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Wetlands in Drylands: 'Hotspots' of Ecosystem Services in Marginal Environments

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Introduction

Many of the world's extensive drylands host permanent and temporary wetlands, including features as diverse as floodplains, marshes, swamps, pans and oases. Their presence in climatically variable, moisture stressed environments means that these wetlands are key providers ('hotspots') of ecosystem services, including water and food supply. Land use, population and climate change threatens the functioning of many wetlands in drylands, however, and interdisciplinary scientific studies of the implications for ecosystem services are urgently needed to support sustainable development planning. This brief provides an overview of the state of scientific understanding of wetlands in drylands and their ecosystem services, and identifies key knowledge gaps and data requirements. This will provide the basis for informed discussion among policy makers as part of their preparations for the 2015 Global Sustainable Development Report.

Background

Ecosystem services are defined as the benefits that people obtain from ecosystems. The Millennium Ecosystem Assessment (MEA) provided a state-of-the-art appraisal of the condition of the world's ecosystem services, and assessed the consequences of ecosystem change for human wellbeing. The MEA classified ecosystem services into four main types: provisioning, regulating, supporting, and cultural. It also noted that although our human species is buffered against environmental changes by culture and technology, we remain fundamentally dependent on the flow of ecosystem services.

Alongside coverage of various terrestrial and marine ecosystems, the MEA gave special consideration to the world's wetlands. The marshes, fens, swamps, peatlands, shallow water bodies and rivers in tropical, temperate, arctic and dryland regions were noted as delivering a wide range of ecosystem services, such as water supply and purification, flood regulation, fish and fibre, medicinal plants, carbon sequestration, coastal protection, and recreational and tourism opportunities (MEA 2005). The MEA (2005) and UNEP's Global Deserts Outlook (Ezcurra 2006) both recognised that in climatically variable, moisture stressed drylands, wetlands may be disproportionately important for some aspects of ecosystem service provision. Indeed, in some arid or hyperarid settings, wetlands may provide the *only* supply of fundamental water and food resources.

Despite their recognised importance, scientific understanding of the functioning of wetlands in drylands and their associated ecosystem services is incomplete. In particular, despite pressures from land use, population and climate change, a number of critical knowledge gaps hamper attempts to manage wetlands in drylands for sustainable development. Are ecosystem services maximised when wetlands in drylands are converted for agriculture or when left in a semi-altered or largely natural state (Scoones 1991; Rebelo et al. 2010)? Even where wetlands in drylands are protected by legislation, other questions remain. For instance, should management priorities be to maximize water supply, water quality, biodiversity, carbon sequestration, or other ecosystem services?

The foregoing illustrates that wetlands in drylands and their ecosystem services span the three dimensions of sustainable development: environmental, social and economic. Considering the Millennium Development Goals beyond 2015, wetlands in drylands can still make a critical contribution to eradication of poverty and hunger and to ensuring environmental sustainability. To realize this potential, however, there is an urgent need for interdisciplinary scientific studies of different wetlands in drylands, rigorous assessment of potential changes to ecosystem service provision, and translation of such findings into management policy and practice.

Wetlands in drylands: facts and figures

- According to UNEP (1992), drylands include hyperarid, arid, semiarid and dry subhumid environments, and collectively cover ~50% of Earth's land surface.
- Various permanent and temporary wetlands can persist in drylands wherever there is a positive surface water balance for at least part of the year. This commonly occurs where river inflows combine with factors that impede drainage, including tectonic faulting, swelling soils, and ponding by wind-blown sediments (Tooth and McCarthy 2007).
- Individual wetlands in drylands may be small in comparison to some wetlands in more humid environments but collectively can cover a significant area (e.g. ~5% of the sub-Saharan African land surface – Rebelo et al. 2010).
- Wetlands occupy transitions between terrestrial and aquatic environments, and are maintained by complex interactions between the atmosphere, geosphere, hydrosphere, and biosphere. As part of living and working landscapes, wetlands also interface with social, political, and economic spheres. Hence, they can form a key part of sustainable development planning.

Scientific debates

Most scientific studies have tended to focus on the more-or-less permanently-saturated tropical, temperate and arctic wetlands (Mitsch and Gosselink 2007), and it is commonly assumed that findings can be readily transferred to drylands. But how does the climatic variability and strong moisture deficit in drylands influence wetland character and function? Tooth and McCarthy (2007) proposed that by comparison with humid region wetlands, many wetlands in drylands are distinguished by: 1) more frequent and/or longer periods of desiccation; 2) channels that commonly decrease in size and even disappear downstream; 3) higher levels of chemical sedimentation owing to greater evapotranspiration and non-biological and biological sequestration; 4) more frequent fires that reduce the potential for thick organic accumulations and promote wind erosion; and 5) longer timescales of development that may extend back many tens of thousands of years. These propositions can be re-examined in terms of ecosystem service provision, although additional data are needed to answer some fundamental questions. Do wetlands in drylands necessarily serve to purify water for downstream users, or might there be situations where water quality actually decreases downstream of wetlands, such as when dry season grazing increases fecal contamination of the desiccating water bodies (Alexander and Blackburn 2013)? How do downstream decreases in channel size and high evapotranspirative losses influence the transport and storage of pollutants entering wetlands (Ellery et al. 2009)? Are wetlands in drylands stores of carbon (e.g. through incorporation of atmospheric CO_2 into vegetation and organic-rich soils) and therefore important contributors to global climate regulation, or do dry season fires simply burn off the vegetation and organics, thereby returning CO_2 straight back to the atmosphere (Kotze 2013)? Did some wetlands in drylands play an important role in early human origins by enabling survival and migration in marginal environments (Reynolds et al. 2011)?

These gaps in scientific understanding couple with uncertainties over the economic valuation of some ecosystem services (ten Brink et al. 2012), making it difficult to manage wetlands for sustainable

development. To what extent are the provisioning, regulating, supporting and cultural services compatible? When wetlands in drylands are the subject of competing human interests (e.g. agriculture versus conservation), how do we resolve potential conflicts and maximize ecosystem service provision for the widest possible benefit of present society and future generations? New holistic analyses of wetlands in drylands and their ecosystem services are needed to address such questions.

Wetlands in drylands: scientific research to support sustainable development

- Most wetlands researchers have tended to focus descriptions or analyses on short timescales (e.g. weeks, months, years) and long-term (decades or more) anthropogenic and climatic changes influencing wetlands are poorly understood.
- In wetlands in drylands, critical data and knowledge gaps include the influence of seasonal or longer term desiccation on waterborne diseases, pollutant dispersal, and carbon dynamics.
- Without integrated understanding of the functioning of wetlands in drylands, full assessment of the implications for ecosystem service provision under various land use, population and climate change scenarios cannot be made.
- These assessments are critical for underpinning sustainable development policies for wetlands in drylands, and thereby ensuring continued benefits to society.

Issues for further consideration

A recent workshop on wetlands in drylands[1] highlighted the need for sustained engagement in wetland science and management. Identification of key requirements can form the basis for consideration by policy makers:

- Expansion of an international forum to strengthen the wetland in dryland science-policy interface;
- Greater sharing and exchange of field, laboratory, remotely sensed or computational data;
- Holistic analyses of wetlands in drylands and their ecosystem services in the past, present, and future. For instance, studies of past wetland dynamics and their importance to human evolutionary and behavioural development can improve societal appreciation of wetland cultural services, provide context for present management challenges, and help to anticipate and manage future changes to provisioning, regulating and supporting ecosystem services;
- Promotion of sustainable development approaches that integrate wetland protection, rehabilitation and artificial construction with 'source-to-sink' catchment management approaches. Wetlands in drylands and their ecosystem services may play a key role in enhancing societal resilience to future changes.

Footnote:

1. A workshop entitled "Wetlands in Drylands: Past, Present and Future Trends in Ecosystem Service Provision" was held near Parys, Free State Province, South Africa (9^{th}-12^{th} November 2014). The workshop was administered by the Royal Society and jointly funded through the Department for Business Innovation and Skills (UK) and the National Research Foundation (South Africa), and was attended by 17 predominantly early-mid career scientists, representing 11 universities in South Africa and overseas. A declaration on the 'Status and Future of Wetlands in Drylands' that incorporates some of the points made here is being prepared by the workshop participants, and will be hosted on a bespoke website.

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