Ecosystem Service

Table of Contents

Ecosystem Service

Ecosystem Service 2016

Viana, D. S., L. Santamaría, and J. Figuerola. 2016. Migratory Birds as Global Dispersal Vectors. *Trends in Ecology & Evolution* **31**:763-775.

(Abstract)

Propagule dispersal beyond local scales has been considered rare and unpredictable. However, for many plants, invertebrates, and microbes dispersed by birds, long-distance dispersal (LDD) might be regularly achieved when mediated by migratory movements. Because LDD operates over spatial extents spanning hundreds to thousands of kilometers, it can promote rapid range shifts and determine species distributions. We review evidence supporting this widespread LDD service and propose a conceptual framework for estimating LDD by migratory birds. Although further research and validation efforts are still needed, we show that current knowledge can be used to make more realistic estimations of LDD mediated by regular bird migrations, thus refining current predictions of its ecological and evolutionary consequences.

Greenland-Smith, S., J. Brazner, and K. Sherren. 2016. Farmer perceptions of wetlands and waterbodies: Using social metrics as an alternative to ecosystem service valuation. *Ecological Economics* **126**:58–69.

(Abstract)

The ecosystem goods and services (EGS) model is implicit in many conservation schemes, including agricultural extension programmes with the aim of conserving and protecting wetlands and waterbodies. The design of such programmes requires an understanding of how farmers perceive these features, their associated cost and benefits. Very little research has sought to do this. Employing unstructured interviews with 18 farmers and using ponds and two wetland types on their Nova Scotia farms as in situ visual prompts, we determine which wetland- and pond-related services are recognized by, and most important to, farmers. We see that wetlands and ponds are not valued equally, and that farmers consider ‘farm ponds’ most valuable in EGS terms. We also see seasonal variation in farmer perceptions and recommend multiple-visit elicitation accordingly to establish robust understanding. We analyse our results in the broader context of EGS literature and make comparisons to economic valuations of similar wetlands and ponds from the TEEB database. The implications of this study for effectively integrating extant EGS frameworks with agricultural extension programmes are discussed. Possibilities for improved wetland and waterbody conservation in the agricultural landscape are presented.

Klimaszyk, P., and P. Rzymski. 2016. The complexity of ecological impacts induced by great cormorants. *Hydrobiologia* **771**:13–30.

(Abstract)

Following decades of global extermination, the general population of the great cormorant (*Phalacrocorax carbo L.*) is on the rise. The lack of regular predators, highly skilled fish rapacity,

rapid metabolism, significant rate of excretion and ability to form large nesting colonies on relatively small areas lead to numerous environmental consequences of cormorant presence. Here we comprehensively review the occurrence and distribution of this species and, in particular, its multi-faceted impact on terrestrial and aquatic ecosystems and the main routes through which these impacts are being manifested. The bird-induced chemical loading and its biological and ecological consequences, and the effects on microbial pollution and pathogen dispersion are discussed in particular. The need for further investigation to fully elucidate particular effects is stressed throughout the paper. It is concluded that the environmental effects of great cormorants are rather complex, can lead to serious ecosystem modifications and that the presence of these birds should be taken into consideration in ecological assessment and monitoring.

Ecosystem Service 2015

Whelan, C., C. H. Sekercioglu, and D. G. Wenny. 2015. Why birds matter: from economic ornithology to ecosystem services. *Journal of Ornithology* **156**:S227–S238.

(Abstract)

Birds are conspicuous in many habitats, occur worldwide, are ecologically diverse, and are better known than other vertebrate groups. Birds devour pests, pollinate flowers, disperse seeds, scavenge carrion, cycle nutrients, and modify the environment in ways that benefit other species. Investigation of these ecosystem functions directly as ecosystem services has grown immensely over the last two decades and the ecological relevance of birds is well established. Birds are also observed, fed, and used as artistic and spiritual inspiration by millions of people around the globe. Yet the economic relevance of birds is not widely appreciated and the economic relevance to human society of birds' ecological roles is even less understood. Quantifying the services provided by birds is crucial to understand their importance for ecosystems and for the people that benefit from them. In this paper, we briefly review the rise and fall of economic ornithology and call for a new economic ornithology with heightened standards and a holistic focus within the ecosystem services approach. Birds' ecological roles, and therefore, ecosystem services, are critical to the health of many ecosystems and to human well-being. By understanding and valuing bird services and disservices through careful natural history research, we can better assess the environmental consequences of bird declines and extinctions and communicate these findings to the public and policy makers, thereby increasing public support for the conservation of birds and their habitats.

Yang, Z., and T. Wang. 2015. Responses of estuarine circulation and salinity to the loss of intertidal flats – A modeling study. *Continental Shelf Research* **111**:159–173.

(Abstract)

Intertidal flats in estuaries are coastal wetlands that provide critical marine habitats to support wide ranges of marine species. Over the last century many estuarine systems have experienced significant loss of intertidal flats due to anthropogenic impacts. This paper presents a modeling study conducted to investigate the responses of estuarine hydrodynamics to the loss of intertidal flats in Whidbey Basin of Puget Sound on the northwest coast of North America. Changes in salinity intrusion limits in the estuaries, salinity stratification, and circulation in intertidal flats and estuaries were evaluated by comparing model results under the existing baseline condition and the no-flat condition. Model results showed that loss of intertidal flats results in an increase in salinity intrusion, stronger mixing, and a phase shift in salinity and velocity fields in the bay front areas. Model results also indicated that loss of intertidal flats enhances two-layer circulation, especially the bottom water intrusion. Loss of intertidal flats increases the mean salinity but reduces the salinity range in the subtidal flats over a tidal cycle because of increased mixing. Salinity intrusion limits extend upstream in all three major rivers discharging into Whidbey Basin when no intertidal flats are present. Changes in salinity intrusion and estuarine circulation patterns due to loss of intertidal flats affect the nearshore habitat and water quality in estuaries and potentially increase risk of coastal hazards, such as storm surge and coastal flooding. Lastly, model results suggested the importance of including intertidal flats and the wetting-and-drying process in hydrodynamic simulations when intertidal flats are present in the model domain.

Colloff, M. J., N. D. Crossman, and I. C. Overton. 2015. Ecosystem services from the Coorong, Lakes Alexandrina and Albert Ramsar site., *CSIRO Land and Water, Canberra*.

(Abstract)

Critical components, processes and services (CPS) have been identified as part of an update of the Ecological Character Description of the Coorong and Lakes Ramsar site. We present the evidence base for the supply of 26 ecosystem services from the Coorong and Lakes Ramsar site. Of these, the most important for human well-being based on income generation are commercial and recreational fisheries, irrigation and domestic water supply, flow connectivity and water quality, habitat and resource provision for biodiversity, tourism and recreation. All are dependent, directly or indirectly, upon the flow regime as the over-arching driver of the ecological character of the site. Reductions in freshwater inflows and consequent increases in salinity and low lake levels during the Millennium Drought (1999-2009) led to reductions in supply of some major ecosystem services, though there is some evidence of recovery after the drought broke in 2010. Historical water resource development has led to deterioration in ecosystem condition. Under climate change, unless water allocation arrangements are altered, flows to the site are likely to decrease. Salinity in the Lakes increases as barrage outflows to the Coorong decline. Supply of some ecosystem services is

likely to decline where altered flows and salinity are linked directly or indirectly to ecological components, habitat availability and ecosystem processes. Continued decline in flow, and increase in salinity, as primary determinants of the ecological character of the site due to climate change is likely to lead to major shifts in the nature and extent of supply of ecosystem services in the future. The determination of those ecosystem services that can continue to be supplied under climate change is an urgent priority and should include an assessment of those ecosystem services that will need to be managed for in the future in order to ensure supply and the successful adaptation to climate change for those communities that depend upon those services for their livelihoods.

Reynolds, C., N. A. F. Miranda, and G. S. Cumming. 2015. The role of waterbirds in the dispersal of aquatic alien and invasive species. *Diversity and Distributions* **21**:744–754.

(Abstract)

Aim: To review existing literature on the ability of waterbirds to spread aquatic alien and invasive species, and to assess the relevance of bird-mediated dispersal for the conservation of freshwater ecosystems.

Location: Global.

Methods: Literature review.

Results: A systematic review of the literature revealed that quantitative studies investigating dispersal of alien organisms by waterbirds are rare (n = 14). Most studies citing waterbird dispersal rely on anecdotes or inferences from morphological dispersal syndromes. However, evidence from each stage of dispersal (i.e. emigration, transport and immigration) shows that waterbirds can carry alien plants and invertebrates internally and externally; transport them between water bodies at a variety of spatial scales; and deposit viable propagules in sites suited to aquatic invasive species.

Main conclusions: Our review suggests that waterbirds can and do act as important dispersal vectors for freshwater invasive species. Further experimental and field based research on the numbers and viability of moved alien propagules, and the roles of different species in the bird community, is needed. Furthermore, consideration of the spatially explicit manner in which birds move is imperative to understanding invasive spread. Populations of alien aquatic species in seemingly isolated wetlands can no longer be considered contained if they are able to be spread through waterbird-mediated dispersal, and containment measures must recognize such opportunities for further spread. Changing waterbird movement patterns, driven by climate and land use change, further add to the challenge of managing invasive species and offers an interesting opportunity for future research. The study of waterbird-mediated dispersal of aquatic alien invasive species provides insights not only into species invasions, but more generally into movement ecology, population ecology and biogeography.

Okuyama, T. 2015. Valuing the recreational benefits of wetland biodiversity. *International Journal of Biodiversity and Conservation* **7**:330-345.

(Abstract)

Loss in biodiversity of wetlands is a worldwide problem in maintaining the ecosystem of the earth. Thus, environmental valuation studies have performed benefit calculations to show the value of biodiversity. Here, few studies use the revealed preference methods due to the lack of data on wetland biodiversity. To solve this issue, this paper presented an approach to create data using expert judgment. Data on total numbers of representative species (TNRS) which were selected by experts was employed as indicators of the biodiversity of wetlands, and data on wetland area (AREA) were also employed for analysis. Data on travel behaviors to eleven Ramsar wetlands in Hokkaido, Japan were applied in the repeated discrete choice model. The results indicate that the approach of this paper would be applicable for estimating the relationship between individual behaviors and the biodiversity of wetlands. Next, benefit calculations were performed under the hypothesis that the values of AREA and TNRS improves by 10, 50, and 90%. The benefits of increasing wetland areas ranged from JPY 1 (USD 0.01) per year to JPY 14,901 (USD 182.19) per year. Those of improving wetland biodiversity ranged from JPY 44 (USD 0.54) per year to JPY 3,190 (USD 39.00) per year. Two types of wetlands were revealed by calculations. The first type includes wetlands in which the benefits of AREA are larger than those of TNRS. The second type includes wetlands in which the benefits of TNRS are larger than those of AREA, and the feature of the second type is that the wetland area is smaller than the first type. It means that large wetlands should be protected, and the small one with high biodiversity. Consequently, the research on wetlands species is required. The result indicates that benefits are connected to recreational services of wetland ecosystems.

Hansen, L., D. Hellerstein, M. Ribaudo, J. Williamson, D. Nulph, C. R. Loesch, and W. Crumpton. 2015. Targeting investments to cost effectively restore and protect wetland ecosystems: Some economic insights., U.S. Department of Agriculture, Economic Research Service, Economic Research Report Number 183.

(Abstract)

USDA has spent more than $4.2 billion on wetland restoration and protection over the last two decades. One challenge in allocating these funds is the lack of information on variations in wetland benefits and costs across the Nation. This report discusses the biophysical impacts of new wetlands for eight benefit categories: duck hunting, carbon sequestration, flood protection, nitrogen removal, species protection, open space, sediment removal, and groundwater recharge, as well as the value of these impacts for some categories. In addition, it presents county-level estimates of the costs of restoring and preserving wetlands for some

parts of the United States. Although the estimates range in precision and are not comprehensive, they call attention to some areas where the benefits of new wetlands are likely to exceed costs or perhaps may be insignificant. For example, the benefits of restoring and preserving wetlands near the Missouri River in central North and South Dakota are likely to exceed costs. Findings underscore the need for additional information that may increase the number, accuracy, and spatial resolution of wetland benefit estimates.

Navedo, J. G., S. Hahn, M. Parejo, J. M. Abad-Gómez, J. S. Gutiérrez, A. Villegas, J. M. Sánchez-Guzmán, and J. A. Masero. 2015. Unravelling trophic subsidies of agroecosystems for biodiversity conservation: Food consumption and nutrient recycling by waterbirds in Mediterranean rice fields. *Science of the Total Environment* **511**:288–297.

(Abstract)

Waterbirds can reallocate a considerable amount of nutrients within agricultural fields and between agriculture sites and wetlands. However, their effects on biogeochemical cycles have rarely been quantified. We estimated bird numbers, diet (from stable isotope analysis), food supply, and the food consumption on rice fields by overwintering waterbirds in one of the most important areas for rice production in southwestern Europe and a key area for various migrating and resident waterbird species. Herein, we modelled the nutrient (N and P) recycling in rice fields, and their transport to reservoirs. The energy consumption by waterbirds (96,605 ± 18,311 individuals) on rice fields during winter averaged at 89.9 ± 39.0 kJ/m, with its majority (89.9%) belonging to foraging on rice seeds. Thus, the birds removed about 26% of rice seeds leftover after harvest (estimated in 932.5±504.7 seeds/m in early winter) wherein common cranes and dabbling ducks (four species) were the most important consumers. Waterbirds foraging and roosting in the rice fields recycled more than 24.1 (1.0 kg/ha) of N and an additional 5.0 tons (0.2 kg/ha) of P in the Extremadura's rice fields during winter. Additionally, we estimated that 2.3 tons of N and 550 kg of P were removed from rice fields and transported to reservoirs. The seasonal foraging of wildlife should result in a direct benefit for rice farmers by improving nutrient recycling through defecation by waterbirds with respect to artificial fertilisation. Additionally, rice fields located in the cranes' core wintering areas can provide sufficient food supply to induce habitat shift from their traditional wintering habitat in 'dehesas' to rice fields, which causes indirect socioeconomic benefit through reduced acorn consumption by cranes. Our modelling approach may thus be especially helpful for management decisions regarding rice agroecosystems in areas which are also important for the conservation of migratory waterbirds.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. J. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. Changes in the global value of ecosystem services. *Global Environmental Change* **26**:152–158.

(Abstract)

In 1997, the global value of ecosystem services was estimated to average $33 trillion/yr in 1995 $US ($46 trillion/yr in 2007 $US). In this paper, we provide an updated estimate based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. We also address some of the critiques of the 1997 paper. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 is $125 trillion/yr (assuming updated unit values and changes to biome areas) and $145 trillion/yr (assuming only unit values changed), both in 2007 $US. From this we estimated the loss of eco-services from 1997 to 2011 due to land use change at $4.3–20.2 trillion/yr, depending on which unit values are used. Global estimates expressed in monetary accounting units, such as this, are useful to highlight the magnitude of eco-services, but have no specific decision-making context. However, the underlying data and models can be applied at multiple scales to assess changes resulting from various scenarios and policies. We emphasize that valuation of ecoservices (in whatever units) is not the same as commodification or privatization. Many eco-services are best considered public goods or common pool resources, so conventional markets are often not the best institutional frameworks to manage them. However, these services must be (and are being) valued, and we need new, common asset institutions to better take these values into account.

Kronenberg J. 2014. What can the current debate on ecosystem services learn from the past? Lessons from economic ornithology. *Geoforum* **55**, 164–177.

(Abstract)

Economic ornithology, the golden age of which was 1880s–1920s, can be seen as an antecedent of the concept of ecosystem services. In hundreds of publications, and with official support from prominent government institutions, especially the US Department of Agriculture, economic ornithology emphasized the economic value of services provided by birds. Economic ornithologists underlined the utilitarian character of nature to raise political support for conservation. They contributed to the elimination of bounty laws on birds and feather trade, and to the introduction of bird conservation legislation. However, economic ornithology remained relatively narrow and focused on its core task of identifying useful and harmful birds, especially from the point of view of agriculture. Such an anthropocentric approach, prioritizing narrow and measurable human economic interests, undermined the standing of economic ornithology. Probably most importantly, new developments in the area of industrial pest control made the most highlighted of the birds' services obsolete. This article analyses similarities between economic ornithology and the concept of ecosystem services (in terms of their origins,

development, argumentation for conservation, and criticism). It suggests that unless the proponents of ecosystem services carefully rethink the way they argue for environmental conservation, this concept may share the fate of economic ornithology. Moving beyond the narrow utilitarian and anthropocentric focus, and beyond emphasizing the monetary value of nature, are the most important implications for the current environmental conservation discourse based on the concept of ecosystem services.

Ricaurte LF, Wantzen KM, Agudelo E, Betancourt B, Jokela J. 2014. Participatory rural appraisal of ecosystem services of wetlands in the Amazonian Piedmont of Colombia: elements for a sustainable management concept. *Wetlands Ecol Manage* 22, 343–361.

(Abstract)

Considering the rapid changes in land use in tropical countries and the difficulties of law enforcement in remote areas, management of ecosystems benefits from the landscape approach. Within the landscape approach it is important to assess the different livelihoods of the local populations, as well as the vulnerability of the ecosystems that are supporting these livelihoods. Specifically for wetlands in rural tropical areas that face fast developing agroindustrial land use change, there is little information available on the attitude of stakeholders considering the ecosystems they manage. We used a combination of participatory rural appraisal and participatory mapping methods on rural wetlands in the Amazonian Piedmont region in Colombia, an area that has hardly ever been studied. We found that 77.7 %of the current livelihoods depend directly on the provisioning ecosystem services delivered by the wetlands, where fishing and hunting are the most important services that contribute to the household income. Ecotourism, which is emerging as a promising source of income, was also pointed as one key ecosystem service. However, our results revealed that the wetlands in our study area are very vulnerable (up to 41 % endangered). The main causes for wetland deterioration were cattle ranching, invasive grasses, deforestation, drainage, and burning. We conclude with a brief overview on the pros and cons of reconciling wetland conservation and human development in sensitive regions such as the Amazonian Piedmont in Colombia and other similar regions in the Tropics.

Frazier MR, Lamberson JO, Nelson WG. 2014. Intertidal habitat utilization patterns of birds in a Northeast Pacific estuary. *Wetlands Ecol Manage*.

(Abstract)

A habitat-based framework is a practical method for developing models (or, ecological production functions, EPFs) to describe the spatial distribution of ecosystem services. To generate EPFs for Yaquina estuary, Oregon, USA, we compared bird use patterns among

intertidal habitats. Visual censuses were used to quantify abundance of bird groups and general species richness in: *Zostera marina* (eelgrass), *Upogebia* (mud shrimp)/mudflat, *Neotrypaea* (ghost shrimp)/sandflat, *Zostera japonica* (Japanese eelgrass), and low marsh estuarine habitats. Also assessed were (1) spatial variation within a habitat along the estuary gradient and, (2) temporal variation based on bi-monthly samples over a year at five tidal ranges. *Z. marina* was an important estuarine habitat based on nearly all metrics of bird use, except for shorebird densities. This suggests that reductions in native eelgrass habitat may reduce the abundance and diversity of birds in Yaquina estuary. Our results suggest that a habitat based assessment approach is generally feasible for developing relative EPFs related to the presence of birds within estuarine systems.

Lewis LR, Behling E, Gousse H, Qian E, Elphick CS, Lamarre J-F, Bety J, Liebezeit J, Rozzi R, Goffinet B. 2014. First evidence of bryophyte diaspores in the plumage of transequatorial migrant birds. *PeerJ* **2**, e424.

(Abstract)

Correlations between transequatorial migratory bird routes and bipolar biogeographic disjunctions in bryophytes suggest that disjunctions between northern and southern high latitude regions may result from bird-mediated dispersal; supporting evidence is, however, exclusively circumstantial. Birds disperse plant units (diaspores) internally via ingestion (endozoochory) or externally by the attachment of diaspores to the body (ectozoochory). Endozoochory is known to be the primary means of bird-mediated dispersal for seeds and invertebrates at local, regional, and continental scales. Data supporting the role of bird-mediated endozoochory or ectozoochory in the long distance dispersal of bryophytes remain sparse, however, despite the large number of bryophytes displaying bipolar disjunctions. To determine if transequatorial migrant shorebirds may play a role in the ectozoochory of bryophyte diaspores, we developed a method for screening feathers of wild birds. We provide the first evidence of microscopic bryophyte diaspores, as well as those from non-bryophyte lineages, embedded in the plumage of long distance transequatorial migrant birds captured in their arctic breeding grounds. The number of diaspores recovered suggests that entire migratory populations may be departing their northern breeding grounds laden with potentially viable plant parts and that they could thereby play significant roles in bipolar range expansions of lineages previously ignored in the migrant bird dispersal literature.

Green AJ, Elmberg J. 2014. Ecosystem services provided by waterbirds. *Biological Reviews* **89**, 105–122.

(Abstract)

Ecosystem services are ecosystem processes that directly or indirectly benefit human well-being. There has been much recent literature identifying different services and the communities and species that provide them. This is a vital first step towards management and maintenance of these services. In this review, we specifically address the waterbirds, which play key functional roles in many aquatic ecosystems, including as predators, herbivores and vectors of seeds, invertebrates and nutrients, although these roles have often been overlooked. Waterbirds can maintain the diversity of other organisms, control pests, be effective bioindicators of ecological conditions, and act as sentinels of potential disease outbreaks. They also provide important provisioning (meat, feathers, eggs, etc.) and cultural services to both indigenous and westernized societies. We identify key gaps in the understanding of ecosystem services provided by waterbirds and areas for future research required to clarify their functional role in ecosystems and the services they provide. We consider how the economic value of these services could be calculated, giving some examples. Such valuation will provide powerful arguments for waterbird conservation.

Ecosystem Service 2013 and earlier

2013

Natuhara, Y. 2013. Ecosystem services by paddy fields as substitutes of natural wetlands in Japan. *Ecological Engineering* **56**:97–106.

(Abstract)

This paper reviews research on the ecosystem services or multifunctionality of paddy rice cultivation in Japan, focusing on biodiversity as a basis for ecosystem services, with the aim of describing the current status and impact of the subject and exploring options for sustainable practices. Ecosystem services provided by paddy fields include; groundwater recharge, production of non-rice foods, flood control, soil erosion and landslide prevention, climate-change mitigation, water purification, culture and landscape, and support of ecosystems and biodiversity. Among these services, the value of services that regulate ecosystem functions was estimated to be US$ 72.8 billion in Japan. More than 5000 species have been recorded in paddy fields and the surrounding environment. Because paddy fields are artificially disturbed by water level management, plowing, and harvest, most species move between paddy fields and the surrounding environment. The linkage between paddy fields and the associated environment plays an important role in biodiversity. Two changes that have affected the ecosystem of paddy fields are modernization and abandonment of farming. Satoyama, a traditional socio-ecological production landscape, which provided a functional linkage between paddy fields and the associated environment has lost its functions. Biodiversity-conscious rice farming has been promoted by collaborations among farmers, consumers and governments. Biodiversity certification programs are successful examples of biodiversity-conscious framing. In these programs incentives include direct payments and/or premium prices paid by consumers, as well as farmers' willingness to improve the safety of

food and environment.

McInnes RJ. 2013. Recognizing Ecosystem Services from Wetlands of International Importance: An Example from Sussex, UK. *Wetlands* **33**, 1001–1017.

(Abstract)

The benefits human societies derive from wetlands are well established, although not necessarily enshrined in legislation or incorporated into local management regimes. The wise use of wetlands, as promulgated under the Ramsar Convention on Wetlands, is intended as a mechanism to ensure that the benefits delivered to society through ecosystem services are maintained and, where appropriate, restored. The designation process for Ramsar Sites explicitly records information on ecosystem services as well as the more traditionally recorded information on the biodiversity and management procedures. Analysis of four Ramsar Sites from the county of Sussex in southeast England showed that even for internationally important wetlands there is a failure to recognize the full value of the benefits provided and, importantly, several valuable ecosystem services remain unrecognized. The gap between recognized and unrecognized ecosystem services has implications for the consideration of wetlands in decision-making and the protection and wise use of all wetlands within Sussex and beyond. Conclusions drawn from the analysis of the examples presented are used to assist the future development of guidance for wetland managers and decision makers regarding the recognition of ecosystem services.

Washburn T, Sanger DM. 2013. Microhabitat variability of macrobenthic organisms within tidal creek systems. *Hydrobiologia* **702,** 15–25.

(Abstract)

Tidal creeks are transitional habitats between fresh and salt water with large spatial heterogeneity. As a result, there are most likely various microhabitats at different spatial scales. This study attempted to determine at what scales the macrobenthic communities in tidal creeks differ. Samples were collected in headwater, intertidally dominated areas and downstream, subtidally dominated areas of tidal creek habitats at three exposure levels. Samples were analyzed to determine distributions of dominant higher taxa of annelids, crustaceans, and mollusks with particular interest to two dominant species: the oligochaete *Monopylephorus rubroniveus* (Levinsen) and the polychaete *Streblospio benedicti* (Webster). Finally, family diversity, evenness, and community composition were examined. While *M. rubroniveus* was primarily found in intertidal exposures in the headwaters, *S. benedicti* was found throughout all of the creek lengths and exposure levels. Communities in the marsh appeared to be similar throughout the length of the creek.

Communities in the intertidal and subtidal exposure levels differed between the headwaters and downstream areas and between each other in the headwaters. PERMANOVA found communities to differ among all exposure levels and orders. Thus, it is important to take into account both longitudinal position and microhabitat when sampling these communities.

Barnes RSK. 2013. Distribution patterns of macrobenthic biodiversity in the intertidal seagrass beds of an estuarine system, and their conservation significance. *Biodiversity and Conservation***22,** 357-372.

(Abstract)

Intertidal stands of seagrass are important elements in the ecology of many estuaries yet the manner in which their associated macrobenthic biodiversity is distributed throughout any single estuary has never been determined. This has now been attempted for the Knysna estuarine bay in the Garden Route National Park, South Africa, an important site for one vulnerable and declining seagrass, Cape dwarf-eelgrass (*Nanozostera capensis*), and for several associated animals. Although spanning a salinity range of < 5–35, the seagrass beds of this estuary contained a unitary fauna with local variation in frequency and abundance of the various species. Faunal biodiversity was highest along the main estuarine channel in the marine-influenced region and declined both upstream and into the sheltered peripheral zones, overall faunal abundance being inversely correlated with species diversity (though not with species richness). This pattern results in the beds around the 4 km shoreline of a single island near the mouth supporting 91 % of the total macrobenthic invertebrate species present in the system. This situation is discussed in relation to such data as are available from other comparable systems and to the conservation of estuarine seagrass faunal biodiversity. It is concluded that in general and with caveats for some individual species of concern where conservation resources are limited attention would most profitably be focused on the seagrass meadows of downstream estuarine areas.

Palmer-Felgate EJ, Acreman MC, Verhoeven JTA, Scholz M, Maltby E, Stratford CJ, Newman J, Miller J, Coughlin D. 2013. How effective are reedbeds, ponds, restored and constructed wetlands at retaining nitrogen, phosphorus and suspended sediment from agricultural pollution in England? *Environmental Evidence* **2,** 1-6.

(Abstract)

A high priority topic within the Department for Environment, Food and Rural Affairs (DEFRA) water quality program is the mitigation of diffuse rural pollution from agriculture. Wetlands are often cited as being effective at reducing nutrient and sediment loadings to receiving waters. However, the research in this area is inconsistent, and whilst most studies have shown that

both natural and constructed wetlands retain nutrients and sediments, others have shown that they have little effect, or even increase nutrient and sediment loads to receiving water bodies. DEFRA has commissioned a systematic review on the use of wetlands to mitigate N, P and SS inputs from agriculture to receiving freshwater in England. The review will encompass a comprehensive literature search on all available material on the subject, both published and unpublished within the British Isles. Specific inclusion criteria will be adhered to and a formal assessment of the quality and reliability of the studies will be undertaken. The data will then be extracted and a data synthesis undertaken. The review will inform an evidence-based policy that can be implemented by stakeholders.

Reid JRW, Colloff MJ, Arthur ADA, McGinness HM. 2013. Influence of Catchment Condition and water resource development on waterbird assemblages in the Murray-Darling Basin, Australia. *Biological Conservation* **165,** 25–34.

(Abstract)

River regulation and water resource development have resulted in significant deterioration in aquatic ecosystems worldwide, including reductions in wetland extent, changed flow regimes, and declines in biodiversity. The impacts on the composition and distribution of waterbird assemblages has not been studied previously at the scale of a major river basin. We investigated the relationship between waterbird assemblage composition and ecosystem health across the 21 catchments of the Murray-Darling Basin in south-east Australia, which contains major wetlands that have been adversely affected by river regulation and over-allocation of water for irrigation. We allocated 51,000 surveys of 96 waterbird species, obtained from the New Atlas of Australian Birds database, to 117 one-degree grid squares for multivariate statistical analysis (MVA). Hierarchical clustering showed five main groups of squares reflecting strong biogeographic gradients. Pronounced spatial autocorrelation in the waterbird assemblage data was found. Unequal survey effort across grid squares and varying taxonomic scope also hindered conventional MVA and interpretation. To circumvent these constraints, survey data were recompiled at the half-degree square resolution after removing surveys with few waterbird records, leaving 17,448 surveys of 80 species. A novel sequential approach of multivariate regression of distance matrices, ordination of Bray–Curtis residuals, and post hoc correlation of the independent variable was used to test the hypothesis that assemblage composition varies systematically with Catchment Condition, after controlling for spatial autocorrelation, biogeographic trends and unequal survey effort. Ordination of the residuals of the half-degree square Bray–Curtis association matrix revealed a strong relationship between a nine-point index of Catchment Condition and waterbird assemblage composition. The colonial nesting waterbird guild (egrets, herons, ibis and spoonbills), was uniquely identified as being aligned with catchments in moderate to good condition. Waterbird assemblage composition shows significant spatial variation throughout the Murray-Darling Basin, influenced by the hydrological and ecological condition of catchments as well as by natural biogeographic factors. The least degraded catchments offer the best habitat for the colonially nesting waterbird guild, the group most adversely affected historically by river

regulation and water diversions. These catchments require protection from water resource development if such habitat is to be maintained. Our results support the conservation objective of improving wetland health in degraded catchments through delivering environmental flows to ensure breeding and population maintenance of colonial nesting waterbirds.

2012

Endo I, Walton M, Chae S, Park G-S. 2012. Estimating Benefits of Improving Water Quality in the Largest Remaining Tidal Flat in South Korea. *Wetlands* **32**, 487–496.

(Abstract)

This study, employing contingent behavior approach, examines the benefits of improving water quality in the largest remaining tidal flat in South Korea. The southern tidal flat of Ganghwa Island, a major stopping point for significant numbers of migratory birds on the Austral-Asian flyway, draws thousands of visitors every month. However, the current water quality, degraded due to pollution, negatively affects ecosystem services that the tidal flat provides for many creatures, including the last remaining populations of endangered black-faced spoonbill. Questionnaire surveys targeting visitors to the tidal flat have been conducted in 2009. Application of the negative binomial model has indicated that the total recreational value of the tidal flat is approximately 11.2 billion Korean won (KRW) per year. The annual benefits of improving the water quality by introducing sewage-treatment plants are estimated as KRW 13.4 billion, while the costs of constructing and operating the plants account for less than 3% of the benefits. There is a strong economic justification for investing in the plants to improve the water quality. These findings are useful for policymakers to positively consider public spending in the tidal flat conservation.

Legagneux P, Gauthier G, Berteaux D, Bêty J, Cadieux M-C, Bilodeau F, Bolduc E, McKinnon L, Tarroux A, Therrien J-F, Morissette L, Krebs CJ. 2012. Disentangling trophic relationships in a High Arctic tundra ecosystem through food web modeling. *Ecology* **93,** 1707-1716.

(Abstract)

Determining the manner in which food webs will respond to environmental changes is difficult because the relative importance of top-down vs. bottom-up forces in controlling ecosystems is still debated. This is especially true in the Arctic tundra where, despite relatively simple food webs, it is still unclear which forces dominate in this ecosystem. Our primary goal was to assess the extent to which a tundra food web was dominated by plant–herbivore or predator–prey interactions. Based on a 17-year (1993–2009) study of terrestrial wildlife on Bylot Island, Nunavut, Canada, we developed trophic mass balance models to address this question. Snow Geese were the dominant herbivores in this ecosystem, followed by two sympatric lemming

species (brown and collared lemmings). Arctic foxes, weasels, and several species of birds of prey were the dominant predators. Results of our trophic models encompassing 19 functional groups showed that < 10% of the annual primary production was consumed by herbivores in most years despite the presence of a large Snow Goose colony, but that 20–100% of the annual herbivore production was consumed by predators. The impact of herbivores on vegetation has also weakened over time, probably due to an increase in primary production. The impact of predators was highest on lemmings, intermediate on passerines, and lowest on geese and shorebirds, but it varied with lemming abundance. Predation of collared lemmings exceeded production in most years and may explain why this species remained at low density. In contrast, the predation rate on brown lemmings varied with prey density and may have contributed to the high-amplitude, periodic fluctuations in the abundance of this species. Our analysis provided little evidence that herbivores are limited by primary production on Bylot Island. In contrast, we measured strong predator–prey interactions, which supports the hypothesis that this food web is primarily controlled by top-down forces. The presence of allochthonous resources subsidizing top predators and the absence of large herbivores may partly explain the predominant role of predation in this low-productivity ecosystem.

Van der Zee EM, van der Heide T, Donadi S, Eklof JS, Eriksson BK, Olff H, van der Veer HW, Piersma T. 2012. Spatially Extended Habitat Modification by Intertidal Reef-Building Bivalves has Implications for Consumer-Resource Interactions. *Ecosystems* **15,** 664–673.

(Abstract)

Ecosystem engineers can strongly modify habitat structure and resource availability across space. In theory, this should alter the spatial distributions of trophically interacting species. In this article, we empirically investigated the importance of spatially extended habitat modification by reef-building bivalves in explaining the distribution of four avian predators and their benthic prey in the Wadden Sea—one of the world's largest intertidal soft-sediment ecosystems. We applied Structural Equation Modeling to identify important direct and indirect interactions between the different components of the system. We found strong spatial gradients in sediment properties into the surrounding area of mixed blue mussel (*Mytilus edulis*) and Pacific oyster (*Crassostrea gigas*) reefs, indicating large-scale (100s of m) engineering effects. The benthic community was significantly affected by these gradients, with the abundance of several important invertebrate prey species increasing with sediment organic matter and decreasing with distance to the reefs. Distance from the reef, sediment properties, and benthic food abundance simultaneously explained significant parts of the distribution of oystercatchers (*Haematopus ostralegus*), Eurasian curlews (*Numenius arquata*), and bar-tailed godwits (*Limosa lapponica*). The distribution of black-headed gulls (*Chroicocephalus ridibundus*)—a versatile species with many diet options—appeared unaffected by the reefs. These results suggest that intertidal reef builders can affect consumer-resource dynamics far beyond their own boundaries, emphasizing their importance in intertidal soft-bottom ecosystems like the Wadden Sea.

Rodríguez-Pérez H, Green AJ. 2012. Strong seasonal effects of waterbirds on benthic communities in shallow lakes. *Freshwater Science* **31,** 1273-1288.

(Abstract)

Little is known about the effects of waterbirds on benthic macroinvertebrates in nontidal habitats. We conducted 4 waterbird-exclusion experiments in a transformed marshland in Doñana Natural Park (southwestern Spain) and compared benthic macroinvertebrates in 3 × 3-m control (no exclusion) and test plots from which Greater Flamingos *Phoenicopterus ruber* or all waterbirds were excluded. The 4 experimental periods coincided with the waterbird breeding season (summer), postbreeding period (autumn), wintering period (winter), and pre- and early breeding season (spring). Densities of waterbirds were relatively low compared to densities reported in other studies, but we found strong effects of excluding flamingos and waterfowl on the structure of the benthic community in autumn, winter, and spring. In winter, numbers of polychaetes and chironomids were nearly 2× higher in exclusion than in control plots. The difference in macroinvertebrate biomass among treatments was strongest in winter when benthic dry mass was 2× higher in flamingo exclosures than in control plots and 2× higher in all-bird exclosures than in flamingo exclosures. Macroinvertebrate richness was 15% lower in control than in all-bird exclosures in winter and 25% lower in control than in all-bird exclosures in spring. Our results suggest that benthic macroinvertebrate communities in this wetland are affected more by predation, bioturbation, and waterbird herbivory than by competition. These findings suggest that waterfowl and the increasing population of flamingos are of great importance in structuring shallow lakes in the Mediterranean region.