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Ecosystem services and dis-services to agriculture

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ABSTRACT

Agricultural ecosystems are actively managed by humans to optimize the provision of food, fiber, and fuel. These ecosystem services from agriculture, classified as provisioning services by the recent Millennium Ecosystem Assessment, depend in turn upon a web of supporting and regulating services as inputs to production (*e.g.*, soil fertility and pollination). Agriculture also receives ecosystem dis-services that reduce productivity or increase production costs (*e.g.*, herbivory and competition for water and nutrients by undesired species). The flows of these services and dis-services directly depend on how agricultural ecosystems are managed and upon the diversity, composition, and functioning of remaining natural ecosystems in the landscape. Managing agricultural landscapes to provide sufficient supporting and regulating ecosystem services and fewer dis-services will require research that is policy-relevant, multidisciplinary and collaborative. This paper focuses on how ecosystem services contribute to agricultural productivity and how ecosystem dis-services detract from it. We first describe the major services and dis-services as well as their key mediators. We then explore the importance of scale and economic externalities for the management of ecosystem service provision to agriculture. Finally, we discuss outstanding issues in regard to improving the management of ecosystem services and dis-services to agriculture.

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1. Introduction

Covering over a third of total global land area (FAOSTAT, 1999)[1], agriculture represents humankind's largest engineered ecosystem. Agricultural ecosystems both provide and rely upon important ecosystem services (ES). Daily (1997) has defined ES as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life". ES can be classified into four main categories: provisioning, supporting, cultural, and regulating services (Fig. 1) (MA, 2005). Agricultural ecosystems are primarily managed to optimize the provisioning ES of food, fiber, and fuel. In the process, they depend upon a wide variety of supporting and regulating services, such as soil fertility and pollination (MA, 2005; NRC, 2005), that determine the underlying biophysical capacity of agricultural ecosystems (Wood et al., 2000). Agriculture also receives an array of ecosystem dis-services (EDS) that reduce productivity or increase production costs (*e.g.*, herbivory and competition for water). The flows of these ES and EDS (Fig. 2) rely on how agricultural ecosystems are managed at the site scale and on the diversity, composition, and functioning of the surrounding landscape (Tilman, 1999).

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[1] Agriculture land use statistics compiled by FAO for 1992-1993.

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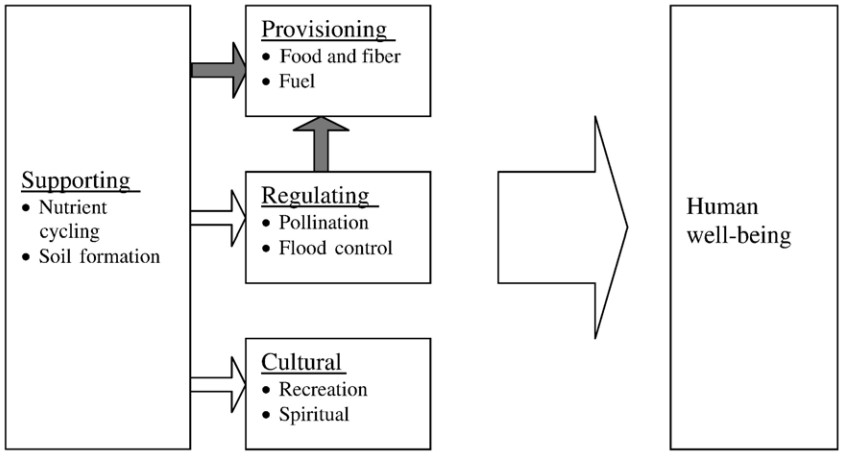

Fig. 1 – Classification of ecosystem services from the Millennium Ecosystem Assessment (adapted and simplified from (Alcamo et al., 2003)). Agricultural lands typically are managed to maximize provisioning services, but demand many supporting and regulating services to do so. Dark arrows indicate the flow of these services that are the primary topic of this paper.

Indeed, the vast scope of agriculture as a "managed ecosystem" (Antle and Capalbo, 2002) embedded in a web of natural ecosystems offers both challenge and opportunity for optimizing the relative flow of ES and EDS to and from agriculture. This paper focuses on ES and EDS to agriculture (see the introduction of this special issue for a discussion of ES and EDS from agriculture). We first describe the major ES and EDS to agriculture and the key mediators. We then explore the importance of scale of ES and EDS provision to agriculture for effective and efficient management and make recommendations for promoting coordinated management practices. Finally, we discuss several outstanding issues in regard to management of ES and EDS to agriculture and recommend potential research directions.

2. Ecosystem services and dis-services to agriculture

A wide variety of ES and EDS confer benefits and costs, respectively, to agriculture. These are supplied by varied species, functional groups, and guilds over a range of scales and influenced by human activities both intentionally and unintentionally. Here we briefly describe the range of major ES

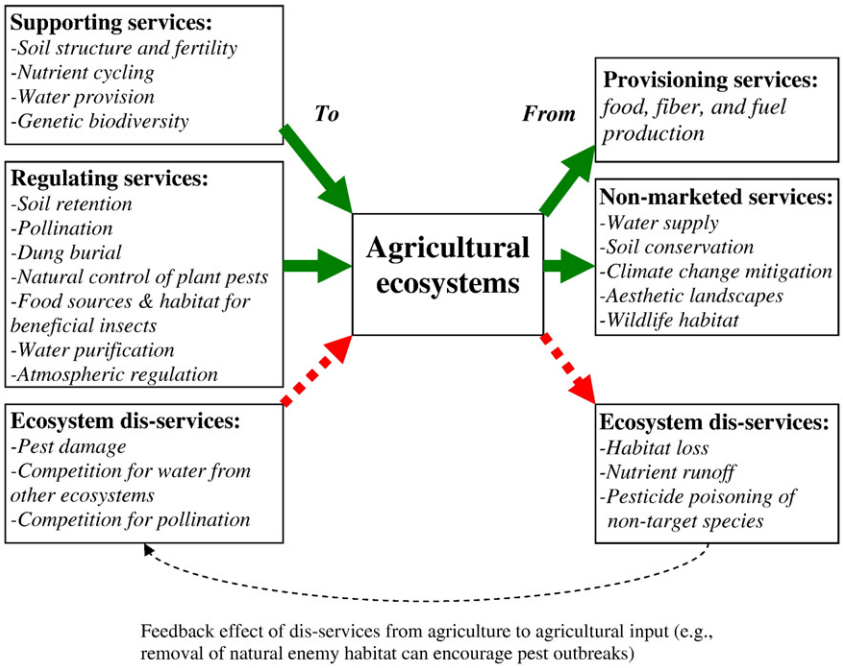

Fig. 2 – Ecosystem services and dis-services to and from agriculture. Solid arrows indicate services, whereas dashed arrows indicate dis-services.

and EDS to agriculture and summarize them in Fig. 2. Treatment of each service is necessarily cursory, and citations are indicative rather than exhaustive.

2.1. Ecosystem services to agriculture

Soil structure and *fertility* play a large role in determining where different kinds of farming take place and the quantity and quality of agricultural output. Earthworms and macro- and micro-invertebrates increase soil structure *via* burrows or casts and enhance soil fertility through partial digestion and communition of soil organic matter (Edwards, 2004). *Nutrient cycling* maintains soil fertility. Microorganisms (bacteria, fungi, actinomycetes) are critical mediators of this ecosystem service. For example, bacteria enhance nitrogen availability through the fixation of nitrogen from the atmosphere. This occurs most often in plants that have symbiotic relationships with N-fixing bacteria, but free-living soil bacteria can fix nitrogen as well (Vitousek et al., 2002). Microorganisms also enhance soil fertility by liberating nutrients from detrital organic matter (*e.g.* plant leaves) and retaining nutrients in their biomass that might otherwise be lost downstream (Paul and Clark, 1996). Non-crop plants can also be key to soil fertility—they are used to replenish nutrients to agricultural land during fallow periods (Ramakrishnan, 1992) or through the so called "rotation effect" (Pierce and Rice, 1988). While the processes above maintain soil fertility, *soil retention* is key to keeping those nutrients in place and available to crops. To do this, cover crops are used to retain soil and nutrients between crop cycles while hedgerows and vegetation along waterways reduce erosion and runoff from fields. Certain farming practices, such as mechanical plowing, disking, cultivating, and harvesting can decimate the flow of soil-based ES *via* disturbing the functioning of soil microbial communities. Conservation tillage, including both no tillage and minimum tillage (Brown, 2003) represents a valid approach to conserving these ES.

Insects provide vital ES to agriculture including dung burial, pest control, and pollination. Beetles in the family Scarabaeidae are especially efficient at providing *dung burial* services (Ratcliffe, 1970). They decompose wastes generated by large animals (a potential EDS from agriculture), thereby recycling nitrogen, enhancing forage palatability, and reducing pest habitat, resulting in significant economic value for the cattle industry (Losey and Vaughan, 2006).

Crop pollination is perhaps the best known ES performed by insects (Losey and Vaughan, 2006). The production of over 75% of the world's most important crops that feed humanity and 35% of the food produced is dependent upon animal pollination (Klein et al., 2007). Bees comprise the dominant taxa providing crop pollination services, but birds, bats, moths, flies and other insects can also be important. Wild pollinators can nest within fields (*e.g.*, ground nesting bees), or fly from nesting sites in nearby habitats to pollinate crops (Ricketts, 2004). There has been increasing evidence that conserving wild pollinators in habitats adjacent to agriculture improves both the level and stability of pollination, leading to increased yields and income (Klein et al., 2003a).

Natural control of plant pests is provided by generalist and specialist predators and parasitoids, including birds, spiders, ladybugs, mantis, flies, and wasps, as well as entomopathogenic fungi (Naylor and Ehrlich, 1997). This ES in the short term suppresses *pest damage* and improves yield, while in the long-term maintains an ecological equilibrium that prevents herbivore insects from reaching pest status. This important ES, however, is increasingly threatened by biodiversity loss (Wilby and Thomas, 2002), modern agricultural practices (Naylor and Ehrlich, 1997), and human alterations of natural ecosystems. For instance, insecticide use in agriculture tends to decimate natural enemy populations, often having the unintended consequence of either exacerbating existing pest problems, or actually leading to the emergence of new pests (Krishna et al., 2003).

For beneficial insects to provide the above direct ES to agriculture, a number of subsequent supporting and regulating services are required. For example, predators and parasitoids rely on a variety of plant resources such as nectar, pollen, sap, or seeds (Wilkinson and Landis, 2005) as alternative *food sources* to fuel adult flight and reproduction. Non-crop areas can provide *habitat* where beneficial insects mate, reproduce, and overwinter. Evidence shows that increased landscape complexity, which typically means increased availability of food sources and habitat for insects as compared to mono-culture landscapes, is correlated with diversity and abundance of natural enemy populations (Thies and Tscharntke, 1999), and with enhanced pest control in some cases (Thies et al., 2003). Enhanced abundance and diversity of natural enemies, however, do not necessarily provide enhanced pest control, since pest densities may also respond positively to landscape complexity (Thies et al., 2005).

In the face of evidence of population declines among beneficial insects (Kremen et al., 2002), interest is rising in habitat management to foster beneficial species. "Conservation biological control" of crop pests is founded on creating a suitable ecological infrastructure within the agricultural landscape to provide resources such as food for adult natural enemies, alternative prey or hosts, and shelter from adverse conditions (Landis et al., 2000). For wild pollinators, the construction of nest boxes, planting of native plant species with sequential flowering, and soil stabilization have been proposed (Vaughan et al., 2004), along with Integrated Pest Management practices that minimize the use of pesticides toxic to pollinators. Beyond specific local practices to protect habitat for beneficial insects, there is a growing evidence that diversified landscapes hold great potential for the conservation of biodiversity and sustaining ES performed by insects (Bianchi et al., 2006). The issues of coordinated habitat management at landscape scales are discussed in a separate section.

Water provision and *purification* fulfill requirements for water of sufficient quantity, timing, and purity for agricultural production. Vegetation cover in upstream watersheds can affect the amount, quality, and stability of the water supply to agriculture. It is not clear that maintaining forest cover increases the absolute amount of water supplied to downstream areas. Other vegetation may do just as well (Groffman et al., 2004). What is clearer is that forests stabilize water flow to reduce differences in flow between wet and dry seasons (*e.g.*, Yangtze basin (Guo et al., 2000)). Forests can also stabilize soil to reduce sediment load in rivers. In Australia,

trees can improve water infiltration within woodlands, reducing surface runoff and soil salinization (Eldridge and Freudenberger, 2005). Wetlands and riparian vegetation can also improve water quality and attenuate floods (Houlahan and Findlay, 2004).

Genetic diversity provides the raw material for natural selection to produce evolutionary adaptations. Similarly, breeders of crops and domestic animals utilize existing genetic variation to select artificially for desirable traits. Failing to maintain sufficient genetic diversity in crops can incur high costs (Hawtin, 2000). For example, the Irish potato famine at the end of the 1830s can be attributed in part to the fact that there were so few different genetic strains of potatoes in the country, making the crop susceptible to the devastating potato blight fungus (Hawtin, 2000). The problem was resolved by using varieties in Latin America, where the potato had originated, that were resistant to the disease (Esquinas-Alcázar, 2001). Genetic diversity is not only important to avoiding catastrophic losses, but also improving or maintaining agricultural productivity. Many important crops could not maintain commercial status without the regular genetic support of their wild relatives (de Groot et al., 2002). In addition, in many crop systems, particularly orchard crops and in the production of hybrid seed, different cultivars (genotypes) are required for seed or fruit set (Free, 1993; Delaplane and Mayer, 2000). Genetic diversity at the species level can also enhance biomass output per unit of land through better utilization of nutrients and reduced losses to pests and diseases (see Tilman, 1999 for a detailed discussion).

Another (abiotic) form of ES to agriculture involves climate, including temperature and precipitation regimes but also the frequency and severity of extreme weather, droughts, floods, etc. Favorable climate confers a cost advantage to those who farm there. Suitable and stable climate relies on *atmospheric regulation*, which like many other ES is influenced by the functioning of multiple ecosystems.

2.2. *Ecosystem dis-services to agriculture*

Crop pests, including herbivores, frugivores, seed-eaters, and pathogens (specifically, fungal, bacterial and viral diseases) decrease productivity and in the worst case can result in complete crop loss. Revenue loss from insect pests and pathogens can be disproportionately high for crops whose price depends heavily on quality, such as fresh produce (Babcock et al., 1992). Ironically, pesticide use has led to increases in pest outbreaks; over-reliance on pesticides in recent decades has led certain species to evolve genetic resistance to specific pesticide compounds, triggering pest outbreaks and resurgence. This can make chemical control more costly and result in unintended negative health outcomes for non-target organisms, including humans (Thomas, 1999).

Non-crop plants can reduce agricultural productivity *via competition* for resources and *allelopathy* (Stoller et al., 1987). In fields, weed competition for sunlight, water and soil nutrients can reduce crop growth by limiting access to required resources (Welbank, 1963). Allelopathy also works at within-field scale, for example *via* toxic root exudates of certain weed species that can impair crop growth (Weston and Duke, 2003).

Competition for ecological resources of value to agriculture also occurs at landscape scales. Water consumed by other plants can reduce water available to agricultural production. For example, trees can reduce the recharge of aquifers used for irrigation (*e.g.*, conifers in South Africa (van Wilgen et al., 1998)). Trees can also transpire water away from rivers and canals (*e.g.*, tamarisk in U.S. (Zavaleta, 2000)). Competition for pollination services from flowering weeds and non-crop plants can also reduce crop yields (Free, 1993).

3. Implications of ES for agricultural management

Ecosystem services and dis-services to agriculture influence both where and how people choose to farm. For example, many major fruit-producing regions in temperate climate zones are located downwind of large bodies of water that helps to regulate local atmospheric temperature changes (Ackerman and Knox, 2006) and reduces the probability of late frosts that might damage fruit blossoms. The major cereal grain producing regions of the North American prairie, the Asian steppe and the South American pampas are all located on deep topsoil with high organic matter and good water holding capacity. Farmers chose these locations because flows of ES to agriculture made them potentially more profitable than elsewhere.

ES to agriculture affect not only the location and type of farming, but also farmland's economic value. While determined in part by crop price, values of agricultural land also depend on production costs linked to ES such as soil fertility and depth, suitable climate and freedom from heavy pest pressure (Roka and Palmquist, 1997).

The scales at which services are provided to agriculture are also critical to how management decisions are made. Many key organisms that provide services and dis-services to agriculture do not inhabit the agricultural fields themselves. Rather, they live in the surrounding landscape or they may move between natural habitats, hedgerows and fields. Table 1 summarizes the major actors and scales of provision for the ES and EDS described in the previous section. The scales at which ES and EDS are rendered determine the relevant management units for influencing their flows to agriculture. If they respond to factors on a small scale then it may be possible to manage them within a single farm. But if they respond to factors on a larger scale, then the management actions of individual farmers must be coordinated, with several different decision-makers involved (Weibull et al., 2003). Table 1 reveals that scarcely any ES or EDS are provided only at the field level, so management will be more effective if performed at larger scales. The appropriate scale at which to manage will depend upon each specific provisioning ES and the supporting and regulating ES on which it relies. Table 1 also highlights the importance of a farm's landscape context in managing many of the supporting and regulating ES and EDS. For example, landscapes that contain diverse habitat types typically are more compatible for beneficial insects and in most cases result in enhanced biological control of pests and provision of pollinators (Kremen and Chaplin-Kramer, in press).

Table 1 – Major ecosystem services (ES) and dis-services (EDS) to agriculture, the scales over which they typically are provided, and main guilds or communities whose activities typically supply them

ES or EDS	Field [a]	Farm [b]	Landscape [c]	Region/globe [d]
Services				
Soil fertility and formation, nutrient cycling	Microbes; invertebrate communities; legumes	Vegetation cover		
Soil retention	Cover crops	Cover crops	Riparian vegetation; floodplain	Vegetation cover in watershed
Pollination	Ground-nesting bees	Bees; other pollinating animals	Insects; other pollinating animals	
Pest control	Predators and parasitoids (*e.g.*, spiders, wasps)	Predators and parasitoids (*e.g.*, spiders, wasps, birds, bats)		
Water provision and purification		Vegetation around drainages and ponds	Vegetation cover in watershed	Vegetation cover in watershed
Genetic diversity	Crop diversity for pest and disease resistance			Wild varieties
Climate regulation	Vegetation influencing microclimate (*e.g.* agroforestry)	Vegetation influencing microclimate	Vegetation influencing stability of local climate; amount of precipitation; temperature	Vegetation and soils for carbon sequestration and storage
Dis-services				
Pest damage	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; range weeds	
Competition for water from other ecosystems	Weeds	Vegetation cover near drainage ditches	Vegetation cover in watershed	Vegetation cover in watershed
Competition for pollination services	Flowering weeds	Flowering weeds	Flowering plants in watershed	

[a] Services provided from within agriculture fields themselves.
[b] Services provided from farm property, but not necessarily in active fields themselves.
[c] Services provided from landscape surrounding typical farms, not from farmer's property.
[d] Services provided from broader region or globe.

The distinct scales at which ES and EDS are provided to agriculture shape farmers' incentives over how to farm to optimize those services. ES provided at the field and farm scale chiefly affect the farm itself, so farmers have a direct, private interest in managing such ES as soil fertility, soil retention, pollination and pest control. At larger scales, farmers face classic economic externality and common pool resource problems. For example, integrated pest management strategies that restore landscape complexity could increase services from natural enemies and pollinators while reducing the pollutant effects of pesticide use (Ehler and Bottrell, 2000; Tilman et al., 2001). But greater landscape complexity is a common pool resource in the sense that i) it is costly for a farmer to exclude others from access to the enhanced pollinator and pest predator services (*i.e.*, non-exclusive, Ostrom, 1990), and ii) to some extent the consumption of the services is rivalrous, so that other farmers that do not bear the costs of supplying these services may actually compete for them. Hence, while a farmer who reserves land for pest predator and pollinator habitat will enjoy some benefits, other benefits will be enjoyed by neighbors who avoid the need to rent bee hives or spray for pests without needing to give up income-generating cropland. Such economic externalities imply that the first farmer, acting alone, would lack the incentive to set aside the optimal amount of habitat for both the farmer and the neighbor (Meade, 1952).

Although public policies exist that aim to create incentives for farmers to act on behalf of the collective good, current policies are not designed to encourage coordinated behavior. For example, the United States currently has programs to reward farmers for voluntary adoption of land management practices that encourage natural pest control. The programs use government sharing of costs (Environmental Quality Incentives Program) and environmental stewardship payments (Conservation Security Program) to promote adoption of certain practices that are determined at the state level. While helpful at the farm and field scale, current programs are not designed to encourage coordinated farming practices across a landscape. Exploratory research into collective action has shown that incentives can be designed to induce coordinated habitat conservation by individual land managers across a landscape (Parkhurst et al., 2002). However no existing policies have been able to achieve this potential for coordinated habitat conservation (Parkhurst and Shogren, 2003).

4. Major issues and research needs

The study of ES is still relatively young, and many unresolved issues remain. How well understood are the ecosystem functions behind the ES that affect agriculture's performance? Certain field-scale dimensions are familiar topics of agronomic research. Crop yield response to soil fertility and water supply has been extensively studied (*e.g.*, Hanks and Ritchie,

1991), as have crop yield responses to pest pressure (*e.g.*, Cousens et al., 1987). However, these same topics have received much less attention at larger scales. Likewise, less attention has been paid to the mechanisms of microbial underpinnings of soil fertility. A major research agenda exists for disaggregating and separately describing those ES in order to identify 1) their separate contributions to agricultural productivity, 2) the most suitable scale for management, 3) context dependency, 4) trade-offs and valuation, 5) management intensity, and 6) the design of incentives to encourage ES provision.

In general, research needs to document and track the individual ES flows and their contributions to agricultural production and/or land value. Much of this depends on better comprehension of the ecological processes that underpin these services (Kremen, 2005). For the non-marketed supporting and regulating ES, the dissemination of scientific information on their contributions to agricultural production could cause the prices of related marketed goods to adjust, resulting in better functioning markets that provide minimum economic incentives for ES conservation. Research needs in this case include measuring the ES in question and documenting their impacts on agriculture. We proceed by highlighting several important ES research needs that could contribute to better agricultural performance.

First, while many ES are known to be important to agriculture, the mechanistic details of their provision remain poorly understood (Kremen, 2005). Although much is known about biochemical relationships, such as crop yield response to fertilizer or pest mortality from pesticides, far less is known about how species in natural ecosystems generate services that support agriculture. Specifically, for each ES, ecological data are needed to answer the following major questions (Kremen, 2005): Which species are most important? How do these species, communities and the services they provide respond to alternative management regimes? What are their requirements for persistence in agricultural landscapes? How stable are species, communities and services over space and time? Over what scales do they provide services to agriculture? Empirical evidence and well-developed models are in early stages for most ES. There is a need for more detailed case studies at the scale of typical land-use decisions (*e.g.*, Guo et al., 2000; Ricketts et al., 2004), and then for meta-analyses to understand typical effect sizes and general trends (Kremen, 2005).

A second need is for deeper understanding of the scales at which ecosystems provide services to people. The ecosystems that supply services to agriculture are often far from the fields that benefit from them (Table 1). This presents novel problems for landscape conservation and management. Typically conservation or farming decisions are informed by the *in situ* value of that parcel (*e.g.*, importance of species that live there, or potential productivity for agriculture). Managing landscapes for ES, however, requires understanding the flows of services from one parcel to others (*e.g.*, flow of pollinators from natural areas to surrounding crops (Ricketts, 2004), flow of water provision services from upland areas to areas downstream (Guo et al., 2000)). ES supply and demand must be analyzed spatially across the landscape, in order to make explicit the locations of ES providers and consumers, and the flows of services from one to the other (Eade and Moran, 1996; Kremen, 2005; Naidoo and Ricketts, 2006).

Third, many of the ES and the ecological functions that supply them are context-dependent (Kremen, 2005). Universal rules about what constitutes an ES and what underlies an ES rarely exist. The importance of a given species, community, or guild in providing ES to agriculture varies widely across crops and regions. For example, trees in the landscape provide an ES in southwestern Australia by improving water infiltration into soil (Eldridge and Freudenberger, 2005), but provide an EDS in South Africa by transpiring water and reducing groundwater recharge (van Wilgen et al., 1998). Note that it is not that trees provide different functions in different settings, but rather that the services or dis-services they provide have different relative values according to the ecological conditions of a given setting. Because the attributes that humans value differ from one setting to another, the same basic ecological processes are laden with different values.

Different members of the same service-providing guild may respond differently to management of agricultural landscapes. In Indonesia, some wild bee species that provide pollination services to coffee decrease in abundance with increasing land-use intensity while others increase (Klein et al., 2003b). The impact of land-use change on coffee production therefore depends on which bees are the major coffee pollinators.

Fourth, decisions regarding management of ES within agricultural landscapes will typically involve trade-offs, some of them among different services (MA, 2005). For example, managing a landscape to maximize food production will probably not maximize water purification for people downstream, and native habitats conserved near agricultural fields may provide both crop pollinators and crop pests (Steffan-Dewenter et al., 2001). The question of whether intensive or extensive agriculture best optimizes the various trade-offs associated with ES provision is an important issue requiring targeted research. Another form of trade-off is between private financial gains and social losses from alternative management choices. For example, controlling crop pests could be accomplished through (a) maintaining populations of natural predators, (b) by labor-intensive hand-spraying, or (c) by aerial spraying. While (a) and (b) are likely to lead to higher private costs, they may entail reduced social costs from ecological disturbance and public health hazards. The goal of public policy should be optimizing these trade-offs to maximize socially desirable outcomes. To date, the majority of studies on ES have focused on a single service, but evaluating these trade-offs will require broader studies that include several ES in the same system (Eade and Moran, 1996).

Evaluating the monetary value of ES that lack markets constitutes one widely understood approach to assessing trade-offs. During the past three decades, numerous empirical valuation studies have emerged for certain ES, such as regulation of air and water quality. The number of studies that have addressed ecological functions that potentially lead to beneficial services is much smaller, as is the number that have explored the values of combined ES (Cropper, 2000). For

effective analysis of trade-offs, future valuation research should focus on policy decision endpoints, and it should address the "adding up" problem of multiple ES from the same decision (Cropper, 2000). Well-designed economic research in collaboration with ecologists continues to be needed both to estimate values to motivate policy and to design effective incentives.

Monetary valuation of ES is not the only way to assess economic trade-offs. Indeed, concerns about the validity of many nonmarket valuation methods (Diamond and Hausman, 1994) and the difficulty of aggregating nonmarket values for different ES counterbalance their ease of use. Because preferences vary across individuals and groups, one useful alternative approach to integrated assessment of agricultural production systems is trade-off analysis that integrates disciplinary data and models to support informed policy decision making (Antle et al., 2003). Future research to aid in the evaluation of alternative agro-ecological systems should innovate in both valuation and trade-off approaches to integrated assessment.

Although understanding the biophysical aspects of ES (*e.g.*, which processes, which species, what habitat requirements, what scales) is necessary, it is not sufficient for improving the management of ES to agriculture. To evaluate trade-offs with other land management options, and to inform policy decisions, it is essential to estimate the economic value of ES with equal rigor to their biophysical relationships (Heal, 2000). But merely stating the economic value of a given service or set of services does not create incentives to maintain it. Policies will typically be required to create markets for currently non-marketed ES or to compensate people whose ecosystem management provides beneficial externalities to others, internalizing ES value into land management decisions. Opportunities exist to manage landscapes to benefit agriculture by providing more supporting and regulating ecosystem services and fewer dis-services. To seize those opportunities will require research that is policy-relevant and collaborative, engaging at a minimum the fields of ecology, hydrology, economics and political science.

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