Interregional flows of ecosystem services: Concepts, typology and four cases

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A B S T R A C T

Conserving and managing global natural capital requires an understanding of the complexity of flows of ecosystem services across geographic boundaries. Failing to understand and to incorporate these flows into national and international ecosystem assessments leads to incomplete and potentially skewed conclusions, impairing society’s ability to identify sustainable management and policy choices. In this paper, we synthesise existing knowledge and develop a conceptual framework for analysing interregional ecosystem service flows. We synthesise the types of such flows, the characteristics of sending and receiving socio-ecological systems, and the impacts of ecosystem service flows on interregional sustainability. Using four cases (trade of certified coffee, migration of northern pintails, flood protection in the Danube watershed, and information on giant pandas), we test the conceptual framework and show how an enhanced understanding of interregional telecouplings in socio-ecological systems can inform ecosystem service-based decision making and governance with respect to sustainability goals.

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1. Introduction

Our increasingly globalized world is characterised by the distant interchange of people, goods, information, and ecosystem services (ES, contributions of ecosystems to human wellbeing). Interregional ES flows are a direct result of the physical links, policies, trade, and resource management decisions in one geographical region that can have significant impacts on ecosystems and biodiversity elsewhere (Kissinger et al., 2011; Koellner, 2011; Liu et al., 2015; Moser and Hart, 2015; Seto et al., 2012). Sustainability challenges are associated with interregional flows, such as the distribution of benefits derived from nature, globally associated costs and interregional dependencies, and broader considerations of equity and responsibilities for sustained ES management.

To date, different aspects of interregional connections have been addressed in largely isolated scientific disciplines. For instance, land system science is studying telecoupling, the complex interrelations between distant coupled socio-ecological systems (Friis et al., 2015; Liu et al., 2013) and displacement of land use (Bruckner et al., 2015; Lambin and Meyfroidt, 2011) or indirect land-use change (iLUC, Lapola et al., 2010). In ecological economics, a discourse on interregional sustainability (Kissinger and Rees, 2010; Kissinger et al., 2011) focuses on accounting for biophysical flows of natural resources, using ecological footprints (Weinzeettel et al., 2014) or the human appropriation of net primary production framework (Erb et al., 2009; Haberl et al., 2009). Further, political ecology is addressing societal effects of change in land tenure (termed ‘land grabbing’) (Rulli et al., 2013). In the policy arena, national and international biodiversity strategies are calling for ecosystem assessments (European Commission, 2011; UNEP, 2010). However, most ecosystem assessments have ignored or underappreciated interregional ES flows (Pascual et al., 2017; Schröter et al., 2016). Considerable progress has been made to prioritize and structure ES research or policy action, and to support communication about ES among disciplines and sectors (Potschin-Young et al., 2017). Ever since the Millennium Ecosystem Assessment (MA, 2005), conceptual frameworks for ES have acknowledged the distinction between ecosystems and social systems, and the need for a connection between these subsystems to attain actual benefits of ES. The ES cascade (de Groot et al., 2010) frames the service itself as this connection and Villamagna et al. (2013) explicitly mention flows from ecosystems to beneficiaries. Several studies have acknowledged different scales in ecosystem service research (Costanza, 2008), and others have quantified or conceptualized flows from providing to benefitting areas (Bagstad et al., 2013; Serna-Chavez et al., 2014). Yet linkages between providing and benefitting areas have mainly been studied at smaller scales (e.g., Garcia-Nieto et al., 2013; Kroll et al., 2012) and there is little knowledge on the magnitude, drivers and effects of interregional ES flows, in particular for regulating and cultural ES, with a few notable exceptions. For instance, López-Hoffman et al. (2010) described provisioning, regulating and cultural ES flows between Mexico and the U.S., and Liu et al. (2016) analysed the telecoupling of water-related ES across China. The UK national ecosystem assessment analysed biomass trade with other world regions and estimated the land requirements in exporting countries (UK NEA, 2011), while Yu et al. (2013) provided virtual land flow analyses for traded crops and timber indicating flows of provisioning services.

Our objective is to synthesise knowledge from various fields to better understand, analyse and support governance of complex interregional ES flows towards interregional sustainability. We develop a framework of interregional ES flows and a typology of four general flow types to guide future ES assessments by building on the concepts of telecoupling (Liu et al., 2013; Liu et al., 2015), also referred to as societal teleconnections (Moser and Hart, 2015) and interregional sustainability (Kissinger and Rees, 2010; Kissinger et al., 2011). We illustrate our framework with four case studies on (a) trade of a provisioning service, coffee, produced under certified schemes in Colombia; (b) flow of cultural and food provision services through migration of the northern pintail duck (Anas acuta) between Canada and the U.S.; (c) regulating services through flood protection along the Danube River; and (d) cultural services derived from information flows of the existence of the giant panda (Ailuropoda melanoleuca) (Box 1). We then address the linkages between interregional ES flows and sustainability. We conclude with the identification of key knowledge gaps that would enable improved consideration of interregional ES flows in science and policy.

Box 1 Introduction to the case studies. (a) Biophysical flow of traded goods: Certified coffee from Colombia as provisioning service

Coffee production, a provisioning service, has been dominated by intensively managed, monoculture, sun coffee plantations, associated with significant environmental implications (Jha et al., 2014). Concerns over the environmental and social impacts of dominant coffee production systems have triggered a shift in consumer preferences in importing countries that has strengthened the market for certified coffee (Manning et al., 2012). Today, Colombia is one of the world’s largest coffee producers. During the last decade, over 80% of the coffee produced in Colombia was exported (FAO, 2017). By 2010, more than 25% of farmers and over 30% of Colombian coffee were part of certification schemes (Rueda and Lambin, 2013). Within certification schemes, farmers are offered financial and technical support through donor agencies, research centres, non-governmental organisations and local cooperatives as well as the Colombian government and the Colombian Coffee Growers Federation (Hughell and Newsom, 2013; Rueda and Lambin, 2013).

(b) Biophysical flow through species migration and dispersal: Provisioning and cultural services provided by northern pintails migrating between Canada and the U.S.

Northern pintails (Anas acuta) are medium-sized dabbling ducks that feed on plants and invertebrates in agricultural and wetland habitats. Due to their beautiful plumage and elongated tail feathers, pintails provide cultural ES through opportunities for bird watching and recreational sport hunting (Austin and Miller, 1995; Mattsson et al., 2012) as well as provisioning services as a food source for Arctic indigenous groups (Goldstein et al., 2014). Pintails migrate in spring from their wintering regions at the coast of California and the
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