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Adaptive community-based biodiversity conservation in Australia's tropical rainforests

THEMATIC SECTION
Community-based natural resource management (CBNRM): designing the next generation (Part 1)

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SUMMARY

In the globally significant Australian tropical rainforests, poor performance of community-based natural resource management (CBNRM) approaches mandated by national policy highlights the importance of the global search for better models. This paper reports on co-research to develop, apply and test the transferability and effectiveness of a new model and tools for CBNRM in biodiversity conservation. Adaptive co-management, designed with specific communities and natural resources, recognized as linked multi-scalar phenomena, is the new face of CBNRM. New tools used to achieve adaptive co-management include a collaborative focal species approach focused on the iconic southern cassowary, scenario analysis, science brokering partnerships, a collaborative habitat investment atlas and institutional brokering. An intermediate-complexity analytical framework was used to test the robustness of these tools and therefore likely transferability. The tools meet multiple relevant standards across three dimensions, namely empowering institutions and individuals, ongoing systematic scientific assessment and securing effective on-ground action. Evaluation of effectiveness using a performance criteria framework identified achievement of many social and environmental outcomes. Effective CBNRM requires multi-scale multi-actor collaborative design, not simply devolution to local-scale governance. Bridging/boundary organizations are important to facilitate the process. Further research into collaborative design of CBNRM structures, functions, tools and processes for biodiversity conservation is recommended.

Keywords: adaptive co-management, Australia, biodiversity conservation, cassowary, CBNRM, collaborative focal species, community-based natural resource management, co-research, design, scenarios

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INTRODUCTION

Biodiversity conservation, particularly in the tropics, remains a pressing environmental conservation challenge, with evidence that a humanity-driven sixth extinction crisis in the history of life on earth is underway (Bradshaw *et al.* 2009). The concept that community-based natural resource management (CBNRM) could address this challenge arose through a global trend to decentralized management in forestry, agriculture, water, fisheries and rural development (Brooks *et al.* 2006; Tacconi 2007). Initial CBNRM efforts delivered limited environmental and social outcomes, leading to robust critiques of the underlying frameworks based on ideals of democracy and harmony between local people and their environments (Agrawal & Gibson 1999; Nunan 2006; Fabricus & Collins 2007). CBNRM theory and practice has since been transformed. Communities are now recognized as contingent and temporary outcomes of interactions between differentiated social actors; environments are dynamic, complex and variable over both space and time; and community/environment interactions occur through diverse evolving institutions at multiple scales (Leach *et al.* 1999; Lane & McDonald 2005; Berkes 2007).

In Australia, CBNRM gained a major impetus in 2002 through a programme which devolved Australian and State governments' responsibilities to organizations with community-based governance structures (Robinson *et al.* 2009). While initially hailed as the solution to intractable environmental problems, subsequent analysis identified the need for improvements to address accelerating threats to the environment and ongoing community engagement challenges, including the marginalization of indigenous peoples (Auditor-General 2008; Hill & Williams 2009). The Australian Government in 2008 refocused attention on leadership and accountability, setting national priorities which CBNRM groups must address to receive funding support (Australian Government 2008). Integrated landscape-scale approaches that link national environmental goals with community priorities, and ensure science integration in CBNRM are encouraged.

This paper reports on co-research to develop, apply and test the transferability and effectiveness of a new model and

Table 1 Intermediate-complexity analytical framework, associated standards from previous research, and our collaborative design tools. *This component includes Pahl-Wostl's (2009) four categories of institutions, actor networks, multi-level interactions and governance modes.

Dimension (Knight et al. 2006)	*Our tools in this dimension*	*Associated ACM criteria (Berkes et al. 2007)*	*Associated conservation actions unified classification (Salasfky et al. 2008)*	*Associated stages in conservation planning (Pressey & Bottrill 2008)*
Empowering institutions and individuals*	Local action committee guiding six-stage collaborative design cycle Collaborative focal species approach Scenario analysis for community visioning Institutional brokering tool	Reason for being Degree of power-sharing Worldview and sense-making Rules and norms Trust and respect Horizontal linkages Vertical linkages	Law and policy External capacity building	Identifying and involving stakeholders Identifying the context for the conservation areas Identifying conservation goals
Ongoing systematic scientific assessment	Multiple science partnerships with brokering outputs Collaborative Habitat Investment Atlas	Use of knowledge Capacity to experiment		Collecting socioeconomic data Setting and reviewing conservation targets
Securing effective on-ground action	Project implementation partnerships, including participatory monitoring	Learning	Land /water protection Land/water management Species management Livelihoods, economic and other incentives	Applying conservation actions to selected areas Maintaining and monitoring established conservation areas

tools for biodiversity conservation based on recognition of the transformed concept of CBNRM in both the national and global discourses. We first present the theoretical foundations from which we interrogate transferability and effectiveness. After describing our study area and co-research methods, we present a results section detailing the collaborative design approach and relevant tools. We discuss the challenges in delivering a new generation of CBNRM models, and implications of this research for theory and practice in biodiversity conservation.

THEORETICAL FOUNDATIONS OF THE NEW CBNRM

The new multi-scalar dynamic conceptualization of both human communities and natural resources moves community-based approaches into the field of adaptive co-management (Armitage *et al.* 2007). Context emerges as a key determinant; strategies that enhance enforcement capacity, as well as those that empower local residents and local livelihoods, have the potential to be effective in different contexts (Borrini-Feyerabend 1996; Stern 2008). Diverse historical, cultural, political and geographical contexts contribute to diversity in the theory and practice of adaptive co-management, and even disagreements on whether it can be forged through design or is an emergent property of complex systems (Berkes *et al.* 2007). However, there is a strong focus on design in the biological sciences literature on conservation planning and action, arising from a perception of urgent threat (Pressey & Bottrill 2008; Salafsky *et al.* 2008). As adaptive co-management, conservation planning and action are all relevant for community-based biodiversity conservation, we sought to interrogate our results drawing on standards across these fields. Such standards employ theory about root causes in the biodiversity conservation problem/solution space, and therefore provide a basis for considering the effectiveness of our model and likely transferability to other biodiversity conservation situations.

We encountered complex and contradictory analytical categories and standards, with multiple strategies, criteria, variables for diagnosis and design, inspired by common pool resource, governance and political ecology theories (Gibson 1999; Susskind 1999; Batterbury & Fernando 2006; Berkes *et al.* 2007; Fabricus & Collins 2007; Ostrom 2007; Wilmsen 2008; Pahl-Wostl 2009; Sandström 2009). We identified four analytical frameworks as most relevant, namely (1) Berkes *et al.*'s (2007) ten criteria for adaptive co-management, (2) Pahl-Wostl's (2009) categories of institutions, actor networks and multi-level interactions, (3) the IUCN's (World Conservation Union) seven categories for conservation action design (Salafsky *et al.* 2008) and (4) Pressey and Bottrill's (2008) eleven stages for design of conservation plans (Table 1). Knight *et al.*'s (2006) three-dimensional conservation implementation model (empowering institutions and individuals, ongoing systematic conservation assessment and securing effective action) provides an overarching framework with capability to encompass all standards and address an identified implementation gap between science and conservation action (Knight *et al.* 2006; Table 1).

Table 2 Qualitative performance evaluation using Mandarano's (2009) framework.

Performance evaluation criteria	*Definition*	*Performance of Mission Beach Habitat Network Action Plan*
Outputs		
High-quality documents	Documents produced through a collaborative process that justify action or identify a clear approach for implementation and are approved by a consensus-based approach	Mission Beach Action Committee role central, involving circulation, draft, commentary and feedback with stakeholders, including through web
Collaborative science	Scientifically sound information produced through a consensus-based approach that stakeholders understand and accept	Multiple science partnerships produced brokering outputs that were understood and accepted by stakeholders
Outcomes Social		
Social capital	New and improved working relationships, formation of trust, norms of reciprocity	Growth of engagement by key actors in MB Action Committee; commitments of many different organizations to implementation partnerships
Intellectual capital	Mutual understanding, shared problem frames, agreed upon data or shared information	Many examples through the brokering outputs; agreed Community Vision
Political capital	Ability to work together for agreed ends, end to a stalemate	National government action to prevent sub-division within habitat linkage identified in Terrain NRM's brokering output 'Wongaling Creek Habitat Linkages'
Innovation	Strategies, actions and ideas that are new to the context, break a stalemate	New state government planning policies that constrain the urban footprint to protect biodiversity at Mission Beach; new significant impact guidelines for cassowary under national legislation
Environmental		
Restoration projects completed	Restoration projects completed by the collaboration or indirectly through actions by others	Thirteen revegetation projects have been completed
Land protected from development	Lands acquired or otherwise protected by collaboration or indirectly through the actions by others	Several voluntary conservation agreements delivered and others under negotiation; lands protected from urban and residential development through above changes to Queensland and Australian Government policy
Changes in environmental parameters	Changes in environmental quality appropriate to the goals	Negligible change evident; cassowary death rates still high and habitat loss continuing although slowed
Perceptions of improved environmental quality	Participants' perception of success in improving environmental parameters are indirect measures of environmental outcomes	Participants' perception is that the momentum of development impacts has been slowed but the situation not yet reversed

We also aimed to determine our model's effectiveness through evaluating the social and environmental outcomes. Mandarano's (2009) performance evaluation framework of eleven criteria for considering outputs, social and environmental outcomes enabled an integrated evaluation addressing gaps identified in previous evaluative studies (Table 2).

METHODS

Study area

The Australian wet tropical rainforests have high species diversity and remarkable levels of endemism, including over 30% of Australia's species of frogs and 60% of its bats, with some seventy-three species of vertebrates endemic to these rainforests (Moritz 2005). World Heritage listing recognizes the international significance of these forests, including contributions to global understanding of both biological and human dimensions of landscape evolution (Stork & Turton 2008). Rapid human population growth and peri-urban land-use intensification associated with sea-change and tree-change lifestyle choices continue to threaten forest integrity; these are highly contested landscapes (Stork *et al.* 2008). The tropical rainforests' vulnerability to climate change has highlighted the urgent need for reversing habitat loss and improving habitat quality (Williams & Middleton 2008; Williams *et al.* 2008).

The study area at Mission Beach (Fig. 1) supports extraordinary levels of biodiversity in less than 30 000 ha (0.00004% of the Australian continent), and includes 36% of Australia's bird species, 13% of the remaining wet tropical lowland rainforest and 5% of all Australian vascular

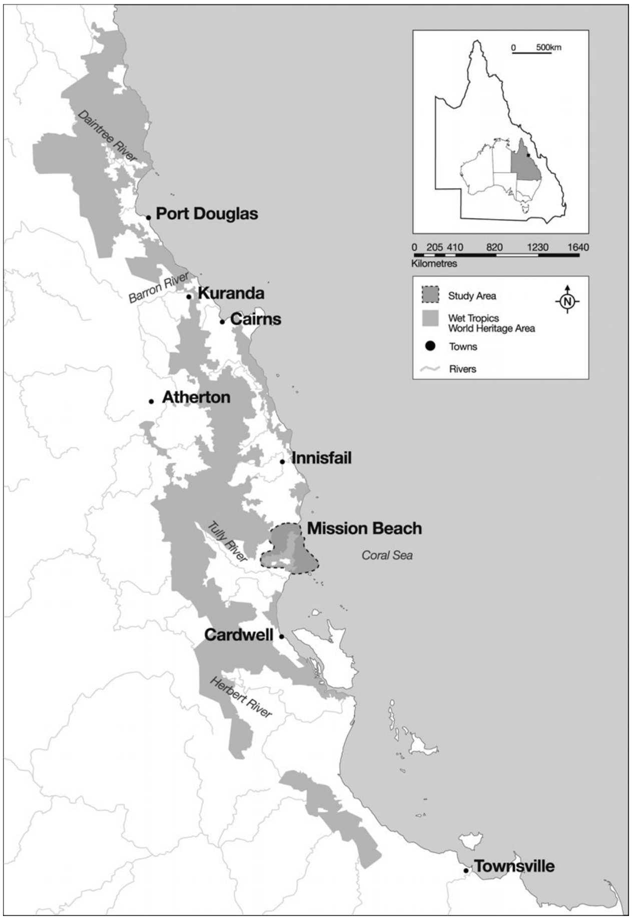

Figure 1 Mission Beach, the case study site in the Australian wet tropical rainforests.

plant species. Mission Beach has significant irreplaceable biodiversity, including unique native grassland and rainforest communities on a coastal basalt headland (Chenoweth EPLA [Environmental Planning and Landscape Architecture] 2007). It is an important site for conservation of the endangered southern cassowary (*Casuarius casuarius johnsonii*), which is threatened by habitat loss, fragmentation and degradation, roads and traffic, dog attacks, hand feeding, diseases and natural catastrophes particularly cyclones (Latch 2007). The 2006 Australian Census reported Mission Beach as having a population of 4103 residents and 1646 tourists. Residents live in several villages, on farms and in rural-residential blocks. Employment is primarily in tourism and agriculture, while construction, manufacturing and education are also important sectors (Williams *et al.* 2009).

Participatory co-research methods

The development, application and testing of our model and tools for CBNRM in biodiversity conservation occurred over a three-year period from 2006 to 2009. We used a participatory co-research approach, combining action research methods with bringing researchers and practitioners together in an equitable working relationship (Greenwood & Levin 2007). Two-way negotiation of information and capacity between scholars and practitioners produced our new model and tools (Wilmsen 2008).

We regarded participatory research as creating a long-term learning community, supporting a dialogic network to co-produce knowledge (Davidson & O'Flaherty 2007). Our core participatory co-research team included three people from Terrain NRM, a non-government organization mandated by the Australian Government to undertake CBNRM (Robins & Dovers 2007); and one social and two biological scientists. The Mission Beach Habitat Network Action Committee (hereafter the action committee) provided a forum for a wider dialogue with civil society, industry, scientific and government actors who had decision-making roles at local, regional and national scales. Data sources to underpin the research included biophysical and social data held by the core co-research team, policies, plans, media releases, annual reports, funding applications, budgets, terms of reference, minutes of meetings, consultation reports, historical essays, and data held by researchers and others represented on the action committee. Participant observation occurred at three community meetings each of approximately fifty people and in numerous smaller meetings with stakeholders held throughout the research. Validity was established through convergent triangulation between multiple data sources and the regular conduct of critically reflexive reviews; transferability and effectiveness were tested by applications of analytical and evaluative frameworks (Robinson 1998; Mandarano 2009).

RESULTS

Collaborative design of CBNRM for biodiversity conservation context

The centre of our model was an adaptive collaborative design cycle for CBNRM which prepares the ground for effective ongoing investment in both regulatory and incentive-based biodiversity conservation (Sayer & Campbell 2004). CBNRM is facilitated through an action committee whose members include representatives from civil society, government, industry and indigenous sectors to undertake decision-making, using multiple participatory tools and processes. The organization mandated with responsibility for CBNRM (in this case Terrain NRM [Terrain Natural Resource Management]) acts as bridging/boundary organization for the whole process, championing the action committee, the adaptive design cycle and associated multi-scale participatory tools and processes (Berkes 2009). Context determines the key design challenges, identified at Mission Beach as institutional fragmentation and uncoordinated decision-making, disparate stakeholder perspectives and knowledge systems, competing visions, competing priorities and poor science integration.

The design cycle produced through our co-research involved six stages: (1) exploratory analysis of the natural resources and human community; (2) facilitation of community ownership and a shared community vision, in this case using the collaborative focal species approach and scenario analysis tools; (3) identification and prioritization of strategies and projects, in this case using science brokering partnerships and collaborative habitat investment atlas tools; (4) forging of implementation partnerships, in this case through the institutional brokering tool and incentives (offsets, auctions, competitive grants, tenders) to secure habitat protection and restoration; (5) participatory monitoring to build common understandings of the efficacy of actions on biodiversity condition and other identified values; and (6) updating and refining that relies on social learning and empowerment.

Collaborative focal species approach to facilitate community ownership

Recognition of the multiple values held by people about biodiversity formed the starting point of efforts to address the poor community cohesion identified in the exploratory analysis (Stern 2005). The action committee established the overall goal of developing an ecologically viable habitat network that protects community values. We undertook stakeholder analysis that identified community values centred on biodiversity, aesthetic/lifestyle and Djiru (aboriginal people's) cultural attributes. An assessment of the significance of each was undertaken (Chenoweth EPLA 2007; Falco-Mammone 2007; The Djiru Traditional Owners and Girringun Aboriginal Corporation 2007). The cassowary emerged as an icon of high significance from all three perspectives.

Djiru Traditional Owners considered the relationship with the *gunduy* (cassowary) to be integral to their identity and wellbeing as 'rainforest people' and the health of rainforest. For Djiru people, the cassowary is a 'cultural keystone' species, a culturally salient species that significantly shapes cultural identify, reflected in fundamental roles in diet, materials, medicine and spiritual practices (Garibaldi & Turner 2004). For the wider community, the cassowary is a flagship species that reflects the aesthetic and lifestyle values, and is important to the tourism economy (Simberloff 1998; Falco-Mammone 2007). The cassowary is a unique disperser of forest tree species and is thus integral to their persistence (Westcott *et al.* 2005). The cassowary conservation requirements are such that it can also be considered an ecological focal species; its ecological and habitat requirements must be protected to secure the future of multiple species and communities in the same area (Lambeck 1997; Hugget 2007).

The term collaborative focal species encapsulates this combined capacity as an ecological focal species, a cultural keystone species and a flagship species, providing community ownership and a unifying focus for transformation of this linked social and ecological system. The success of the cassowary in providing this unification is evident through public and agency enthusiasm for numerous cassowary events during the period of this research, including a Cassowary Summit, an art exhibition 'This is Cassowary Country', a DVD 'No *wabu*, no *wuju*, no *gunduy* (no rainforest, no food, no cassowary)', a number of community-based cassowary surveys (Hardesty & Westcott 2008), and in adoption of the name 'Cassowary Coast Council' by the new local government authority.

Scenario analysis to facilitate a shared community vision

Scenario analysis is a useful systematic method for thinking creatively about possible complex, contested and uncertain futures (Peterson *et al.* 2003). The co-research team initially proposed development of several scenarios to address conflicting community perceptions and generate options for interventions. However, the action committee viewed simplicity as the foremost requirement, directing that it would be most useful to understand the implications of current trends. Two scenarios were therefore developed, one depicting the current situation, and a business-as-usual scenario of the future in 2025 based on a projection from current trends in human population and land use change.

The scenarios were generated by defining focal issues, assessing the current 'system' including key drivers of change and uncertainties and investigating changes in land use and biodiversity impacts over the last five years. Forward projections for habitat based on these trends identified that by 2025, conversion of 470–528 ha of existing forested habitat to intensive land use, on top of the 2004 intensive land use area of 622 ha, would be required, an increase of 75–85%. The change in quality of vegetation cover was similarly dramatic with the clearing of a further 302 ha of remnant vegetation required, with the greatest losses being coastal forests, recognized as critically endangered habitat. Further degradation of native vegetation through agricultural land use is also projected within an important rainforest corridor for connectivity from the coast to the uplands in the wet tropics (Williams *et al.* 2009).

As well as these changes to habitat quality and associated biodiversity impacts, the business-as-usual 2025 scenario highlighted striking changes to the cultural and lifestyle values, with urban strip development replacing the current pattern of villages in the rainforest. This scenario therefore highlighted threats to the values of all key interest groups, mobilizing community cohesion in resistance to these trends. Workshop participants uniformly agreed that their desired future differed vastly, and found common ground in an overall vision statement: 'Mission Beach is a sanctuary for wildlife and habitat; its defining feature is a strong human community that acts to protect its special values. Mission Beach is an exemplar of sustainable living, both environmentally friendly and culturally diverse. Mission Beach has a tropical landscape character where urban, farming, and forest communities blend to maintain a harmonious setting with strong visual appeal.'

Table 3 Multiple science partnerships and associated brokering outputs (see URLs http://www.rrrc.org.au/ and http://www.terrain.org.au/programs/biodiversity/mission-beach.html).

Science partnership	*Brokering output*
Status and trends of biodiversity and ecosystem services	Biodiversity significance of Mission Beach (report) Collaborative Habitat Investment Atlas: trends in native vegetation cover
Rainforest biota of significance	Conservation significance and biodiversity condition and status assessment for collaborative investment (report) Participatory cassowary faecal DNA survey Atlas: distribution of biota of conservation significance
Climate change	Atlas: predicted future vegetation patterns under climate change scenarios
Invasive species	Invasive species dispersal models to guide control Atlas: invasive species distributions and density data
Indigenous landscapes	Indigenous cultural significance of Mission Beach (report)
Sustainable tourism	Aesthetic and lifestyle significance of Mission Beach (report) Mission Beach ecotourism strategy
Impacts of development	Mission Beach cassowary road management Study (report) Wongaling corridors fauna crossings (report) Atlas: habitat quality and canopy cover data
Restoration ecology	Monitoring revegetation projects for biodiversity in rainforest landscapes toolkit (report)
Conservation planning	Collaborative atlas: data on targets for national protected area system, and vegetation condition; Auction workshop for coordinated conservation investment (report)

Science brokering partnerships and the collaborative atlas

Scientific partnerships that deliver brokering outputs are effective in bridging the gap between scientists and practitioners, overcoming the significant barriers to uptake by conservation practitioners of the scientific literature (Gonzalo-Turpin *et al.* 2008). We co-produced the key science partnerships (supported through various Australian research institutions) and the associated brokering outputs (Table 3); cooperative production of these outputs between the action committee and the scientists through multiple rounds of engagement and comments on drafts ensured that the subsequent strategies and projects integrated the scientific findings.

The collaborative habitat investment atlas provided a means of brokering information from multiple science partnerships into a highly visual and interactive platform (Table 3). The atlas was developed as a participatory tool to prioritize investment, recognizing existing optimization methods do not target multiple decision-makers at many levels (Joseph *et al.* 2009). Included in the atlas over time is information relevant to biodiversity value, costs of land for acquisitions, costs of incentives, protection available through land-use planning, land-owner willingness to be involved, levels of entrepreneurship, social capital and burnout in rural communities (Knight & Cowling 2007). The atlas promotes dynamic interaction among stakeholders through variables whose weightings in the analysis can be simply altered by use of a slider bar and formula-based dynamic attributes that are automatically updated as changes are made in the weighting of variables (Oroton Family Foundation and Placeways 2009). Once the model has been created, a colour code enables site suitability to be visualized spatially. The weights and attributes in the model can be altered in a stakeholder workshop, and the results displayed visually. The current atlas combines three relevant models: biodiversity sensitivity, level of protection and threat (Fig. 2).

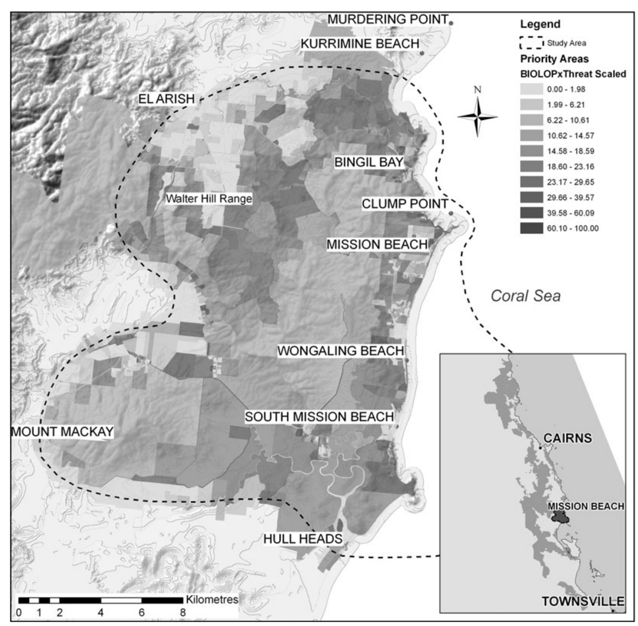

Figure 2 Collaborative Habitat Investment Atlas: integrated model of biodiversity sensitivity, level of protection, and threat (BIOLOP). Scaled composite index: higher value areas are those with high biodiversity sensitivity, high threat, and low level of existing institutional protection.

Institutional brokering for implementation

Our institutional brokering tool drew on recognition that management of boundaries between knowledge, planning and policy systems at different levels can overcome institutional

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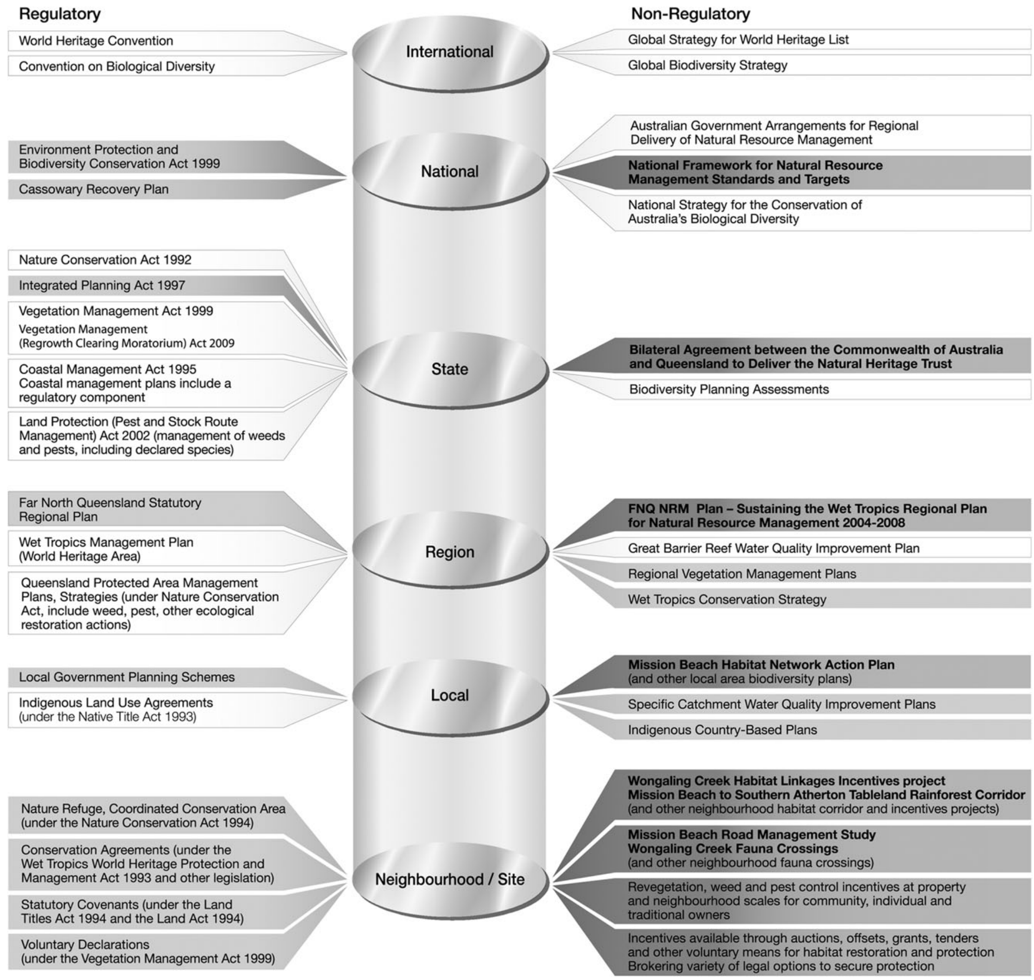

Figure 3 Institutional brokering framework: instruments highlighted in dark grey represent spheres of direct action; those in paler grey represent key sites for brokering outputs; other instruments provide important context (after Peterson *et al.* 2007).

fragmentation (Cash *et al.* 2006). The tool combines an institutional brokering framework (Fig. 3), an officer employed to explicitly focus on cross-scale brokering and a set of brokering outputs (reports and submissions) produced by the co-research team.

Much more effective alignment between institutions at local, state and national level has been achieved. Under the Environment Protection and Biodiversity Conservation Act 1999 (URL http://www.environment.gov.au/epbc/index.html), the Australian Government refused an application to develop a property identified as a key cassowary habitat and movement corridor in the Wongaling Creek Habitat Linkages report brokered by Terrain NRM into these higher level institutions. A new national policy with provisions for protection of cassowaries at Mission Beach has been released (DEWHA [Department of the Environment, Water, Heritage and the Arts] 2009). A new statutory plan under the Integrated Planning Act (1997) Queensland (URL http://www.dip.qld.gov.au/ipa), imposed rules that constrained the urban footprint at Mission Beach to minimize impacts on ecological and cultural values identified in a submission by Terrain NRM and other reports (Minister for Infrastructure and Planning 2009). Further mechanisms under relevant legislation, including master planning and strategic assessment for Mission Beach, are under discussion. Major government investments into incentives are also being sought.

Evaluation and analysis

We interrogated the adaptive co-management model and tools according to the analytical framework and associated standards from the scholarly literature (Table 1). The action committee and collaborative design process empowers institutions and individuals through power-sharing, building rules, norms, mutual trust and respect, horizontal linkages and stakeholder engagement. The collaborative focal species enables sense-making between individuals with different world views and values, for example scientific, traditional and local knowledge systems. Scenario-analysis for community visioning uses the capacity of threat to inspire community cohesion in resistance. The institutional brokering tool provides vertical linkages, addresses law, policy and external capacity building.

Multiple science partnerships and the collaborative habitat investment atlas are powerful tools for ongoing knowledge integration, experimentation, collection of socioeconomic data and conduct of biodiversity conservation assessments. Project implementation partnerships take account of the standards for securing effective on-ground action (Table 1). The analysis demonstrated the model met standards arising from the literature on adaptive co-management, conservation planning and action.

The qualitative evaluation using Mandarano's (2009) performance criteria framework identified important outputs and outcomes, particularly in strengthening institutions (Table 2). However, the incentives for private habitat protection and restoration have been few, and the decline of biodiversity at Mission Beach is ongoing; cassowaries continue to die from vehicle strikes and, although the rate of habitat clearing and fragmentation has slowed, it has not yet stopped. A greater level of financial investment into incentive-based habitat strategies in parallel with the regulatory improvements would increase would strengthen the biodiversity conservation outcomes.

DISCUSSION

The new face of CBNRM as adaptive co-management, designed for the context, presents a significant challenge. The task involves multiple partnerships, knowledge systems, institutions, actors at many levels and considerable technical and social complexity in both the collaborative design process and the enabling tools. A brokering/boundary organization (Terrain NRM) facilitated this engagement of relevant actors at multiple scales into the design processes. Berkes (2009) previously highlighted the role such boundary/bridging organizations play in knowledge coproduction, trust building, sense making, learning, vertical and horizontal collaboration, conflict resolution, catalysing cooperation between different levels of governance, and across resource and knowledge systems. Our identification of the collaborative design role reinforces the significance of bridging/boundary organizations. Multiple design dynamics emerge in CBNRM for biodiversity conservation, for example the urgency of the problem, a view that adaptive co-management can be forged rather than just emerge and an active rather than passive approach.

The Australian Government's new policy agenda with its emphasis on competition, whereby bodies previously mandated with carriage of CBNRM will compete with others for available resources and the public mandate, does not appear to take account of the time and resources required to build an effective boundary/bridging organization (Robinson *et al.* 2009). Rather than enhancing the outcomes from CBNRM, the new policy risks creating a landscape that is crowded with multiple actors whose contributions and connections are confused and conflicting. Given the urgency of the biodiversity conservation challenge in the Australian tropical rainforests, this would be a regrettable outcome.

CONCLUSIONS

In Australia's globally-significant and highly threatened tropical rainforests, the new face of CBNRM is adaptive co-management, designed for specific communities and natural resources, recognized as linked multi-scalar phenomena. Design occurs in an adaptive cycle: (1) exploratory analysis; (2) community ownership; (3) strategies and projects; (4) implementation partnerships; (5) participatory monitoring; and (6) updating and refining. Effective tools, suited to the context, are required at each stage. In this case, exploratory analysis identified the key design challenges as institutional fragmentation and multiple decision-makers, disparate stakeholder perspectives and knowledge systems, competing visions, competing priorities and poor science integration. The cassowary as a collaborative focal species provided community ownership and a unifying focus for transformation of this linked social and ecological system. Scenario analysis for community visioning facilitated community cohesion on biodiversity goals. Multiple science partnerships that produced brokering outputs, and a collaborative atlas, facilitated strategies and projects with priorities underpinned by science integration. An institutional brokering tool, including a brokering framework, a local area planner/broker and a set of brokering outputs, has achieved significant institutional alignment and improvement of conservation outcomes.

An intermediate-complexity analytical framework drawn from the scholarly literature identified three dimensions, and associated diverse standards, for interrogating our model and tools, namely empowering institutions and individuals, ongoing systematic scientific assessment and securing effective on-ground action. Our analysis found that the six-stage collaborative design process, together with the set of tools applied, addressed multiple standards for success from adaptive co-management, conservation planning and conservation action literature. The model therefore focused on root causes identified in previous research and is likely to be transferable to other biodiversity conservation situations. The analysis reinforced previous findings about the importance of bridging/boundary organizations, focusing attention on their role in design. Evaluation using Mandarano's (2009) performance framework identified effectiveness in the achievement of many positive social and environmental outcomes, while highlighting the need for greater financial resources and the significant ongoing challenge in turning the tide of biodiversity loss in tropical rainforests.

Effective CBNRM lies in the outcomes from empowering multi-scale multi-actor collaborative design processes not, as originally conceived, in the power of devolution to local-scale governance. Bridging/boundary organizations are important in facilitating the process, and biodiversity conservation may benefit from investment in development and capacity of such organizations. Further research and development of theory and practice in collaborative design of CBNRM structures, functions, tools and processes for biodiversity conservation is recommended.

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