SPECIAL FEATURE: PERSPECTIVE

# Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses

**Jeffrey Sayer[a,1], Terry Sunderland[b], Jaboury Ghazoul[c], Jean-Laurent Pfund[d], Douglas Sheil[b,e,f], Erik Meijaard[b,g,h], Michelle Venter[a], Agni Klintuni Boedhihartono[a], Michael Day[b], Claude Garcia[b,i], Cora van Oosten[j], and Louise E. Buck[k]**

*[a]Center for Tropical Environmental and Sustainability Science, School of Earth and Environmental Sciences, James Cook University, Cairns, QLD 4870, Australia; [b]Center for International Forestry Research, Bogor 16000, Indonesia; [c]Department of Environmental Systems Science, Institute of Terrestrial Ecosystems, Eidgenössische Technische Hochschule, 8092 Zurich, Switzerland; [d]Fauna, Forests and Nature Service, 2108 Couvet, Switzerland; [e]Institute of Tropical Forest Conservation, Mbarara University of Science and Technology, Kabale, Uganda; [f]School of Environmental Science and Management, Southern Cross University, Lismore, NSW 2480, Australia; [g]People and Nature Borneo Futures Project, Consulting International, Jakarta 15412, Indonesia; [h]School of Biological Sciences, University of Queensland, St. Lucia, QLD 4072, Australia; [i]Goods and Services of Tropical Forest Ecosystems Research Unit, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Unité Propre de Recherche, F-34398 Montpellier, France; [j]Centre for Development Innovation, Wageningen University and Research Centre, 6700 AB, Wageningen, The Netherlands; and [k]EcoAgriculture Partners and Department of Natural Resources, Cornell University, Ithaca, NY 14853*

Edited by Kenneth G. Cassman, University of Nebraska, Lincoln, NE, and accepted by the Editorial Board December 21, 2012 (received for review June 21, 2012)

**"Landscape approaches" seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals. Here we synthesize the current consensus on landscape approaches. This is based on published literature and a consensus-building process to define good practice and is validated by a survey of practitioners. We find the landscape approach has been refined in response to increasing societal concerns about environment and development tradeoffs. Notably, there has been a shift from conservation-orientated perspectives toward increasing integration of poverty alleviation goals. We provide 10 summary principles to support implementation of a landscape approach as it is currently interpreted. These principles emphasize adaptive management, stakeholder involvement, and multiple objectives. Various constraints are recognized, with institutional and governance concerns identified as the most severe obstacles to implementation. We discuss how these principles differ from more traditional sectoral and project-based approaches. Although no panacea, we see few alternatives that are likely to address landscape challenges more effectively than an approach circumscribed by the principles outlined here.**

food security | integrated development approaches | social ecological systems | agriculture environment trade offs | Convention on Biological Diversity

Global demand for agricultural land is on a collision course with environmental protection goals. We face a "perfect storm" as we struggle to feed a burgeoning population on a diminishing supply of land, water, nutrients, and biodiversity (1). Despite global efforts, ambitious targets and massive expenditure, there are as yet no general and effective solutions for meeting both nature conservation goals and human needs (2, 3). The Food and Agricultural Organization estimates a 70% increase in food production is needed to feed a projected population of 9.1 billion people by 2050 (4). Food production goals have to be met in ways that alleviate poverty, improve nutrition, and conserve the environment. Interactions among these challenges require that they be addressed in a concerted way. Sectoral approaches, despite still being predominant, have long been recognized as inadequate (5). For example, agricultural expansion and intensification threatens environmental goods and services (6), which could in turn undermine efforts to meet future food demands (7), while also affecting livelihoods and health (8). There are many uncertainties: climate change threatens to reduce crop production in some regions, but will perhaps provide new opportunities elsewhere (9); competing demands on land for climate change mitigation, biodiversity conservation, and agriculture implies tradeoffs, many of which are poorly understood and not easily resolvable (10). There will be no single best answer, and societies will have to confront challenges that transcend traditional agricultural and environmental boundaries. People and societies must make decisions. We contend that the quality of decision-making is a function of the process by which the decision is reached, and achieving objectives is an ongoing process subject to negotiation, learning, adaptation, and improvement. To this end, we identify 10 principles to guide the process of decision-making in landscape contexts. These principles emphasize that the integration of agricultural and environmental priorities will require a people-centered approach applied at landscape scales. We examine the multiple ways in which this is being approached and the validity of the underlying concepts.

Author contributions: J.S., T.S., J.-L.P., A.K.B., C.v.O., and L.E.B. designed research; J.S., T.S., J.-L.P., A.K.B., C.v.O., and L.E.B. performed research; J.S., T.S., J.-L.P., A.K.B., and C.v.O. contributed new analytic tools; J.S., T.S., J.G., J.-L.P., D.S., E.M., M.V., A.K.B., M.D., and C.G. analyzed data; and J.S., T.S., J.G., D.S., E.M., M.V., A.K.B., M.D., and C.G. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission. K.G.C. is a guest editor invited by the Editorial Board.

[1]To whom correspondence should be addressed. E-mail: jeffrey.sayer@jcu.edu.au.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1210595110/-/DCSupplemental.

"Landscape approaches" have gained prominence in the search for solutions to reconcile conservation and development tradeoffs (11), and the term has evolved to encompass a wide variety of interpretations. Early conservation theory promoted landscape-scale thinking, particularly through the principles of island biogeography (12); debates about the appropriate size, number, and distributions of reserves and connectivity between them (e.g., refs. 13, 14); and metapopulation theory for maintaining viable populations (15). "People" and "society," however, were notably absent from such considerations, and, as a result, conservation has been beset by disappointments and failures (16–18). Thus, although conservation theory provided a stimulus and foundation for landscape approaches, their further development has come from the recognition of the need to address the priorities of people who live and work within, and ultimately shape, these landscapes (19). These priorities are often not aligned, and hence challenges are often "wicked" problems with no clear definitive formulation or final solution (20). In view of this, and also considering that system behavior is not wholly predictable, continuous adaptation and even "muddling through" (21, 22) is necessary (23, 24). Landscapes provide the setting over which wicked problems unfold, and the landscape approach provides the social-ecological systems' framework by which we can grapple with them (25–29).

A variety of landscape approaches are widely applied to complex real-world situations (30). Generally, they have been viewed as a means to conceptualize and implement integrated multiple-objective projects. A rich terminology has developed with the evolution of the various approaches. "Landscapes" have been defined in various ways. Drawing on ecosystem definitions, we define a landscape as an area delineated by an actor for a specific set of objectives (31). It constitutes an arena in which entities, including humans, interact according to rules (physical, biological, and social) that determine their relationships. In many cases, the objectives, arena, entities, and rules will change: our point is that the landscape is defined in broad conceptual terms rather than simply as a physical space (32).

The implementation of people-centered landscape approaches to environmental management has been embraced widely, with many conservationists now focused on multifunctional landscapes, and not solely on protected areas (11, 33). However, although many of the biophysical concepts and principles have been relatively well summarized and shared (e.g., refs. 28, 34), the human and institutional issues lack recent synthesis in the scientific literature. Here we fill that gap and discuss 10 principles that reflect the prevailing views in recent literature. They are based on current approaches and statements of "good practice" and on an extensive multidisciplinary consultation with a range of professional institutions, four formal workshops, and 137 further consultations via an online questionnaire (*SI Text*). Representing a consensus view, these principles were discussed by the Convention on Biological Diversity (CBD) during the 15th Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (35). Following a lengthy consultative process and eventual acceptance by the CBD, we expect that these principles will have traction in guiding landscape approaches to environmental management for some time to come. The principles are targeted at those seeking development and conservation outcomes in multiple-stakeholder contexts. Although some principles may not apply to some situations, and the full set may not be sufficient, these principles have broad support as guides to best practice. We advocate the use of these principles to address the critical emerging need to increase agricultural production and conserve environmental values.

## Results

Our review of the literature failed to identify a universal definition for a landscape approach. The term is used to cover a diversity of approaches, many of which are very similar to those embodied in the various manifestations of the ecosystem approach (e.g., www.cbd.int/ecosystem/principles.shtml). Many practitioners use the two terms, landscape approach and ecosystem approach, interchangeably to loosely describe any spatially explicit attempt to simultaneously address conservation and development objectives. These terms share the virtue of being constructively ambiguous—meaning that people can agree on these approaches in principle while disagreeing on many key details that remain subject to negotiation. There are, however, communities of practice who apply narrower meanings. For example, the Society for Landscape Ecology has a strong focus on modeling the biophysical elements of landscapes (36), whereas, in much of Europe, landscape approaches are still largely synonymous with spatial planning (37). The de facto use of landscape approaches by most conservation organizations has evolved from the dominant paradigm of the late 20th century of integrated conservation and development projects (5, 38). It describes an approach to reconciling conservation and development through interventions in different components of a landscape matrix—some of which are managed toward livelihood development goals and others for conservation. The evolution of integrated conservation and development projects and ecosystem approaches toward landscape approaches has been incremental. The main substantive innovations have been the recognition of the need to address the complex interactions between different spatial scales, and the need to embrace the full complexity of human institutions and behaviors (38, 39).

Biodiversity conservation has been addressed in an explicitly "landscape context" since at least 1983 (40). The early uses of landscape focused on biophysical attributes (41). In 1997, a comprehensive account of ecosystem management used the term landscape only in the context of the visual (i.e., scenic) impacts of forest management interventions (42). The Forest Stewardship Council principles for Sustainable Forest Management (43), the Pan-European Indicators for Sustainable Forest Management,* and the CBD Principles of an Ecosystem Approach (www.cbd.int/ecosystem/principles.shtml), all developed in the 1990s, make only cursory reference to landscapes. This contrasts with the most recent 2012 revisions of the Forest Stewardship Council principles in which the landscape concept is much more prominent (http://ic.fsc.org/principles-and-criteria.34.htm).

More recently, the landscape concept has been central to some major international conservation initiatives. For instance, the Congo Basin Forest Partnership articulates its programs around 12 priority landscapes (http://carpe.umd.edu/works/landscape_detail.php?lid=8). The Worldwide Fund for Nature has advocated the conservation of forests in a landscape context since at least 2003 (44), and has configured a significant part of its conservation portfolio into a series of Global Initiatives, several of which work at landscape scales and address social and institutional issues. In 2007, the International Union for Conservation of Nature launched the "Landscapes and Livelihoods" initiative (www.iucn.org/about/work/programmes/forest/fp_our_work/fp_our_

*Ministerial Conference on the Protection of Forests in Europe. *Improved Pan-European Indicators for Sustainable Forest Management*. MCPFE Expert Level Meeting, 7–8 October 2002, Vienna, Austria. Available at http://www.foresteurope.org/documentos/improved_indicators.pdf.

work_initiatives/fp_our_work_ll/), explicitly addressing the dual goals of environmental conservation and poverty alleviation. Similarly, a Center for International Forestry Research/World Agroforestry Centre initiative, the "Landscape Mosaics" project, with case studies from Cameroon, Tanzania, Madagascar, Laos, and Indonesia, focused on wider landscape approaches to integrate agriculture, conservation, and other functions (45).

**Ten Principles of Landscape Approach.** The 10 principles of the landscape approach have now been adopted by the Subsidiary Body on Scientific, Technical and Technological Advice of the CBD, and have been submitted for consideration by the Conference of the Parties of the CBD in Hyderabad, India, in November 2012. The 10 principles are the product of an intergovernmental and interinstitutional process, and we present them in their official form. We provide our own interpretation of the justification and conceptual underpinnings of each principle. We also give examples of lessons learned in their application. The principles represent the consensus opinion of a significant number of major actors on how agricultural production and environmental conservation can best be integrated at a landscape scale (46).

***Principle 1: Continual learning and adaptive management.*** Landscape processes are dynamic. Despite the underlying uncertainties in causes and effects, changes in landscape attributes must inform decision-making. Learning from outcomes can improve management.

Nonlinear relationships, external shocks, and unforeseen interactions and thresholds imply neverending potential for surprise. Each surprise is an opportunity for learning, leading to the development of new understandings as a basis for revised strategies. This learning and revision requires continual adjustment in which new knowledge is derived from multiple sources. Adaptive management and, more recently, "adaptive collaborative management" have emerged as practical approaches to this process of continual learning (47–49).

***Principle 2: Common concern entry point.*** Solutions to problems need to be built on shared negotiation processes based on trust. Trust emerges when objectives and values are shared. However, stakeholders have different values, beliefs, and objectives. Totally aligned objectives are unlikely, costly to establish, or devoid of immediate significance. Identifying immediate ways forward through addressing simpler short-term objectives can begin to build trust.

Each stakeholder will only join the process if they judge it to be in their interest. Initially achieving consensus on overarching objectives may be difficult. Launching the process by focusing on easy-to-reach intermediate targets may provide a basis for stakeholders to begin to work together. In working toward this first goal, there will be opportunities for shared learning. The process will build the confidence and the trust needed to address further issues. Forest landscape negotiations in California (29) and the Pacific Northwest of the United States (50) illustrate how incremental progress can be made toward shared goals.

***Principle 3: Multiple scales.*** Numerous system influences and feedbacks affect management outcomes, but these impacts unfold under the influence of a diverse range of external influences and constraints.

Outcomes at any scale are shaped by processes operating at other scales. Influences include feedback, synergies, flows, interactions, and time lags, as well as external drivers and demands. An awareness of these higher and lower level processes can improve local interventions, inform higher-level policy and governance, and help coordinate administrative entities. Studies by Ostrom in various sites illustrate the importance of addressing multiple scale issues (51).

***Principle 4: Multifunctionality.*** Landscapes and their components have multiple uses and purposes, each of which is valued in different ways by different stakeholders. Tradeoffs exist among the differing landscape uses and need to be reconciled.

Many landscapes provide a diverse range of values, goods, and services. The landscape approach acknowledges the various tradeoffs among these goods and services. It addresses them in a spatially explicit and ecosystem-driven manner that reconciles stakeholders' multiple needs, preferences, and aspirations. The difficulties of quantifying and managing the interactions among these multiple functions have been extensively studied in the European Union (37).

***Principle 5: Multiple stakeholders.*** Multiple stakeholders frame and express objectives in different ways (principle 2). Failure to engage stakeholders in an equitable manner in decision-making processes will lead to suboptimal, and sometimes unethical, outcomes. All stakeholders should be recognized, even though efficient pursuit of negotiated solutions may involve only a subset of stakeholders. Solutions should encompass a fair distribution of benefits and incentives.

Developing a landscape approach requires a patient iterative process of identifying stakeholders and recognizing their concerns and aspirations. Progress requires communication, which needs to be developed and nurtured, and mutual respect of values is essential. There is often a need to address conflicts, and issues of trust and power. Stakeholders and their concerns are not static but will change. Although many management agencies aspire to involving all stakeholder groups in decision-making, the transaction costs of doing this comprehensively can be prohibitive and total agreement can be elusive (29).

***Principle 6: Negotiated and transparent change logic.*** Trust among stakeholders is a basis for good management and is needed to avoid or resolve conflicts. Transparency is the basis of trust (principle 2). Transparency is achieved through a mutually understood and negotiated process of change and is helped by good governance.

The need to coordinate activities by diverse actors requires that a shared vision can be agreed upon. This requires a broad consensus on general goals, challenges, and concerns, as well as on options and opportunities. All stakeholders need to understand and accept the general logic, legitimacy, and justification for a course of action, and to be aware of the risks and uncertainties. Building and maintaining such a consensus is a fundamental goal of a landscape approach (principle 2). Numerous attempts to secure consensus around major tropical land conversion projects and the widespread use of the principle of free, prior, and informed consent illustrate the potential and the difficulties of reaching broad agreement on such issues (52).

***Principle 7: Clarification of rights and responsibilities.*** Rules on resource access and land use shape social and conservation outcomes and need to be clear as a basis for good management. Access to a fair justice system allows for conflict resolution and recourse.

The rights and responsibilities of different actors need to be clear to, and accepted by, all stakeholders. Clarification of conflicting claims will require changes, ideally negotiated, that may be legal or informal. When conflict arises, there needs to be an accepted legitimate system for arbitration, justice, and reconciliation. Recent decades have seen major changes in the mandates and management cultures of natural resource management agencies. Clarifying rights and responsibilities is now replacing the command-and-control approach. Facilitation and negotiation are emerging as the core business of resource management agencies (53).

***Principle 8: Participatory and user-friendly monitoring.*** Information can be derived from multiple sources. To facilitate shared learning,

information needs to be widely accessible. Systems that integrate different kinds of information need to be developed.

When stakeholders have agreed on desirable actions and outcomes, they will share an interest in assessing progress. In a landscape approach, no single stakeholder has a unique claim to relevant information, and the validity of different knowledge systems must be recognized. All stakeholders should be able to generate, gather, and integrate the information they require to interpret activities, progress, and threats (principle 1). The gathering and interpretation of information is a vital part of developing and updating the "theories of change" on which the landscape approach is based (principle 6). Participatory monitoring in the Sangha Tri-National Landscape as part of the Congo Basin Forest Partnership has demonstrated how local stakeholders and government agencies can learn and adapt together (54).

***Principle 9: Resilience.*** Wholesale unplanned system changes are usually detrimental and undesirable. System-level resilience can be increased through an active recognition of threats and vulnerabilities. Actions need to be promoted that address threats and that allow recovery after perturbation through improving capacity to resist and respond.

Perturbations impinge on all landscapes and their social and ecological structures. Maintaining and bolstering resilience, which is the capacity to avoid or deflect such threats and to absorb and recover from their manifestations, is vital to sustain processes and benefits in the longer term. Factors that contribute to system resilience are diverse and reflect ecological, social, and institutional attributes. Resilience may not be well understood in every situation, but can be improved through local learning and through drawing lessons from elsewhere (principles 1 and 10). The challenge in agricultural landscapes is often to bring about transformational change while maintaining the attributes of the landscape that provide resilience to undesirable changes (55, 56).

***Principle 10: Strengthened stakeholder capacity.*** People require the ability to participate effectively and to accept various roles and responsibilities. Such participation presupposes certain skills and abilities (social, cultural, financial).

Effective participation makes demands of stakeholders. The complex and changing nature of landscape processes requires competent and effective representation and institutions that are able to engage with all the issues raised by the process. The learning process of the landscape approach is one means by which stakeholders can improve their capacity to judge and respond. It also provides a platform to share experiences within and among sites. The proliferation of local nongovernmental organizations addressing rural issues is a reflection of this and is recognized by the increasing willingness of development assistance agencies to support local civil society groups.

## Discussion

The main driver of rural landscape change in coming decades is likely to be the intensity and spatial extent and location of agriculture. Agricultural intensification offers opportunities to close the substantial yield gap that afflicts many production systems, but this in itself is unlikely to be sufficient to meet the demands of a growing and increasingly affluent global population. Demands for nonfood land-based commodities, including wood products, vegetable oils, and biofuels (as well as mined resources), will also compete for space with agriculture. Intensification of land use and the inevitable expansion of land that is allocated to agriculture will combine to determine environmental outcomes.

The manner in which society responds to this, and the degree to which agriculture is constrained by measures to maintain environmental values, will not be determined at global or even national scales, but rather across landscapes in which agricultural and environmental objectives interact and often compete, ecosystem processes unfold, decisions impinge on other interests, and emergent properties of aggregated land use patterns are realized. Agricultural landscapes are no longer just farmed entities: they are now recognized as providing multiple values and services to diverse interest groups (37). Management of such landscapes is increasingly being seen as an evolving outcome of ongoing negotiation, and frequent conflict, among these interest groups. The principles of the landscape approach provide a framework by which outcomes negotiated among stakeholders can be reached most effectively. The means by which conflicting objectives are resolved will be subject to changing societal desires and will vary from place to place and over time. Thus, payments for environmental services, a currently popular approach in dealing with land use conflicts, are only likely to be successful if developed with due regard to the 10 principles. Similar issues are relevant to the implementation of the Reducing Emissions from Deforestation and Forest Degradation program, the expansion of oil palm in Southeast Asia, or the development of various mining interests in the Congo Basin. Current land use and environment conflicts often exist because of a failure to address one or more of the 10 principles.

Landscape approaches have emerged as the most widely advocated means to address growing pressures on land, water, and other resources, and to accommodate the needs of present and future generations. These approaches facilitate the simultaneous framing of development and conservation goals. They provide a process to steer the evolution of landscapes toward desirable futures. However, this broad engagement also means more objectives, tradeoffs, and complexity (57). A small selection of case studies (Table 1) identifies methods and tools that can be used to address each of the 10 principles, and also highlights some of the associated challenges.

There are challenges at many levels. A questionnaire survey of practitioners revealed that governance issues and those of poor institutional capacity are judged by practitioners and other experts to be the most pervasive (*SI Text*). Many of the challenges, governance and otherwise, reflect the conceptual changes needed to implement a landscape approach (53).

Landscape approaches imply shifting from project-oriented actions to process-oriented activities (58). This requires changes at all levels of interventions, from problem definition to monitoring and funding (Table 2). It ties stakeholders to long-term, iterative processes, giving them responsibilities and empowering them. It tends away from top-down engineered solutions toward more bottom-up negotiated actions that emerge from a process akin to muddling through (11).

Strategies applied to the wicked problems that are addressed through landscape approaches are not objectively right or wrong, they are simply more or less acceptable to different stakeholders (59). Stakeholders, including conservationists, need to recognize that working at landscape levels inherently changes how we look at the outcomes of our interventions. The straightforward concepts of success and failure become ambiguous in a multiple-stakeholder context in which someone's gain is someone else's loss. (For example, in the case of conservation interventions, did we or did we not stop the conversion of forest to crops?) Changes in one component of the landscape, even if desired, can have unintended and undesirable repercussions (60). Landscape approaches therefore demand an open-minded view of outcomes and acknowledgment of the tradeoffs likely to be involved in any

**Table 1. Selection of case studies, methods, and tools that might be used to address each of the 10 principles, together with associated challenges**

| Principle | Tools and "how-to" | Constraints | Source |
|---|---|---|---|
| 1. Continual learning and adaptive management | Adaptive management: https://miradi.org/ | Expensive, slow, difficult to show results, disconnect with funding cycles, risk aversion, requires analytical skills, burn out | 47–49 |
| 2. Common concern entry point | Approaches, www.cifor.org/mla/_ref/home/index.htm, http://satyadi.com/wordpress/wp-content/uploads/2010/04/COAIT_Manual_Part_I_RS_Format_2.pdf; Proactive conciliation tool, ref. 68, http://treadwell.cce.cornell.edu/ecoag1a/?p=41 | Lack of common entry point, entrenched position, conflict and distrust | 29, 50, 69 |
| 3. Multiple scale | Participatory GIS, www.iapad.org/toolbox.htm, ref. 70; see also participatory modeling, principle 8 | Lack of methods for scaling up, endless complexity, time lags, limited predictability, disconnect between levels, difficulty of linking local to macroscale drivers of change | 51 |
| 4. Multifunctionality | Multiple resource assessment and management: www.cifor.org/mla/_ref/home/index.htm, ref. 71 | Difficulty to manage diversity and complexity, tradeoffs, incorporate multiple intangible values | 37 |
| 5. Multiple stakeholder | ELDIS participatory approach, http://community.eldis.org/.59c6ec19/; social network mapping, ref. 72 | Conflicting objectives, hidden agendas, identifying appropriate stakeholders, lack of capacity, power imbalance, lack of conceptual frameworks, distrust, high transaction costs, communication breakdowns | 29, 73 |
| 6. Negotiated and transparent change logic | Theories of change: www.policy-powertools.org/index.html http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/measuring+environmental+results | Hidden agendas, conflict of interests, lack of accountability, corruption, different norms and mediation institutions | 50 |
| 7. Clarification of rights and responsibilities | Games: www.cifor.org/lpf/_ref/index.htm, www.policy-powertools.org/Tools/Understanding/TFR.html, www.rightsandresources.org/tenure_trends.php, | Legitimacy, overlapping rights or claims, unequal access to justice, corruption, power imbalances, lack of awareness, knowledge and education | 53 |
| 8. Participatory and user friendly monitoring | Participatory modeling: http://cormas.cirad.fr/ComMod/en/, www.cifor.org/conservation/_ref/research/research.2.htm, http://wwf.panda.org/what_we_do/how_we_work/conservation/forests/publications/?uNewsID=120980 | High transaction costs, lack of capacity, no linkage to decision making and benefits, formal vs. informal monitoring, social and political structure, credibility | 54 |
| 9. Resilience | Resilience assessment: www.resalliance.org/index.php/resilience_assessment, ref. 74 | Complexity, difficult to operationalize, inherent uncertainty in system, insufficient information, basic concept used ambiguously | 55, 56 |
| 10. Strengthened stakeholder capacity | Participatory GIS, see principle 3: approaches to capacity building, www.undp.org/content/undp/en/home/ourwork/capacitybuilding/approach/, ref. 75 | Lack of basic education and skills, limited government and institutional investments, short term projects, ubiquitous situations of weak governance and institutional failures make operationalization difficult | Broad range of approaches widely used, e.g., refs. 47, 50, 54, 58, 67 |

system change (61). Such compromises require decision-makers to consider all stakeholders and to work toward their inclusion in the processes.

Attempts to superimpose landscape approaches onto existing institutions through short-term projects will rarely work. The time scales involved and the concomitant difficulty to define and measure progress make it hard to retain the interest of donors. This may be more so because landscape approaches rarely have a clear endpoint. They deal with processes steered by individual decisions of multiple actors (e.g., farmers, land managers, policy makers) and influenced by the extent and nature of public debate and participation. However, the development of systems and institutions

**Table 2. Contrasts between sectoral and landscape approaches to environmental problems**

| Issue | Sectoral or project approach | Landscape approach |
|---|---|---|
| Problem addressed | Simple | Complex (even "wicked") |
| Objectives and endpoint | Precisely defined | Loosely defined |
| Objective setting | Fixed in advance | Regularly revisited |
| Planning | Linear (grand design) | Nonlinear and in frequent need of revision (muddling through) |
| Scale | Local: Generally one or two major land uses | Larger scale: multiple interacting land uses |
| Scope | Generally well defined | Fuzzy and evolving (subject of consultation and negotiation) |
| Emphasis | Goal-driven | Process-driven |
| Success and failure | Easily identified ("black and white") | Perception of positive and negative outcomes are stakeholder dependent and determined by changing contexts ("shades of gray") |
| Monitoring | Progress can be measured, simple, evidence-based—defined in advance | Complex, targets move and desired outcomes may require modification over time |
| Learning | Informal and project cycle level | Integral and continuous, social learning |
| Management and governance | Clear and well defined organizational roles and structures | Organizational roles evolve and often overlap; civil society has increasing significance |
| Authority | Largely centralized and clear | Decentralized/distributed, potentially dynamic and negotiated |
| Time scale | Short to medium term (a few years) | Many years to several decades |
| Role of other actors | Subjects of a project | Participants within a process |
| External factors viewed as | Constraints and contexts | Possible subjects of higher level interventions to reduce threats or enable processes or outcomes |
| Negotiations to achieve | Specific outcomes | Engagement and to determine what is mutually acceptable |
| Role of science | To lead and define | To detect patterns, inform interpretation and contribute to evaluation and learning |
| Funding | Carefully budgeted; fits present-day donor cycles | Indeterminate (ideally institutionalized to support a long-term vision) |

to facilitate constructive debate among interest groups toward a common understanding and resolution of complex objectives is a critical but neglected field within environmental management. Public participation, information dissemination, achieving consensus through public dialogue, and, notably, elevating the importance of the reflective process over that of the technical expert, is captured in our vision of the landscape approach. Changes in the mandates and cultures of natural resource management institutions in the past few decades in some countries have shown how progress can be made. Pressures for independent certification of forest management have contributed to the emergence of new types of institutions that have succeeded in facilitating landscape approaches (53).

The quality of stakeholder engagement, the degree to which various stakeholders concerns are acknowledged, and the investment in building trust and developing a shared vision will ultimately dictate the success or failure of the process. These processes are lengthy and incur significant transactions costs (29). Success has come in advanced economies in which civil society has greater influence and governance is strong. Less developed countries often lack the capacity and resources to maintain complex multiple-stakeholder processes for the time that is necessary, and the donors that support these countries rarely stay the course. Evidence-based decision-making is a vital component of management (38), but its limitations should be recognized. Evidence needs to be transparent to engender trust (principle 6) and accessible to facilitate participation (principle 8) and learning (principles 1 and 6). Transparency and accessibility also invite critique, often with assumptions being challenged and uncertainties manipulated to suit specific agendas, unless a common agenda can be agreed upon (principle 2). Although critique is to be welcomed, ongoing public debate on many environmental issues with few realistic solutions (not least climate change) illustrates the difficulties associated with rationalizing solutions from evidence without due regard to other social processes (principle 5). Nonetheless, the societal trend in many of the world's regions toward devolution, democratic participation, increased transparency, and improved access to information (62, 63) will facilitate the acceptance and uptake of a people-centered landscape approach to solving the problems at the agriculture–environment nexus.

The landscape approach does not constrain other efforts to address, manage, or reconcile this agriculture–conservation nexus, as outlined in this special issue and elsewhere (64, 65). Thus, a "designer" landscape of spatially segregated protected and productive areas (66), often the predominant paradigm of conservation biology or environmental engineering, is not precluded by a landscape approach. This might be the agreed-upon solution emerging from a landscape process. Such planning is often a necessary but not sufficient step toward achieving appropriate outcomes, as classical spatial planning may be insufficiently flexible to accommodate multiple and changing perspectives. The conceptual and sometimes spatial segregation of protection and production functions of land will thus be an unlikely outcome unless human population density is very low: the presence of many people implies many different interests (as well as higher pressure on land and its resources) and hence increasing land use and resource conflicts. As global population continues to increase in coming decades, particularly so in the tropics, dependencies on land and natural resources will increase. Landscapes will be expected to provide an increasing number of functions. Issues of multifunctionality (principle 4), accommodation of multiple stakeholder interests (principle 5), and clarity of rights and responsibilities of these stakeholders (principle 7) will become paramount, whereas strict protected areas (with conservation as a dominant objective) may increasingly become geographically and conceptually peripheral.

A shift in thinking toward resolving tradeoffs, as well as facilitating synergies, between conservation and economic interests often proposes "optimal" solutions based on quantitative analyses of system properties. Indeed, conventional spatial land use planning relies on models developed by experts with the intention of delivering optimal solutions. Such tools and analyses are important in understanding processes, feedbacks, and interactions across scales (principle 3), and system vulnerabilities and responses to perturbations (principle 9). They are fundamental to adaptive learning (principle 1). Optimization, however, is an illusion unless constrained in its application to specific and clearly defined objectives. Multiple stakeholders (principle 5) and different interests and values (principle 2) will usually preclude the emergence of a single best solution. This underscores the landscape approach as an iterative, flexible, and ongoing process of negotiation, decision-making, and reevaluation, informed by science but shaped by human values and aspirations.

This approach does have limitations when viewed from the perspective of conventional land management. The landscapes approach framework, and the wicked problem contexts to which it frequently applies, is not amenable to simple performance assessments, priority setting, or analytical evaluation. Components of the landscape can be assessed, and tradeoffs can be measured, but securing information about the overall success of a negotiated strategy, which is itself under frequent revision and change, is a challenge.

Above all, people lie at the heart of the landscape approach, and the 10 principles reflect this. We believe the principles will provide a normative basis for the landscape approach and enable it to be applied in a more consistent way. This will allow the multiple benefits that flow from a landscape to be enjoyed by a wider range of stakeholders. The principles shift the center of gravity of decision making to local people, and from the "what" and "where" to the "how" and "why" of managing the agriculture–environment nexus.

It is important to stress that these principles should not be treated as a number of boxes to be ticked in designing landscape projects. They are principles that need to be taken into account in reforming resource management agencies. These agencies must have the multidisciplinary staff capacity and resources to perform these functions and must be able to draw on the principles in ways that meet the particular needs of the problems they are confronting (24). The principles provide options that can be deployed selectively to meet the challenges found in a universe of unique landscape situations. They should shape the culture of resource management agencies and processes and not replace or duplicate these institutions. The 10 principles of the landscape approach are an innovation that should help address the challenge of increasing agricultural production while minimizing negative impacts on the environment.

## Methods

We reviewed publications concerned with landscape approaches. Our goal was to understand how the term "landscape approach" had been used, and to identify elements of best practice. We developed simple indicative principles and summary guidelines based on key issues and concepts. The results were summarized (67) and were subsequently the subject of further discussion and elaboration at workshops in Bayanga, Central African Republic, in mid-2008; Kigali, Rwanda, in late 2008; Bali, Indonesia, in May 2009; and Neuchatel, Switzerland, in December 2009. This was followed by extensive virtual consultation and the final development of the landscape principles presented. The present paper is the consolidation of these discussions and results developed during a meeting in Cairns, Australia, in May 2012.

Professionals working in conservation landscapes (within development and conservation fields and academics) were addressed via an online questionnaire to assess the utility of the 10 principles and determine perceived obstacles to their implementation. The survey was designed to determine the ways in which respondents understood the term landscape approach and the obstacles they encountered in implementing such an approach. The respondents were asked to evaluate the 10 principles and provide comments on their relevance and potential issues in their implementation. Further information on this survey is provided in the Supporting Information.

**ACKNOWLEDGMENTS.** We thank the following people who contributed to the elaboration of these landscape principles: Mark Aldrich, Zach Anderson, Edmund Barrow, Bruno Bokoto, Bruce Campbell, Tim Christophersen, Carol Colfer, Neil Collier, Louis Defo, Nigel Dudley, Chris Elliot, Wendy Elliot, Dominique Endamana, Antoine Eyebe, Bob Fisher, Peter Frost, Lionel Giron, Manuel Guariguata, Petrus Gunarso, Stephen Kelleher, Yves Laumonier, Stewart Maginnis, Jeff Milder, Robert Nasi, Cleto Ndikumagenge, Zach Ndongmo, Zacharie Nzooh, Manuel Ruiz-Perez, Susanna Raffe, Patrick Robinson, Patrick Seiber, Gill Shepherd, Andrew Taber, Gen Takao, Takeshi Toma, John Watts, Peter Wood, and Leonard Usongo. This work was supported by the US Agency for International Development and the Netherlands Directorate General for International Cooperation.

**1** Godfray HCJ, et al. (2010) Food security: The challenge of feeding 9 billion people. *Science* 327(5967):812–818.
**2** Barrett CB (2010) Measuring food insecurity. *Science* 327(5967): 825–828.
**3** Balmford A, Green R, Phalan B (2012) What conservationists need to know about farming. *Proc Royal Soc B: Biological Sciences* 279 (1739):2714–2724.
**4** United Nations Food and Agriculture Organization (2009) *Harvesting Agriculture's Multiple Benefits: Mitigation, Adaptation, Development and Food Security: Policy Brief* (FAO, Rome).
**5** Sayer JA, Campbell B (2005) *The Science of Sustainable Development: Local Livelihoods and the Global Environment* (Cambridge Univ Press, Cambridge, UK).
**6** Millenium Ecosystem Assessment (2005) *Ecosystems and Human Well-Being. Current Status and Trends: Findings of the Condition and Trends Working Group* (Millenium Ecosystem Assessment, Washington, DC).
**7** Vörösmarty CJ, et al. (2010) Global threats to human water security and river biodiversity. *Nature* 467(7315):555–561.
**8** Foresight Program (2011) *The Future of Food and Farming: Challenges and Choices for Global Sustainability* (Government Office for Science, London).
**9** Lobell DB, Schlenker W, Costa-Roberts J (2011) Climate trends and global crop production since 1980. *Science* 333(6042): 616–620.
**10** Sandker M, Ruiz-Perez M, Campbell BM (2012) Trade-offs between biodiversity conservation and economic development in five tropical forest landscapes. *Environ Manage* 50(4):633–644.
**11** Sayer JA (2009) Reconciling conservation and development: Are landscapes the answer? *Biotropica* 41(6):649–652.
**12** Kingsland SE (2002) Creating a science of nature reserve design: Perspectives from history. *Environ Model Assess* 7(2):61–69.
**13** Diamond JM (1975) The island dilemma: Lessons of modern biogeographic studies for the design of natural reserves. *Biol Conserv* 7(2):129–146.
**14** Simberloff D, Abele LG (1982) Refuge design and island biogeographic theory: Effects of fragmentation. *Am Nat* 120(1): 41–50.
**15** Shaffer M (1987) Minimum viable populations: Coping with uncertainty. *Viable Populations for Conservation*, ed Soulé ME (Cambridge Univ Press, Cambridge, UK), pp 69–86.
**16** Chan KMA, et al. (2007) When agendas collide: Human welfare and biological conservation. *Conserv Biol* 21(1):59–68.
**17** McShane TO, et al. (2011) Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biol Conserv* 144(3):966–972.
**18** McShane TO, Newby SA (2004) Expecting the unattainable: The assumptions behind ICDPs. *Getting Biodiversity Projects to Work: Towards More Effective Conservation and Development*, eds McShane TO, Wells MP (Columbia Univ Press, New York), pp 49–74.
**19** Lawrence A, ed (2010) *Taking Stock of Nature* (Cambridge Univ Press, Cambridge, UK).
**20** Horst WJ, Webber MM (1973) Dilemmas in a general theory of planning. *Policy Sci* 4:155–169.
**21** Lindblom CE (1959) The science of "muddling through" *Public Adm Rev* 19(2):79–88.
**22** Wollenberg E, et al. (2007) Facilitating cooperation during times of chaos: Spontaneous orders and muddling through in Malinau District, Indonesia. *Ecol Soc* 12(1):3.
**23** Ludwig D (2001) The era of management is over. *Ecosystems* 4:758–764.
**24** Sayer JA, Bull G, Elliott C (2008) Mediating forest transitions: "Grand design" or "muddling through." *Conserv Soc* 6(4):320
**25** Sayer JA, Maginnis S, Laurie M (2005) Forests in landscapes: Ecosystem approaches to sustainability. (Earthscan, London).
**26** Stork N, Turton SM (2008) *Living in a Dynamic Tropical Forest Landscape* (Blackwell, Oxford).
**27** Sayer JA, et al. (2007) Assessing environment and development outcomes in conservation landscapes. *Biodivers Conserv* 16(9): 2677–2694.
**28** Salt D, Lindenmayer D (2008) *The Bowral Checklist. A Framework for Ecological Management of Landscapes.* (Land and Water Australia, Canberra).
**29** Balint PJ, Stewart RE, Desai A, Walters LC (2011) *Wicked Environmental Problems: Managing Uncertainty and Conflict* (Island Press, Washington, DC).
**30** Pfund JL (2010) Landscape-scale research for conservation and development in the tropics: fighting persisting challenges. *Curr Opin Environ Sustainability* 2(1–2):117–126.
**31** Gignoux J, Davies I, Flint S, Zucker J-D (2011) The ecosystem in practice: Interest and problems of an old definition for constructing ecological models. *Ecosystems* 14(7):1039–1054.
**32** Farina A (2000) The cultural landscape as a model for the integration of ecology and economics. *Bioscience* 50(4): 313–320.
**33** Laven DN, Mitchell NJ, Wang D (2005) Conservation practice at the landscape scale. *George Wright Forum* 22(1):5–9.
**34** Lindenmayer D, et al. (2008) A checklist for ecological management of landscapes for conservation. *Ecol Lett* 11(1): 78–91.
**35** United Nations Environment Programme (2011) Report on How to Improve Sustainable Use of Biodiversity in a Landscape Perspective: Executive Summary (UNEP/CBD/SBSTTA/14/13). United Nations Environment Programme Subsidiary Body on Scientific, Technical and Technological Advice, 15th Meeting, Montreal, Canada November 7–11, 2011. Available at http://www.cbd.int/doc/

meetings/sbstta/sbstta-15/official/sbstta-15-13-en.pdf. Accessed May 16, 2012.
**36** Li C, Raffaele L, Chen J (2011) *Landscape Ecology in Forest Management and Conservation* (Springer, Berlin).
**37** Van Ittersum MK, et al. (2008) Integrated assessment of agricultural systems—A component-based framework for the European Union (SEAMLESS). *Agric Syst* 96(1–3):150–165.
**38** Sunderland T, Sayer J, Minh-Ha H (2012) *Evidence-Based Conservation: Lessons from the Lower Mekong* (Earthscan/Routledge, New York).
**39** Reid WV, et al. (2010) Environment and development. Earth system science for global sustainability: grand challenges. *Science* 330(6006):916–917.
**40** Noss RF (1983) A regional landscape approach to maintain diversity. *Bioscience* 33(11):700–706.
**41** Franklin JF (1993) Preserving biodiversity: Species, ecosystems, or landscapes? *Ecol Appl* 3(2):202–205.
**42** Kohm KA, Franklin JF (1997) *Creating a Forestry for the 21st Century: The Science of Ecosystem Management* (Island Press, Washington, DC).
**43** Forest Stewardship Council (1996) *Principles and Criteria for Forest Management* (Forest Stewardship Council, Bonn, Germany).
**44** Sayer JA, Elliot C, Maginnis S (2003) Protect, manage and restore; Conserving forests in multi-functional landscapes. Proceedings, 2003 World Forestry Congress, Synthesis (Food and Agriculture Organization of the United Nations, Rome, Italy). Available at http://www.fao.org/docrep/ARTICLE/WFC/XII/0484-C3.HTM. Accessed January 18, 2013.
**45** Pfund JL, et al. (2011) Understanding and integrating local perceptions of trees and forests into incentives for sustainable landscape management. *Environ Manage* 48(2):334–349.
**46** Korn H, Bockmühl K, Schliep R (2011) *Report of the European expert meeting in preparation of SBSTTA-15, 26-28 September, 2011* (Bundesamt für Naturschutz, Bonn, Germany).
**47** Colfer CJP, et al. (2011) Participatory action research for catalyzing adaptive management: Analysis of a 'fits and starts' process. *J Environ Sci Eng* 5:28–43.
**48** Smith CB (2011) Adaptive management on the central Platte River—science, engineering, and decision analysis to assist in the recovery of four species. *J Environ Manage* 92(5):1414–1419.
**49** Velázquez A, et al. (2009) Building participatory landscape-based conservation alternatives: A case study of Michoacán, Mexico. *Appl Geogr* 29(4):513–526.
**50** Lee KL (1993) *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Island Press, Washington, DC).
**51** Ostrom E (2007) A diagnostic approach for going beyond panaceas. *Proc Natl Acad Sci USA* 104(39):15181–15187.
**52** Rist L, Feintrenie L, Levang P (2010) The livelihood impacts of oil palm: Smallholders in Indonesia. *Biodivers Conserv* 19(4):1009–1024.
**53** Sayer JA, Collins M (2012) Forest governance in a changing world: Reconciling local and global values. *Round Table* 101(2): 137–146.
**54** Endamana D, et al. (2010) A framework for assessing conservation and development in a Congo Basin Forest Landscape. *Tropical Conserv Sci* 3(3):262–281.
**55** Walker B, Salt D (2012) *Resilience Practice: Engaging the Sources of Our Sustainability* (Island Press, Washington, DC).
**56** Walker B, Sayer J, Andrew NL, Campbell B (2010) Should enhanced resilience be an objective of natural resource management research for developing countries? *Crop Sci* 50:10–19.
**57** Salafsky N (2011) Integrating development with conservation: A means to a conservation end, or a mean end to conservation? *Biol Conserv* 144(3):973–978.
**58** Sayer J, Wells MP (2004) The pathology of projects. *Getting biodiversity projects to work: towards better conservation and development*, eds McShane TO, Wells MP (Columbia University Press, New York), pp 35–48.
**59** Bal P, Nath CD, Nanaya KM, Kushalappa CG, Garcia C (2011) Elephants also like coffee: Trends and drivers of human-elephant conflicts in coffee agroforestry landscapes of Kodagu, Western Ghats, India. *Environ Manage* 47(5):789–801.
**60** Phalan B, Onial M, Balmford A, Green RE (2011) Reconciling food production and biodiversity conservation: Land sharing and land sparing compared. *Science* 333(6047):1289–1291.
**61** Sunderland T, Ehringhaus C, Campbell B (2007) Conservation and development in tropical forest landscapes: A time to face the trade-offs? *Environ Conserv* 34(4):276–279.
**62** Price D (2009) Global democracy promotion: Seven lessons for the new administration. *Wash Q* 32(1):159–170.
**63** Accascina G (2000) Information technology and poverty alleviation. *The Role of Information and Communication Technologies in Rural Development and Food Security* (FAO, Rome).
**64** Brussaard L, et al. (2010) Reconciling biodiversity conservation and food security: Scientific challenges for a new agriculture. *Curr Opin Environ Sustainability* 2(1–2):34–42.
**65** Foley JA, et al. (2011) Solutions for a cultivated planet. *Nature* 478(7369):337–342.
**66** Koh LP, Levang P, Ghazoul J (2009) Designer landscapes for sustainable biofuels. *Trends Ecol Evol* 24(8):431–438.
**67** International Union for Conservation of Nature (2008) *Learning from Landscapes*.Arbor Vitae Special Issue (IUCN Gland, Switzerland).
**68** Jesus F, ed (2001) *P.A.C.T. A Pro-Active Conciliation Tool Analysing Stakeholders' Inter-Relations*.CGPRT Publication (ESCAP) no. 41. (Coarse Grains, Pulses, Roots and Tubers Centre, Bogor, Indonesia). Available at http://www.uncapsa.org/publication/cg41.pdf.
**69** Brown M, Bonis-Charancle JM, Mogba Z, Sundararajan R, Warne R (2008) Linking the Community Options Analysis and Investment Toolkit (COAIT), Consensys® and Payment for Environmental Services (PES): A Model to Promote Sustainability in African Gorilla Conservation. In *Conservation in the 21st Century: Gorillas as a Case Study*, eds Stoinski TS, Steklis HD, Mehlman PT (Springer, New York), pp 205–227.
**70** Wollenberg L (1999) Participatory Mapping. Report of Workshop "Building an Agenda Together" and Mapping Training. Available at www.cifor.org/acm/methods/pm.html. Accessed May 16, 2012.
**71** Selman P (2009) Planning for landscape multifunctionality. *Community Essay*, 5(2): Available at http://sspp.proquest.com/archives/vol5iss2/communityessay.pselman.html. Accessed May 16, 2012.
**72** EBM Tools Network Social Science Working Group. How Can Social Science-Based Software Tools Assist in the Ecosystem-Based Management Process? Available at www.ebmtools.org/sites/natureserve/files/SSWG%20Tools%20Survey_1.pdf. Accessed May 16, 2012.
**73** Reed M (2008) Stakeholder participation for environmental management: A literature review. *Biological Conservation* 141:2417–2431.
**74** Peterson GD (2002) Estimating resilience across landscapes. *Conserv Ecol* 6(1):17.
**75** Clayson ZC, Castañeda X, Sanchez E, Brindis C (2002) Unequal power—changing landscapes: Negotiations between evaluation stakeholders in Latino communities. *Am J Eval* 23(1): 33–44.