An operational model for mainstreaming ecosystem services for implementation

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Research on ecosystem services has grown markedly in recent years. However, few studies are embedded in a social process designed to ensure effective management of ecosystem services. Most research has focused only on biophysical and valuation assessments of putative services. As a mission-oriented discipline, ecosystem service research should be user-inspired and user-useful, which will require that researchers respond to stakeholder needs from the outset and collaborate with them in strategy development and implementation. Here we provide a pragmatic operational model for achieving the safeguarding of ecosystem services. The model comprises three phases: assessment, planning, and management. Outcomes of social, biophysical, and valuation assessments are used to identify opportunities and constraints for implementation. The latter then are transformed into user-friendly products to identify, with stakeholders, strategic objectives for implementation (the planning phase). The management phase undertakes and coordinates actions that achieve the protection of ecosystem services and ensure the flow of these services to beneficiaries. This outcome is achieved via mainstreaming, or incorporating the safeguarding of ecosystem services into the policies and practices of sectors that deal with land- and water-use planning. Management needs to be adaptive and should be institutionalized in a suite of learning organizations that are representative of the sectors that are concerned with decision-making and planning. By following the phases of our operational model, projects for safeguarding ecosystem services are likely to empower stakeholders to implement effective on-the-ground management that will achieve resilience of the corresponding social-ecological systems.

adaptive management | land-use planning | social–ecological systems | stakeholder engagement

There has been an impressive growth in research on ecosystem services in recent years. However, few studies are embedded in a social process designed to ensure effective on-the-ground management of areas that deliver ecosystem services. It is unlikely that the outcomes of technically sophisticated assessments published in scientific journals will lead to implementation via a "trickle-down" effect (1–3). As a mission-oriented, pragmatic discipline (4), ecosystem service research should be geared for implementation, and scientists should assist this process by responding to stakeholder needs from the outset and by becoming involved in the messy process of collaborating with and empowering stakeholders in strategy development and implementation (1, 5–7). How to do this is the topic of this article.

There are some excellent examples of research that have resulted in the protection of ecosystem services (e.g., refs. 8–10). But they are few and are cited repeatedly in the literature. Our wish is that ecosystem service research does not become another bandwagon driven by technological sophistication and characterized by societal irrelevance. As a cornerstone of sustainability science (11), ecosystem service research needs to be user-inspired, user-useful, and user-friendly. Although research-for-implementation models exist for integrated natural resource management (7) and conservation planning (5), we know of no article that spells out pragmatically and comprehensively the process for achieving the safeguarding of ecosystem services on the ground. Our article seeks to fill this gap.

To provide a real-world context, we have chosen to focus on the internalization, or "mainstreaming" (12), of ecosystem service concerns into the land-use (and water-use) planning sector. Land-use planning is a normative discipline (4) in the sense that it provides the legally entrenched norms and rules for making decisions about how natural resources are to be used. In many parts of the world, governments are institutionally obliged to iteratively conduct participatory, spatially explicit, land-use planning aimed at integrating requirements for social, economic, and environmental sustainability. Flaws notwithstanding (13), this process provides a window of opportunity for mainstreaming ecosystem services into the activities of organizations that are empowered to make routine decisions about the use of land and water resources (14, 15).

We restrict ourselves to ecosystem services—defined as the end products of nature that benefit humans (16)—provided by natural and semi-natural habitats (wild nature). Thus, we do not consider agriculture or aquaculture ecosystems, acknowledging, of course, that wild nature does provide services essential for the success of these ecosystems. First, this article provides some background on mainstreaming, a relative newcomer to the biodiversity lexicon. The second and substantive part provides a pragmatic, operational model for guiding the things we need to do for implementing the safeguarding of ecosystem services. Our account draws on our collective experience over the past decade in user-inspired research and implementation in the nature conservation and water sectors (e.g., refs. 14 and 17–20).

What Do We Mean by Mainstreaming?

In the context of natural resource management and conservation, the objective of mainstreaming is to internalize the goals for safeguarding resources into economic sectors and development models, policies, and programs, and therefore into all human behavior (12). The concept is entrenched in several articles of the Convention on Biological Diversity and is the explicit objective of the Global Environmental Facility's GEF-4 program, with its particular emphasis on ecosystem services.

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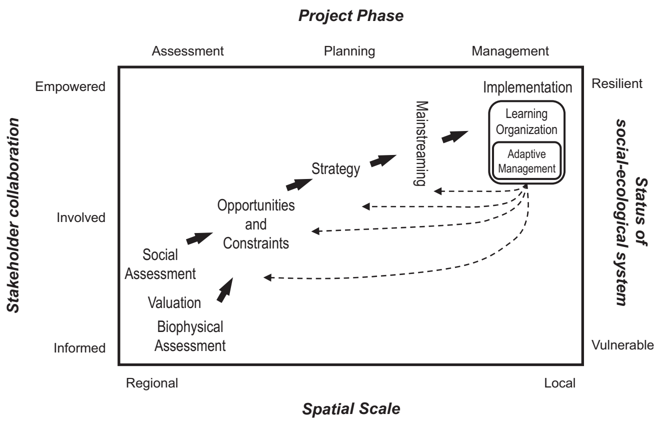

Fig. 1. An operational model for implementing the safeguarding of ecosystem services.

Based on South African experience, there are four elements of a framework for achieving: mainstreaming: (*i*) prerequisites, elements without which mainstreaming cannot happen; (*ii*) stimuli (or windows of opportunity), elements external and internal to the sector that catalyze awareness of the need for mainstreaming; (*iii*) mechanisms, the actual activities that seek to effect mainstreaming; and (*iv*) outcomes, the measurable indicators of mainstreaming effectiveness (20). The most frequently cited prerequisites in these projects were democratic and accountable governance, awareness and knowledge, and organizational and institutional capacity.

Mainstreaming is achieved primarily through behavior change. In the context of this article, it requires that the safeguarding of ecosystem services is institutionalized in land-use planning policies and is reflected in the day-to-day activities of this sector.

Operational Model

Here we discuss operational issues: the things that need to be done to mainstream ecosystem services. Fig. 1 shows the three phases of the model (assessment, planning, and management) and their relationships to spatial scale, degree of stakeholder engagement, and status of the social-ecological system—the integrated and interactive relationships between humans and ecosystem services (21, 22). Our operational model is based on one devised by Knight *et al.* (5) for conservation planning. Any project for safeguarding ecosystem services should strive to arrive at the top right-hand corner in Fig. 1, where the adaptive management of the social-ecological systems associated with the defined suite of ecosystem services has been mainstreamed into an appropriate land-use planning framework and governed by learning organizations that are representative of, and supported by, the full range of stakeholders in the study area (a learning organization is one skilled at creating and acquiring knowledge and modifying its behavior to reflect new insights) (23). Thus, stakeholders are empowered to implement effective on-the-ground management of ecosystem services, and social-ecological systems are resilient (they can absorb shocks and surprises) (1, 22, 24). Getting there is a social process riddled with complexity, contention, uncertainty, surprise, disappointment, and triumph. It will take a long time—in many cases, decades—to achieve this goal (25). Below we describe some elements of this pathway to resilience by outlining the key actions associated with each of its major phases: assessment, planning, and management.

Assessment Phase. The assessment is a structured process that provides knowledge useful for policies, strategies, and management but does not prescribe these (5, 14, 26). The assessment seeks to answer questions inspired by the beneficiaries and managers of ecosystem services; in our situation, it must provide knowledge useful for mainstreaming ecosystem services into local land-use planning. We identify three types of assessment: social, biophysical, and valuation (Fig. 1).

A key requirement of the assessment phase is the establishment of multidisciplinary and multisector teams (5, 27, 28). Although teams engage in empirical research, their activities should be coordinated by the goals defined for ecosystem services research, which, in turn, are defined by the requirements of land-use planning, a normative discipline (4). This hierarchy of coordination provides operational meaning to the notion of ecosystem service research as a truly interdisciplinary activity (4).

Teams should include researchers from the natural and social sciences and the humanities; scientists and managers from the natural resource management (water, fisheries, agriculture, forestry, conservation, etc.) and human well being (health, social development, safety and security, land-use planning, etc.) sectors; and nongovernmental and other citizen-based organizations. In addition to data collected by using standard scientific methods, assessment teams also should record tacit (or implicit) and traditional knowledge because a great deal of useful information is associated with these informal systems (29, 30).

Teamwork is both difficult and rewarding. It requires emotionally intelligent leadership, which is rare. There may be confusion and contention about values assigned to nature: conservationists typically view nature as axiomatically "good," whereas other stakeholders perceive the value of nature in a relative sense (31). This kind of confusion needs to be managed by effective leaders, as do power asymmetries and concealed agendas. However, if properly managed, teamwork provides excellent opportunities for rapid, collaborative learning based on both explicit and tacit knowledge and for challenging or changing deeply entrenched world views or mental models (3, 30).

Social assessment. The social assessment should precede the biophysical one (Fig. 1), because it identifies the owners and beneficiaries of ecological functions that actually deliver services and, hence, require biophysical assessments. It also identifies markets for ecosystem services and other incentives for their safeguarding, as well as individual, institutional, and governance barriers to implementation (32).

The social assessment should provide knowledge on the needs, values, norms, and behaviors of individuals, institutions, and organizations in the study area. In other words, it provides an understanding of how an area works in socioeconomic terms and why. Without the understanding of the social system provided by the social assessment, implementation is likely to be poorly targeted. Specific issues requiring research will vary with context; however, knowledge of the spatial patterns of population density, human needs (for example, subsistence, protection, and identity), income distribution, current and future trends in land use, land prices, infrastructure, the social capital of natural resource management organizations, nature-related values, preferences and ethics, and incentives for behavior change are likely to emerge as important topics in most cases (26, 33–36). Wherever feasible, data need to be captured spatially and matched to the scale used in the biophysical assessment (37).

Social assessments take time and can be costly. Adequate budgets should be secured (38, 39).

Biophysical assessment. Biophysical assessment provides knowledge on the types and location of the biophysical features that provide ecosystem services, the spatial and temporal flows of services in relation to beneficiaries, and the impacts of land and water transformation on delivery (e.g., refs. 40–44). Heal (33) makes the important point that it is the biophysical rather than the valuation assessment that provide the knowledge-based case for safeguarding services. For example, a simple model that predicts the reduction of water supply below the projected demand as a consequence of unchecked devastation by humans of a watershed (e.g., refs. 8 and 9) is likely to provide a more compelling case to stakeholders for protecting the watershed than dubious estimates of the reduction in the aggregated monetary value of all of the watershed's goods and services (most of which have no market value).

Other than research on the links between biodiversity and ecosystem services (45), very little research has been done on the ecology of ecosystem services. Kremen (40) provides a useful operational framework for studying ecological aspects of ecosystem services that we do not repeat here other than to reiterate—as others have done (e.g., refs. 43 and 46)—the importance of measuring the spatiotemporal scales over which services operate.

Of the published biophysical assessments, most focus on mapping services, their flows, and the impacts of habitat transformation on these flows (e.g., 41–44). A feature of many studies is the identification and mapping of natural features that have no direct beneficiaries or markets and in whose protection few people have an obvious interest. Invariably, these studies are not user-inspired and lack social assessments for identifying the suite of services that fulfill social needs, both presently and potentially. In short, without beneficiaries, there are no services.

An important component of the biophysical assessment is the development of dynamic models of landscape change—the spatially explicit depiction of alternative futures (38, 47). These products allow stakeholders to envision the consequences of particular policy frameworks regarding land and water use. However, they need to be interpreted visually and depicted as plausible scenarios that stakeholders comprehend. We return to this very important point later on in this article.

Valuation assessment. Just as the study of the nature-related values (beliefs) that people hold is contentious, so is the study of the values they assign (in monetary or ranking terms) to nature (48). There is a large and growing literature on the conceptual, technical, and operational aspects of the economic valuation of ecosystem services (e.g., refs. 49–51). We do not review typologies and techniques for economic valuation but rather focus on several issues that are relevant for a socially engaged valuation assessment.

The valuation assessment is located at the intersection of the social and biophysical assessments (Fig. 1) and should be informed by these (46). Most studies advocate, albeit with caution, the monetary valuation of ecosystem services because "most societies have an intuitive notion of economic value" (51) and it provides "a metric than can be deployed across competing land uses" (52). Monetary valuation can be particularly effective in enabling informed tradeoffs in cost–benefit analyses, where the focus is on assessing the marginal change in the provision of an ecosystem service that has market value (e.g., amount of water produced) relative to a competing land use that also is traded on the market (e.g., real estate) (33, 52).

But the vast majority of services have no market price (33, 41, 46, 52). To paraphrase Simpson (49), prices are not to be confused with values, and prices are not the only values that are important. Nonmonetary units of value also can be used, for example, cubic meters of clean water, jobs created, and lives saved (27). Because money is the most commonly used interchangeable commodity, valuation in monetary terms may send the message that a service is more easily replaced by human-manufactured providers than it actually is (53).

Throughout the world, land-use decisions are seldom made on the basis of the outcomes of economic valuation studies; they usually are made by officials and politicians—many of whom are poorly informed—or, in functional democracies, by variously informed citizens. We recommend, where circumstances permit, encouraging stakeholders to reach consensus on assigning subjective values to ecosystem services. Such discourse-based approaches (54, 55) enable social influence and consensus to define knowledge about the value of ecosystem services. As Starbuck (3) states: "Acceptance by people is crucial, because knowledge is what people say it is."

Identify opportunities and constraints for implementation. The concluding stage of the assessment phase is a structured process in which all project participants identify opportunities and constraints for implementing actions to safeguard ecosystem services. Because of different value systems, research traditions, and mental models, this process can be difficult (38, 39, 56); it requires excellent facilitation and leadership. We cannot overstate the importance of this phase: the outcomes provide the bridge between assessment and planning by providing knowledge essential for identifying strategic implementation objectives (Fig. 1).

Identifying opportunities and constraints can be challenging because of the complex outcomes of the three assessments. There is a need to frame and depict in ways that harmonize with stakeholders' values, needs, and cognitive skills, the complexity of outcomes characterized by situations of "numerous possible futures underpinned by numerous possible solutions" (57). Most stakeholders are likely to lack the cognitive capacity to comprehend and absorb the significance of models that depict dynamic, long-term, continuous, and multiscale processes with complex feedback and uncertain outcomes (3, 29, 58). They find it much easier to relate to models that are described by discrete events, possibilities, pictures, emotions, and stories, and that provide prospects for harnessing their energies and skills (59–62).

Scenario planning is one way that the assessment team can display implementation opportunities and constraints in a manner that is comprehensible to a broad range of stakeholders. This powerful tool deals with uncertainty by providing plausible, descriptive narratives or pathways to the future. Scenario planning has a long history in business science where it has been used to challenge mental models, facilitate behavior change, promote collaborative learning, and confront tradeoffs (56). It also has been used to good effect in the natural resource sector (7, 63, 64) and was adopted by the Millennium Assessment (65, 66). In the context of our model, scenario assumptions are defined by implementation opportunities and constraints, and these are used to set parameters for spatially explicit models of alternative futures that can be depicted as maps and visual narratives (38). Scenarios can be especially effective when they capture alternative futures visually and dramatically, in such a way as to reduce stakeholder confusion by providing clarity about complex issues and vague language (67, 68). By providing compelling, positive alternatives to the status quo, scenarios can harness stakeholders' energies for strategy development and, thereby, overcome their sense of helplessness about the future (69–72).

Planning Phase. The second phase of the operational model is planning, which is explicitly collaborative, involving all key stakeholders, including researchers (Fig. 1). Collaborative planning is a discourse-based process that comprises the identification of a vision, a strategy to realize this vision, specific strategic objectives, and instruments, tools, and organizations for implementing actions to achieve the objectives.

Strategy development. The overall aim of this stage of the planning process is to collaboratively identify a set of strategic objectives and specific actions for the safeguarding of ecosystem services. These objectives should seek to exploit the implementation opportunities and overcome the constraints identified in the assessment phase. Scientists need to develop and present at the strategy workshops products (for example, visually compelling scenarios and maps) that are user-useful and user-friendly (5, 14).

Strategy development is essentially a process for learning (56, 73)—an opportunity for nonexperts to gain an understanding of the issues at stake and for experts to appreciate the concerns and contributions of other stakeholders, including decision makers and the socially marginalized. The involvement of nonexperts also is an important opportunity to engender pro-nature behavior change: appropriately framed information and involvement in a process of developing a strategy to achieve a mutually desired state—the vision—can rapidly change people's norms (62, 74, 75). It forces them to confront realities about unsustainable futures that will be harmful to themselves and their offspring and to contribute by exploring possible solutions to these problems (72, 75–77).

In the strategy process, scientists are enablers (5, 26). They need to frame issues clearly and communicate in simple and accessible language the benefits and costs of particular actions and their associated uncertainties (58, 67, 78–80). Their role is to help stakeholders understand issues so as to avoid confusion and overcome helplessness (69, 71).

The strategic objectives need to be an unambiguous and tractable list of actions and behaviors that are clearly linked to instruments for implementation, which are supported by appropriate institutions (5, 81). The instruments available will be context-specific and, because many instruments are complementary, they should be identified as an optimal mix (5). They may include financial incentives (e.g., direct and indirect payments for service delivery), governance-based instruments (e.g., enforcement of existing legislation, capacity-building, and the establishment of cooperative governance structures), and value-based instruments (education and recognition) (28, 29, 38, 52, 82, 83). In the cases where markets exist for ecosystem services—for example, carbon sequestration, nature-based tourism, and water supply—institutions and organizations may need to be established to capture the values of these (52, 83).

Mainstreaming. Mainstreaming, the internalization of ecosystem service safeguarding into the policies and practices of the land-use planning sector, is located at the interface of the planning and management phases of the operational model (Fig. 1). Optimal mainstreaming requires effective governance, organizational and institutional capacity, and awareness of and a comprehensive knowledge about the ecology and value of ecosystem services (20). The assessment and planning phases provide knowledge about ecosystem services, increased awareness of the importance of these services among stakeholders (and may have already initiated a change in mental models or even behavior), and identify opportunities and constraints regarding governance and capacity for implementation.

The rationale, benefits, and mechanisms for safeguarding ecosystem services need to be mainstreamed into all of those sectors that feed into land-use planning, e.g., water, forestry, agriculture, tourism, and urban planning. At least three things need to be considered when launching a mainstreaming initiative.

First, decision makers in all of the relevant sectors need to be made aware of the importance for sustaining society of safeguarding ecosystem services and, where they exist, of their legal mandates to do so, which is most effectively done by identifying "win–win" situations that address both natural resource and socioeconomic concerns (12). For example, this was done to mainstream restoration projects in South Africa that delivered on both ecosystem service and social equity goals (84, 85). Communication to decision makers must be effective (78, 80); it often may be necessary to emphasize as compelling "sound bites" the immediate, social, and economic benefits of ecosystem service protection (59) rather than less certain benefits that may only manifest in the longer term.

Second, new organizations and institutions will be required to address the tricky problem of coordinating governance across such a wide array of sectors (22). We discuss cooperative governance in the next section of this article.

Third, increased awareness and knowledge about environmental concerns, and even embracing pro-nature values, does not necessarily translate into adopting pro-nature behavior (62, 86). Therefore, pragmatic solutions are required to overcome the inertia in engendering pro-nature behaviors of individuals and organizations that are required for mainstreaming. Social marketing is very promising in this respect: rather than attempting to understand the complex causes of behavior, it takes existing behaviors as a given and then seeks to identify the barriers to behavior change and to design specific incentive-based programs to overcome these barriers (86, 87). Incentives relate to both internal barriers (e.g., absence of skills, opposing values, and beliefs) and external barriers (e.g., inadequate infrastructure and support). Social marketing has been extremely successful in achieving behavior change in the health, social development, and waste management sectors but has yet to penetrate natural resource management and conservation sectors. Depending on the outcome of the assessment of governance and institutional capacities, it may be necessary to implement programs of social marketing to bring about rapidly the desired levels of behavior change.

Mainstreaming is an ongoing process that needs to be responsive to windows of opportunity and other unintended surprises arising from, among others, market emergence, infrastructure development, and political changes and associated shifts in power regimes (20, 26).

Management Phase. Management comprises the final phase of our operational model for achieving resilience of the social-ecological systems associated with ecosystem services. The overall objective of this phase is to undertake and coordinate actions, including additional research, that achieve the protection of biophysical features that provide ecosystem services and ensures the flow of services to beneficiaries.

Actions may include the implementation of social marketing projects, the restoration of vegetation for carbon credits, the protection of watersheds key for water delivery, or the protection of viewsheds for nature-based tourism—it depends on what has emerged from the assessment of implementation opportunities and constraints. We recommend, as others have done (1, 14), the adoption of an adaptive management framework that embodies an action-reflection cycle, or "learning by doing" (24, 30). In this regard, the adoption of a quasi-experimental approach, whereby the effectiveness of interventions can be assessed relative to situations where intervention is withheld (88), can be extremely effective in unraveling the complexities of social-ecological systems (14). Static products such as user-useful and user-friendly maps of ecosystem services and guidelines for managing them, which can be mainstreamed directly or via social marketing into local integrative planning processes, potentially are very useful (e.g., 14).

Adaptive management needs to respond effectively to the complex feedback, opportunities, and shocks that characterize social-ecological systems and provide insights that can be incorporated into the iterative processes of assessment and planning (Fig. 1). Therefore, adaptive management needs to be institutionalized in a suite of learning organizations (5, 14, 28, 78), each focusing on a different ecosystem service. Such organizations must be representative of the sectors that are concerned with land-use decision-making and planning and should foster a spirit of colearning, cogovernance, and accountability (22, 23, 56), which is not always easy to achieve (19); key individuals and good leadership are of paramount importance for effective learning organizations (22, 89). The learning organization should have the authority to restrict access to ecosystem service providers, the wherewithal to offer incentives for their safeguarding, the capacity to monitor ecological and social conditions, the expertise to evaluate the outcomes of interventions, and sufficient flexibility to respond rapidly to changed circumstances (35, 57).

Conclusions and Caveats

At the core of our operational model are three elements: socially relevant, user-inspired research, stakeholder empowerment, and adaptive management embedded in learning organizations. The goal is the achievement of social and ecological resilience in an uncertain world.

The activities prescribed by the model will not be easy to implement. Socially engaged, multi- and interdisciplinary research is relatively rare. Our process requires a fundamental change, or transformation, in the way research generates knowledge (3, 4). Researchers will need to be responsive to stakeholder needs, collaborate with many groups with values and norms foreign to their own, operate as facilitators of knowledge transfer to stakeholders, and be prepared to engage time-consuming processes that are not sympathetic to career aspirations and performance benchmarks predicated by the accumulation of publications in high-impact journals (7, 90). Moreover, the education philosophies of almost all universities are not conducive to multi- and interdisciplinary research; instead, they encourage the atomization of disciplines and entrench the boundaries between them (4, 58, 91). However, the recent emergence of sustainability science (11) is a very positive development. The operational model presented here provides many opportunities for conducting research on the complex problems inherent in managing social-ecological systems. Recognition of the importance of this research through enhanced funding and status can provide the impetus for its growth.

Implementing the operational model for most projects will take a lot of time (25) and incur large costs, especially transaction costs (92, 93). In developing countries, donor organizations fund projects that are geared to specific deliverables subject to the time-related tyrannies of log frames, which may not be appropriate for ecosystem service projects. Our operational model is a process that does have hallmarks for evaluation but is simply too complex and uncertain of outcomes to specify, with any degree of realism, tangible outputs in short (1- to 5-year) timeframes.

The operational model specifies a process that engenders stakeholder collaboration and bottom-up decision-making, which is consistent with the notion that although most environmental problems are regional or global, the solutions are at the local and individual scales (94). However, there are many cases where well intentioned, bottom-up projects fail because of failures of regional and global institutions to support their outcomes (25, 95, 96). Bottom-up implementation needs to be complemented by the policies and practices of regional and global trade and financial institutions (97). Of great importance is the incorporation of the value of ecosystem services into the accounting systems of these institutions (16).

Related to this is the need to project ecosystem services research into the realm of transdisciplinarity by addressing directly the values, ethics, and morals associated with individuals, organizations, and institutions (4, 92, 98). Do we want a world that promotes wealth accumulation and self-interest, or one that fosters equity and common good? Questions such as these raise issues about the kinds of economic systems we desire: ones based on perpetual growth or ones that strive for a steady state (98, 99). Sadly, the prevailing consumerist economic paradigm, the high discount rates held by most humans, and their disconnect for the natural world (58, 69, 100) do not augur well for the radical transformations required to place the world on a path to sustainability. Planning to ensure the persistence of ecosystem services in guaranteed to be an important and stimulating challenge.

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