biogeochemistry	131	3	303-319	10.1007/s10533-016-0280-y
489	Plankton metabolism and physical forcing in a productive embayment of a large oligotrophic lake: insights from stable oxygen isotopes	Bocaniov S. A. et al.	2012	Freshwater Biology	57	3	481-496	10.1111/j.1365-2427.2011.02715.x
490	Consequences for pelagic energy mobilisation of a sudden browning episode without a clear increase in DOC concentration: a case of a boreal pristine lake	Peltomaa E. and Ojala A.	2016	Aquatic Sciences	78	4	627-639	10.1007/s00027-015-0452-1
491	The Stoichiometry of Carbon, Nitrogen, and Phosphorus in Particulate Matter of Lakes and Oceans	Hecky R. E. et al.	1993	Limnology and Oceanography	38	4	709-724	10.4319/lo.1993.38.4.0709
492	Organic carbon decomposition rates controlled by water retention time across inland waters	Catalán N. et al.	2016	Nature Geoscience	9	May	1-7	10.1038/ngeo2720

493	Effects of Acid on Plant Litter Decomposition in an Arctic Lake	McKinley V. L. and Vaestel J. R.	1982	Applied and Environmental Microbiology	43	5	1188-1195	
494	Biogenic carbon flows through the planktonic food web of the Amundsen Gulf (Arctic Ocean): A synthesis of field measurements and inverse modeling analyses	Forest A. et al.	2011	Progress in Oceanography	91	4	410-436	10.1016/j.pocean.2011.05.002
495	Salp contributions to vertical carbon flux in the Sargasso Sea	Stone J. P. and Steinberg D. K.	2016	Deep-Sea Research Part I: Oceanographic Research Papers	113		90-100	10.1016/j.dsr.2016.04.007
496	Decomposition rate of the giant jellyfish <i>Nemopilema nomurai</i> in Sado Island.	Igushi N. et al.	2006	FRA, Japan Sea National Fisheries Research Institute report.				http://jsnfri.fra.affrc.go.jp/Kurage/kurage_hp18/Sado_bunkai.pdf .
497	Response of Bacterial Communities to Different Detritus Compositions in Arctic Deep-Sea Sediments	Hoffmann K. et al.	2017	Frontiers in Microbiology	8	Febru ary	Art.266	10.3389/fmicb.2017.00266
498	'Total' sediment biomass and preliminary estimates of organic carbon residence time in deep-sea benthos	Rowe G. et al.	1991	Marine Ecology Progress Series	79	1-2	99-114	10.3354/meps079099
499	Fish food in the deep sea: Revisiting the role of large food-falls	Higgs N. D. et al.	2014	PlosOne	9	5	e96016	10.1371/journal.pone.0096016
500	Food for the deep sea: utilisation, dispersal and flux of necton falls at the Santa Catalina Basin floor	Smith C. R.	1985	Deep-Sea Research	32	4	417-442	10.1371/journal.pone.0096016
501	Trophic flows, kelp culture and fisheries in the marine ecosystem of an artificial reef zone in the Yellow Sea	Wu Z. et al.	2016	Estuarine, Coastal and Shelf Science	182		86-97	10.1016/j.ecss.2016.08.021
502	Macroscopic network properties and short-term dynamic simulations in coastal ecological systems at Fildes Bay (King George Island, Antarctica)	Ortiz M. et al.	2016	Ecological Complexity	28		145-157	10.1016/j.ecocom.2016.06.003
503	Trophic network model of the Northern Adriatic Sea: Analysis of an exploited and eutrophic ecosystem	Barausse A. et al.	2009	Estuarine, Coastal and Shelf Science	83	4	577-590	10.1016/j.ecss.2009.05.003
504	Food-web dynamics in the South Catalan Sea ecosystem (NW Mediterranean) for 1978-2003	Coll M. et al.	2008	Ecological Complexity	217	1-2	95-116	10.1016/j.ecolmodel.2008.06.013
505	Anthropogenic Enrichment Alters a Marine Benthic Food Web	Tewfik A. et al.	2013	Ecology	86	10	2726-2736	10.1890/04-1537
506	Meiofaunal production and energy transfer efficiency in a seagrass <i>Posidonia oceanica</i> bed in the western Mediterranean	Danovaro R. et al.	2002	Marine Ecology Progress Series	234		95-104	10.3354/meps234095
507	Ecosystem trophic structure and energy flux in the Northern Gulf of California, Mexico	Morales-Zárate M. V. et al.	2004	Ecological Modelling	174	4	331-345	10.1016/j.ecolmodel.2003.09.028
508	A preliminary trophic model of the continental shelf, south- western Gulf of Mexico	Manickchand-Heileman S. et al.	1998	Estuarine, Coastal and Shelf Science	46	6	885-899	10.1006/ecss.1997.0324
509	Balance between autotrophic and heterotrophic components and processes in microbenthic communities of sandy sediments: a field study.	Sundbäck K. et al.	1996	Estuarine, Coastal and Shelf Science	43		689-706	10.1006/ecss.1996.0097
510	Macrobenthic secondary production in the intertidal zone of the Ria Formosa – a lagoon in southern Portugal	Sprung M.	1994	Estuarine, Coastal and Shelf Science	38		539-558	10.1006/ecss.1994.1037
511	Estudio ecológico de la macrofauna del estuario de La Foz (NO de España): L Composición, estructura, variación estacional y producción de las comunidades	Anadón R.	1986	Investigacion Pesquera	44	3	407-444	
512	The Influence of Allochthonous Leaf Detritus on the Occurrence of Crustacean Detritivores in the Soft-bottom Macrobenthos of the Po River Delta Area (northwestern Adriatic Sea)	Mancinelli G. and Rossi L.	2002	Estuarine, Coastal and Shelf Science	54	5	849-861	10.1006/ecss.2001.0861
513	Tidal influence on particulate organic carbon export fluxes around a tall seamount	Turnewitsch R. et al.	2016	Progress in Oceanography	149		189-213	10.1016/j.pocean.2016.10.009
514	Vertical Carbon Flux of Biogenic Matter in a Coastal Area of the Aegean Sea: The Importance of Appendicularians	Zervoudaki S. et al.	2014	Estuaries and Coasts	37	4	911-924	10.1007/s12237-013-9723-z
515	Microbial respiration and trophic regimes in the Northern Adriatic Sea (Mediterranean Sea)	La Ferla R. et al.	2006	Estuarine, Coastal and Shelf Science	69	1-2	196-204	10.1016/j.ecss.2006.04.005
516	Microbial contribution to carbon biogeochemistry in the Central Mediterranean Sea: Variability of activities and biomass	La Ferla R. et al.	2005	Journal of Marine Research	57	1-2	146-166	10.1016/j.jmarsys.2005.05.001
517	Emergence of amphibiotic insects from a floodplain lake in the Usman Forest in the Central Russian forest steppe	Silina A. E.	2016	Contemporary Problems of Ecology	9	4	421-436	10.1134/S1995425516040107
518	Emergence of Trichoptera from Findley Lake and two ponds in the coniferous forest of the Cascade Mountains, USA	Sherk T. and Rau G.	1991	Proceedings of the 6th International Symposium on Trichoptera	26	2-4	321-330	
519	Macrobenthos. In: Hobbie et al. Limnology of tundra ponds: Barrow, Alaska	Butler M. et al.	1980	In: Hobbie et al. Limnology of tundra ponds: Barrow, Alaska	chapter 7		251-298	
520	Boomerang ecosystem fluxes: Organic carbon inputs from land to lakes are returned to terrestrial food webs via aquatic insects	Scharnweber K. et al.	2014	Oikos	123		1439-1448	10.1111/oik.01524
521	Dispersal of Terrestrial Plant Litter into a Subalpine Lake	Rau G. H.	1976	Oikos	27	1	153-160	10.2307/3543445
522	Airborne carbon deposition on a remote forested lake	Preston N. D. et al.	2008	Aquatic sciences	70	3	213-224	10.1007/s00027-008-8074-5
523	Mangrove (<i>Avicennia marina</i> subsp. <i>australasica</i>) litter production and decomposition in a temperate estuary	Gladstone-Gallagher R. V. et al.	2013	New Zealand Journal of Marine and Freshwater Research	48	1	24-37	10.1080/00288330.2013.827124
524	Substance and energy flows formed by the emergence of amphibiotic insects across the water–air boundary on the floodplain lakes of the Volga River	Djomina I. V. et al.	2016	Contemporary Problems of Ecology	9	4	407-420	10.1134/S1995425516040053
525	Periodical cicada detritus impacts stream ecosystem metabolism	Menninger H. L. et al.	2008	Ecosystems	11		1306-1317	10.1007/s10021-008-9194-4

526	Invasive European bird cherry (<i>Prunus padus</i>) reduces terrestrial prey subsidies to urban Alaskan salmon streams	Roon D. A. et al.	2016	Can. J. of Fish. and Aq. Sci.	73	11	1679-1690	10.1139/cjfas-2015-0548
527	A terrestrial-aquatic food web subsidy is potentially mediated by multiple predator effects on an arboreal crab	Yeager L. A. et al.	2016	Journal of Experimental Marine Biology and Ecology	475		73-79	10.1016/j.jembe.2015.10.017
528	How hydroperiod and species richness affect the balance of resource flows across aquatic-terrestrial habitats	Schriever T. A. et al.	2014	Aquatic sciences	76	1	131-143	10.1007/s00027-013-0320-9
529	Above and belowground organic matter and root, shoot ratio in a cerrado in Central Brazil.	Abdala G. C. et al.	1998	Brazilian Journal of Ecology	2	1		http://www.seb-ecologia.org.br/revista2/art2.html
530	Biomass, nutrient pools and response to fire in the Brazilian cerrado	Castro de E. A.	1996	MSc Thesis, Oregon State University, USA				http://hdl.handle.net/1957/35021
531	An African savannas: synthesis of the Nylsvley study.	Scholes R. J. and Walker B. H.	1993	book, Cambridge University press, Cambridge, UK				10.1017/CBO9780511565472
532	Reconstructing the seasonal dynamics and relative contribution of the major processes sustaining CO2 emissions in northern lakes	Vachon D. et al.	2016	Limnology and Oceanography	62	2	706-722	10.1002/lno.10454
533	The role of sediments in the carbon budget of a small boreal lake	Chmiel H. E. et al.	2016	Limnology and Oceanography	61	5	1814-1825	10.1002/lno.10336
534	Seasonality of photochemical dissolved organic carbon mineralization and its relative contribution to pelagic CO2 production in northern lakes	Vachon D. et al.	2016	Journal of Geophysical Research: Biogeosciences	121	3	864-878	10.1002/2015JG003244
535	High net CO2 and CH4 release at a eutrophic shallow lake on a formerly drained fen	Franz D. et al.	2016	Biogeosciences	13	10	3051-3070	10.5194/bg-13-3051-2016
536	Metabolic and physiochemical responses to a whole-lake experimental increase in dissolved organic carbon in a north-temperate lake	Zwart J. A. et al.	2016	Limnology and Oceanography	61	2	723-734	10.1002/lno.10248
537	Assessment of Top-Down and Bottom-Up Controls on the Collapse of Alewives (<i>Alosa pseudoharengus</i>) in Lake Huron	Kao Y.-C. et al.	2016	Ecosystems	19	5	803-831	10.1007/s10021-016-9969-y
538	Application of Ecopath model on trophic interactions and energy flows of impounded Manwan reservoir ecosystem in Lancang River, southwest China	Deng L. et al.	2015	Journal of Freshwater Ecology	30	2	281-297	10.1080/02705060.2014.942893
539	Contributions of mesozooplankton to vertical carbon export in a coastal upwelling system	Stukel M. R. et al.	2013	Marine Ecology Progress Series	491		47-65	10.3354/meps10453
540	Responses of a beaded Arctic stream to short-term N and P fertilisation	Benstead J. P. et al.	2005	Freshwater Biology	50	2	277-290	10.1111/j.1365-2427.2004.01319.x
541	Organic carbon flux and particulate organic matter composition in Arctic valley glaciers: Examples from the Bayelva River and adjacent Kongsfjorden	Zhu Z.-Y. et al.	2016	Biogeosciences	13	4	975-987	10.5194/bg-13-975-2016
542	Seasonal variation of allochthonous and autochthonous energy inputs in an Alpine stream	Fenoglio S. et al.	2015	Journal of Limnology	74	2	272-277	10.4081/jlimnol.2014.1082
543	Seasonal fluxes and age of particulate organic carbon exported from Arctic catchments impacted by localized permafrost slope disturbances	Lamoureux S. F. and Lafrenière M. J.	2014	Environmental Research Letters	9	4	45002	10.1088/1748-9326/9/4/045002
544	Recent particulate organic carbon and total suspended matter fluxes from the Ob and Yenisei Rivers into the Kara Sea (Siberia)	Gebhart A. C. et al.	2004	Marine Geology	207		225-245	10.1016/j.margeo.2004.03.010
545	Precipitation and net ecosystem exchange are the most important drivers of DOC flux in upland boreal catchments	Pumpanen J. et al.	2014	Journal of Geophysical Research: Biogeosciences	119		1861-1878	10.1002/2014JG002705
546	Sunlight controls water column processing of carbon in arctic fresh waters	Cory R. M. et al.	2014	Science	345	6199	925-928	10.1126/science.1253119
547	Environmental controls of whole-stream metabolism identified from continuous monitoring of Basque streams Oihana	Izagirre O. et al.	2008	J. of the North Am. Benth. Soc.	27	2	252-268	10.1899/07-022.1
548	Temperature and the metabolic balance of streams	Demars B. O. L. et al.	2011	Freshwater Biology	56	6	1106-1121	10.1111/j.1365-2427.2010.02554.x
549	Ecosystem Alteration of Boreal Forest Streams by Beaver (<i>Castor Canadensis</i>)	Naiman R. J. et al	1986	Ecology	67	5	1254-1269	10.2307/1938681
550	Bacterial production and losses to predators along an open ocean productivity gradient in the Subtropical North East Atlantic Ocean	Vaqué D. et al.	2014	Journal of Plankton Research	36	1	198-213	10.1093/plankt/fbt085
551	High bacterial production, uptake and concentrations of dissolved organic matter in the Central Arctic Ocean	Rich J. et al.	1997	Deep-Sea Research Part II: Topical Studies in Oceanography	44	8	1645-1663	10.1016/S0967-0645(97)00058-1
552	Plankton respiration and carbon flux through bacterioplankton on the Louisiana shelf	Biddanda B. et al.	1994	Limnology and Oceanography	39	6	1259-1275	10.4319/lo.1994.39.6.1259
553	Nutrient pulses driven by internal solitary waves enhance heterotrophic bacterial growth in the South China Sea	Chen T.-Y. et al.	2016	Environmental Microbiology	18	12	4312-4323	10.1111/1462-2920.13273
554	Heterotrophic bacterial responses to the winter-spring phytoplankton bloom in open waters of the NW Mediterranean	Gomes A. et al.	2015	Deep-Sea Research Part I: Oceanographic Research Papers	95		59-68	10.1016/j.dsr.2014.11.007
555	Heterotrophic bacterial production and metabolic balance during the VAHINE mesocosm experiment in the New Caledonia lagoon	Van Wambeke F. et al.	2016	Biogeosciences	13	11	3187-3202	10.5194/bg-13-3187-2016
556	Annual mass drownings of the Serengeti wildebeest migration influence nutrient cycling and storage in the Mara River	Subaluski A. L. et al.	2017	Proceedings of the National Academy of Science	114	29	7647-7652	10.1073/pnas.1614778114

557	Vertical flux of respiratory carbon by oceanic diel migrant biota	Longhurst A. R. et al.	1990	Deep-Sea Research Part I: Oceanographic Research Papers	37	4	685-694	10.1016/0198-0149(90)90098-G
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